Lessons from India in solid waste management: Based on material collected and developed by study fellows and tutors on courses conducted by WEDC in conjunction with AIILSG, Mumbai, India

LESSONS FROM INDIA

IN

SOLID WASTE MANAGEMENT

Edited by Adrian Coad

Based on material collected and developed by study-fellows and tutors
on courses conducted by
The Water, Engineering and Development Centre (WEDC),
of the Institute of Development Engineering, Loughborough University, UK
in conjunction with
The All India Institute of Local Self Government, Mumbai, India

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The Water, Engineering and Development Centre (WEDC) is concerned with education, training, research and consultancy for the planning, provision and management of physical infrastructure for development in low- and middle-income countries.

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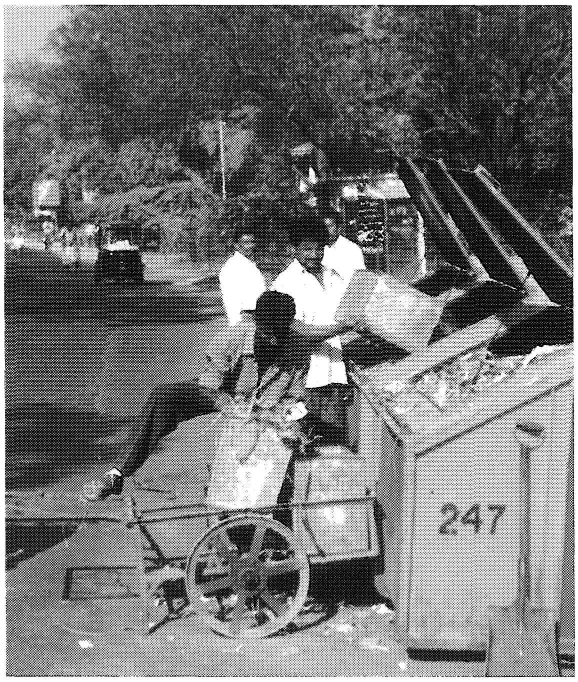

Photo Manfred Scheu

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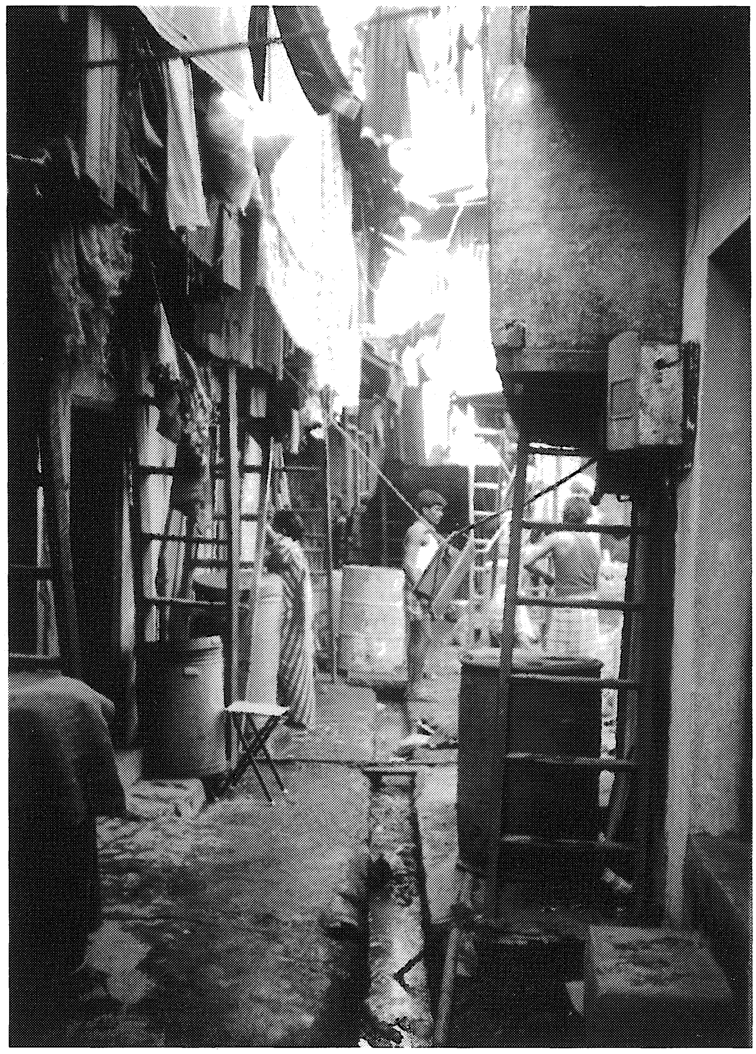

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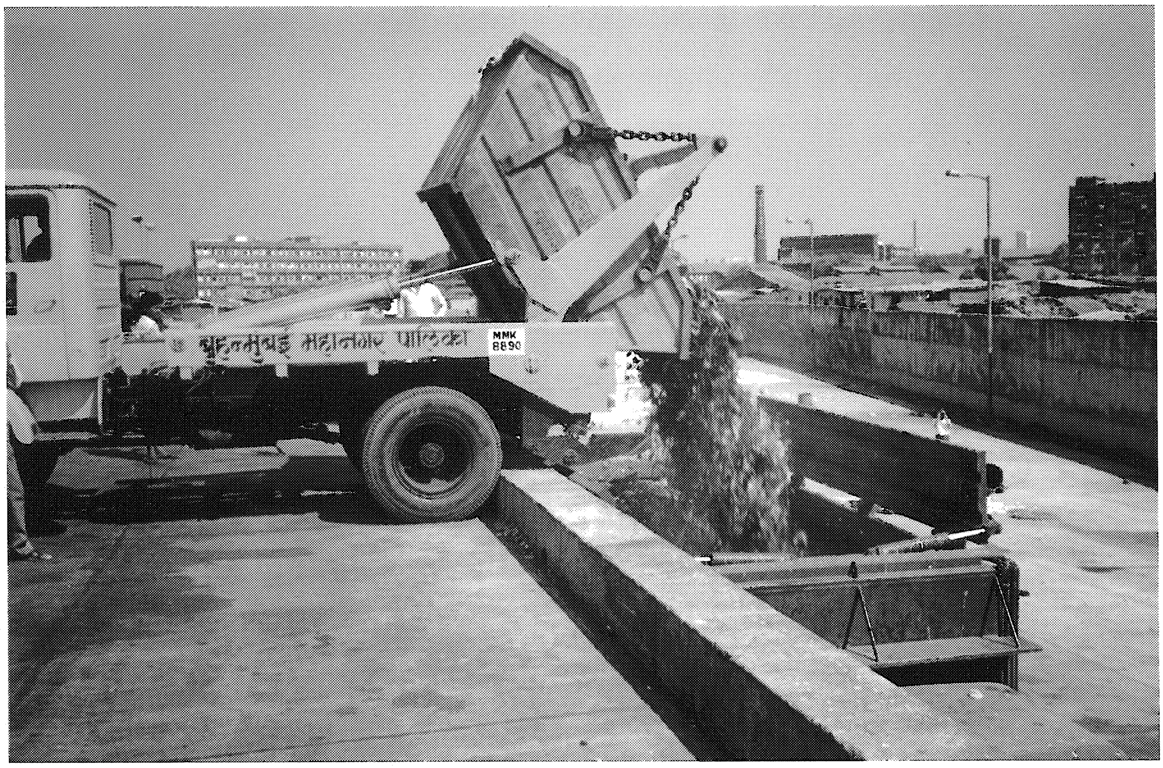

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Editorial

Lessons from India...

There are many reasons why the title of this book must be "Lessons from India".

To start with, the material in this book is derived from three training courses, held over a period of three years. The courses each began in UK, where there were lectures, exercises and site visits, and continued in India, where most of the time was spent on site visits and in collecting information in small teams. In this way, India provided the lessons for the second part of the course, and it is the material collected by the course participants and tutors which forms the substance of this book. The participants on the courses were mostly engineers and administrators with some previous contact with solid waste management. The wide range of disciplines and geographical origins (within India) of the participants gave each person on the courses the opportunity to learn from the other. The courses benefited from the lessons that India passed on, and is hoped that some of this benefit can be passed on to a wider readership.

A shorter report was written after the first such training course operated by Loughborough University; that report was entitled "Observations of Solid Waste Management in Bombay, 1992", and it is available from the All India Institute of Local Self Government in Mumbai and from WEDC, Loughborough University, UK.

This report contains a number of snapshots from the past. It should not be seen as a current review of the status of solid waste management in the locations mentioned. Some of the problems mentioned in the chapters may already have been solved. Since much of the information was collected over a short space of time, it also cannot claim to be comprehensive or complete. So if the material in this book is neither current nor comprehensive, what is its value?

- ◊ Firstly, the chapters present information gathered by impartial outsiders, and will provide useful introductions to a wide range of subjects.
- ◊ Secondly, since different towns and cities are at different stages, experiences that may belong to the past in some cities, may soon happen in others. One city can learn from the mistakes and successes of another. It is hoped that this book will stimulate exchanges of information between municipal officials and engineers in different towns and cities throughout India.
- ◊ Thirdly, the examples that are described in this book can serve as case studies, valuable in their own right, not tied to any time or place, and as such useful for instruction and discussion. Examples and information are drawn from actual field observations and operations records. It is hoped that this book will be used in solid waste management courses, both for conventional teaching and also for discussion and case study exercises. Some chapters contain suggested exercises for assignments and discussions.
- ◊ Fourthly, it is often instructive to follow the methodology of the investigations, even if the collection of data has not been as exhaustive as one would wish. The chapters in this book will suggest how to approach particular problems, how to calculate important indicators and compare the results, what questions to ask, and what other factors to keep in mind.
- ◊ Fifthly, some of the authors have considerable experience in the subjects they are writing about, This book is an opportunity to learn from them and to see how they apply their knowledge in a concrete situation.

India is a huge country, a place of immense variety, energy and talent. India has much to teach the rest of the world. There is ample scope for south-south technology transfer. India's initiative and intellectual energy have resulted in many innovative schemes - on both technological and sociological levels, and others can learn from the successes and failures. I have learned much from Indian colleagues and admired many for their dedication and spirit of service, working long hours, seeking to improve their outputs, often with little thanks or financial reward.

The variety within India is illustrated by statistics found within this report. In only three cities, examples were found of the cost of collection of domestic solid waste varying from Rs 95/- per ton to Rs 895/- per ton, and densities as low as 190 kg/m^3 and as high as 985 kg/m^3 were measured.

This is an interesting time to be considering solid waste management in India. There has been the relaxation of restrictions on imports. The plague epidemic in 1994 focused the attention of many on the state of solid waste collection and disposal services. In 1995 there were some government statements that expressed a concern to see the private sector more involved in services that were being carried out by municipal corporations. The following year, 1996, saw a number of unequivocal orders from Supreme Court concerning the performance of solid waste management functions. This growing concern about accumulations of waste and the risks of toxic materials is found elsewhere in the world, in that there seems to be a growing awareness amongst governments, development agencies and public, that comprehensive solid waste management needs supporting - *comprehensive* meaning here not only the provision of refuse collection trucks, but also the development of systems including public awareness, institutional development and financial management.

The tradition of keeping good records appears to be very strong in India. During the investigations described in this book there were opportunities to compare records with field observations, and the records that were being kept on a routine basis were found to be reliable and useful. Such records are very valuable to the manager who wants to use his or her resources in the most effective way. Examples are shown of how the records were being kept, how records can be used, and how the method of keeping records might be improved.

Many developing economies suffer from dependence on industrialised countries, in terms of their technology, their training and their financing. As a result of government policy, India has developed a high degree of self-sufficiency, and there are many examples of the effects and benefits of such independence. Now there is more freedom to import machinery and ideas, and so there may be interesting opportunities to compare the indigenous with the imported.

A major feature of the way India manages her solid waste is the massive recycling industry, highly organised and interdependent, yet informal and without bureaucracy, apparently efficient and thorough, and providing a livelihood for hundreds of thousands. Unfortunately standards of hygiene and safety are usually very poor, and there are examples of local pollution - from the fires at disposal sites and from the many small and primitive reprocessing industries. Similar systems exist in other Asian countries and in Egypt, where very small incomes (typically one US dollar a day) can sustain an individual or even a family. The system has many opponents, who are concerned for the environment and appalled at the working conditions of so many. It is not easy to determine what government *should* do. It is easier to see what government *can* do - very little - because of the large numbers of poor people with no alternative source of support, people who have considerable power because of the desperateness of their position and their influence at the ballot box.

Much of the material is based on observations in Mumbai (or Bombay as it was called by the British and known until recently). Mumbai is one of the three biggest cities in India, and suffers from shortage of space, difficult transport conditions, a large influx from rural areas putting pressure on urban land and building large slum or squatter settlements, and a huge population. These are problems facing many large cities in the developing world, and municipal officials from mega-cities in other countries can learn from what Mumbai is doing. Other studies were carried out in Ahmedabad, where there has been some very dynamic and innovative leadership in solid waste management, and from Rajkot, also in Gujarat state, which has attracted considerable interest because of the experiments with the use of contractors to undertake municipal services.

This book seeks to address some of the burning issues in solid waste management - how to gain a higher degree of public participation, what type of refuse collection vehicle is most suitable and how it can be kept in good working order, how the productivity of man and machine can be improved, and how solid waste should be disposed of - what method is affordable, reliable and sustainable. This single volume does not pretend to give a complete treatment of solid waste management, but it does aim to be practical and realistic, to show the interdisciplinary nature of the subject and to tackle selected subjects with a useful degree of detail.

Lessons *from* India, but also lessons *for* India. The country is so large that the lessons included here will surely be useful elsewhere in India, as well as elsewhere in the world.

...in solid waste management

As already mentioned, there is a growing international concern to improve standards of solid waste management. As cities grow larger, the problems of removing and disposing of accumulating waste become much more difficult, and threaten to overwhelm many administrations.

Many administrators, and even engineers and consultants, fail to understand the extent to which local conditions affect the choice of techniques, equipment and approaches. They recommend containers, vehicles or other equipment which they have seen working successfully under certain conditions, and they want to apply them in a completely different situation. This approach has led to countless failures and the wasting of millions of dollars. It is necessary to go back to first principles and *question* each step and decision in the selection process. There are countless examples of such mistaken transplantation, but the most common types are:

◊ the specification of containers that are designed for a waste of a much lower density, so that they (or the lifting mechanisms designed to empty them) are quickly broken when they are filled with waste which is six times as heavy as the waste they were designed to contain;
◊ the use of compactor trucks for dense, wet waste, with the result that they are overloaded [especially on the back axle], and they are rapidly damaged by corrosive and abrasive wastes;
◊ the attempt to use incinerators to burn wastes that are too wet or too inert to burn satisfactorily.

Unfortunately there are very few books, currently in print in English, that address the issues of solid waste management in low- and middle-income countries. Most waste management books and journals concentrate on technologically advanced treatment and disposal of waste [subjects which are more suited to laboratory research and the objectives of universities] and they neglect the subjects of collection and transport. Research is often based on the interests or background of academics and the available research or laboratory facilities rather than the needs of the community. More recently there have been books and articles published on recycling of solid wastes in developing economies, but these are largely written from a sociological standpoint, and sometimes give the impression that the author is unaware that there is a large municipal organisation which is trying to solve the solid waste problems in the city in question. There is very little literature in print that can lead a municipal engineer from his present open dump to an intermediate landfill that can significantly reduce the pollution and nuisance from disposal at a cost that can be afforded and sustained. It is hoped that this book will go some way to filling the gap in the literature by discussing some of the issues that concern the formal municipal or private sector operations in large cities.

Solid waste management is not just technology, nor simply the organisation of a workforce. It touches on many disciplines, among them

◊ sociology - to know how to motivate the public to play their part in the solid waste chain and to develop appropriate recycling systems;
◊ management science - to create an organisation that works harmoniously and efficiently and that motivates the staff to do their best for the community they serve;
◊ town planning - to make provision for waste management within urban areas and to locate transfer stations and waste processing and disposal facilities in a socially acceptable and environmentally sensitive way;
◊ mechanical engineering - to specify, design, operate and maintain the appropriate machinery and equipment;
◊ accountancy and financial management - to generate the necessary funds, to use them effectively and to plan and provide for future needs;
◊ architecture - to design attractive and functional buildings and structures for waste storage and management;
◊ geology - to site disposal facilities in places where they will cause the minimum pollution;
◊ civil and environmental engineering - to design, operate and complete environmentally sound and economical sanitary landfills;
◊ chemistry - to define ways of managing difficult and toxic industrial wastes;
◊ environmental science - for environmental impact studies, monitoring pollution from industries and waste management facilities, and research;
◊ public relations - handling complaints, dealing with the press, presenting a positive image.

Personal views on key issues

While compiling this book I have been made aware of some ways of thinking that I believe are responsible for many of our problems in dealing with solid wastes. I will mention them in general terms here, and some of them will reappear later in the book as they apply to a particular issue. Some points are very controversial, but even these should be discussed and reconsidered from time to time. There is no significance in the order in which these points are raised.

Why should anyone want to work in waste management? This is an important question, because clearly there are important benefits when the managers are interested in their work, have been trained by courses and experience over a number of years, and are committed to working in this sphere for many years to come. There are engineers and managers in India who are motivated, talented, committed and dedicated, and it has been very valuable for the course participants to meet such people, to benefit from their knowledge and to learn from observing their example and attitude. Unfortunately there are others who did not wish to be transferred into solid waste management, and who are not interested in the subject, but are concerned to do the minimum necessary until they can find a way to be transferred out. How can the solid waste industry be made more attractive?

The engineer or middle manager - between a rock and a hard place. Perhaps because they are relatively few in municipal organisations, perhaps because they have a strong sense of duty, or perhaps because of their understanding of the importance of their work, engineers have not demanded improved pay and conditions in the same way that unskilled workers have done, with result that their pay and conditions are not attractive. Some engineers in the solid waste management sector work long hours, suffer from the pressures of large, powerful workforces, and receive complaints and blame from the press, the public, elected representatives, and perhaps their superiors The main benefit they have in municipal service is job security, but this does not motivate them to do their best and develop their skills. India has some dynamic management training institutes - it might be very worthwhile for a large municipality to commission one of these institutes to investigate its management climate with the aim of finding ways of improving the situation of engineers and middle managers - but would the corporation be willing to implement change?

Attending a course is not always training, and the need is often motivation rather than training. There is sometimes a tendency to think that attending courses, training and motivation are all the same thing. The training sections of municipalities may not be resourced as they should be. Attitudes to training are often negative or apathetic. Training courses may not be seen as relevant. After a course there may not be the opportunity of putting into practice what has been taught during the course, leading to frustration. The primary need may be motivation - to answer the question "Why should I do it?" rather than "What should I do?" Often training is seen in terms of travel, allowances and a rest, rather than as a step on a ladder.

Should or will? I have learned to react whenever I hear people use the word "should' when discussing solid waste management issues.

"The residents *should* replace the lid on the container when they have deposited their waste."
"People in the street *should* put their waste in the nearest waste container."
"Shopkeepers *should* not put their waste in the containers for domestic waste."
"Rag-pickers *should* not set fire to the waste."

And so on. Sometimes we feel we have done our job when we have declared what people should do. My reaction, when I hear the word "should" is usually to ask:

"Yes, but what *will* they do?"

The public often do not do what they should. This may be because they do not know what they should do, or they do not know why or how. Sometimes what they should do is very difficult to do, for reasons that the engineer or manager may have overlooked. Let us use the word "should" with caution. Let us be prepared to invest in surveys of attitudes and knowledge, and in public awareness campaigns to explain and motivate.

The most expensive solution is not always the best. A solution should be appropriate to the local conditions and situation. A man lost in the desert and dying of thirst would be much happier to find a bottle of mineral water costing ten rupees than a bottle of whiskey costing a thousand rupees, whereas a businessman about to entertain two prospective clients from Scotland would prefer to have the whiskey. Sometimes the most expensive is the best, but this is not always the case. We should not reject or despise low-cost options simply because they are not expensive. Spending money does not guarantee success. There have been many examples of large sums spent on treatment or disposal technologies that have produced little or no benefit, when often a less expensive option, given sufficient support, would have been successful.

Privatisation - the pill to cure all ills? Some politicians and decision-makers talk as if engaging contractors will solve all problems. They forget the pitfalls associated with contractors:-

- The danger that monopolies or lack of competition will result in excessive costs;
- The failure of inexperienced and under-resourced contractors;
- The unwillingness of contractors to invest in the most appropriate equipment, so that, for example, they use open trucks from which the waste may be scattered;
- Exploitation of the workforce in terms of inferior pay and conditions;
- Opportunities for corruption in the awarding of contracts.

There are also advantages associated with engaging contractors to provide municipal services:-

- Freedom from restrictive labour agreements that result in less work being done for higher wages - some municipal workforces are very large, and new systems that require fewer labourers must be manned at the old levels if operated by the municipality, because of agreements with labour unions and pressure from politicians;
- More effective supervision and performance if the contract has satisfactory penalty clauses;
- Lower costs because of competition and better financial management;
- Easier financial planning for the corporation since annual costs are known in advance and capital expenditures are reduced or eliminated.

A compromise, or middle option, that is sometimes ignored, is the creation of a separate publicly owned unit which has financial autonomy and a degree of independence. Sometimes the key to success is to build small administrative units, where the beneficiaries are close to those in charge, and where there is a sense of ownership and responsibility on the part of the public.

Who wants to save money? This book suggests several ways in which the work of waste collection could be done more effectively and at lower cost, but it is not clear whether anyone in India's largest cities is interested in saving money, because of the influence of the labour unions. The wages and other benefits of unskilled municipal workers are much more than would be paid in the private sector. It is clearly in the interests of municipal workers to resist any change that would erode their living conditions. Manning levels are generally high, and wage costs are the main part of the expenditure on solid waste collection services, so the most effective way to cut costs is to find ways to reduce the number of labourers. Strong opposition to this can be expected from the unions and the politicians who seek support from the community from which the labourers are drawn. Unless the decision is made at a high level to resist these pressures and force a cut in costs in spite of strikes and violence, it is unlikely that the power of the unions can be overcome. Faced with these prospects, it is not surprising that officials choose to continue paying excessive wage bills in order to maintain a regular service. Saving money may be down the list of priorities in big cities.

A social service or a cleansing service? Many see municipal services that employ unskilled labour as a social service, like an unemployment benefit, providing a livelihood for people who otherwise would have no work. For this reason they are concerned to maintain existing workforces, and not to find ways to increase efficiency. There are, of course, large numbers of very poor citizens who fall outside this safety net, and if it is a concern for the poor that determines recruitment, it would be better to pay a larger number of people a smaller wage, given the existing wages allocation. It is good for the municipal managers that this does not happen, because it appears to be true that increasing the size of a workforce can result in less work in total being done, because of difficulties of organisation and supervision.

The value put on technical advice It sometimes appears that decisions on the selection of equipment and systems are made by executives and politicians without seeking technical advice from engineers in the relevant fields. In some cases too much attention may have been given to the claims of manufacturers and salesmen. In other cases too much emphasis may be placed on the financial details of a tender, and not enough on the technical content. The selection of the option with the lowest capital cost does not always give the best value in the long term..

Start small There are times when there is not sufficient information about a product, a process or a system. In such cases it is advisable to start in a small way [for example, buying only one truck and observing how it operates, or setting up a process on a pilot scale and operating it for a year or more], and only after trials have proved successful, committing the organisation to a larger investment. Examples are given in which money was wasted because of impatience to implement a project on a large scale without first learning from a pilot trial. There are times when enthusiasm and boldness should be tempered with caution.

About this book

Numbering of chapters and pages. As shown in the list of contents, the book is divided into parts - A, B, C, etc. - each covering a general theme, and within each part there are one or more chapters - A.1, A.2, A-3 etc. The pages are numbered according to the chapters. If there is an appendix for a particular chapter, it follows directly after the chapter, and is denoted by a double letter. [For example, page BB-2.3 is the third page of the appendix that is linked with chapter B-2.] It is hoped that the reader will appreciate the benefits of this system.

Cover photographs The top photograph shows a sweeper using a small handbroom, with her six-bin handcart, in Rajkot, and is linked with chapter A-1. The lower photograph shows the sieving of decomposed wastes at Mumbai's Deonar disposal site; the fine material is mixed with certain additives and sold as a soil conditioner. This practice is discussed in chapter E-1.

Miscellaneous notes

The exchange rate for the Indian Rupee during the time of the investigations was in the region of Rupees 30 to one US dollar.

Usually the Indian numbering system will be used:
one lakh = 100 000, one crore = 10 000 000

A list of abbreviations and technical or Indian words used in this report can be found in appendix 1.

A list of the contributors and others who helped with this work is given in appendix 2

Bombay officially reverted to its original name of *Mumbai* since the investigations were carried out. In general the current official name will be used in this report. Until recently, the municipal government was known as the *Municipal Corporation of Greater Bombay [MCGB].* Earlier, before the suburban area was joined with the city, there was the *Bombay Municipal Corporation [BMC].* Since the name of the City was changed to *Mumbai* the Corporation has been officially known as *Brihan Mumbai Mahanagarpalika*, but in this report the initials *MCGM* will be used for the English translation of this name - *Municipal Corporation of Greater Mumbai.*

I hope that you, the reader, will find this book easy to use, interesting and stimulating.

Adrian Coad
July 1997

Chapter A-1

Primary collection equipment

A-1.1 INTRODUCTION

This chapter is about brooms, handcarts and containers. These items are so simple and commonplace that an engineer or manager might consider it a waste of his or her precious time to bother with such details. Fortunately, municipal engineers in some of India's largest cities have realised the importance of these items. Their importance stems from the large numbers of people that are using this type of equipment, and the great difference it can make to a task to have tools that are appropriate and efficient. A small increase in efficiency, leading to a small financial saving, can be very significant if multiplied by the number of sweepers employed in a large city (which may be several thousands). For example, in 1993 Mumbai had nearly four thousand sweepers' beats (each with two sweepers) and spent Rs 3 crores (approximately $1 million) on primary collection tools. The total length of all the streets in Mumbai requiring sweeping was estimated to be 1525 km. Mumbai uses 25 tons of brooms each year.

Handcarts (or wheelbarrows) are an indispensable tool for street sweeping and waste collection in most countries of the world, yet often their design is very inadequate. A new design of cart was introduced into Ahmedabad in the 1980s in an attempt to improve the efficiency of primary collection operations. The success of this new design is assessed.

It is much more expensive to sweep up ten kilograms of waste that has been scattered on a street than to pick up a container into which ten kilograms of waste have been placed by residents. In an effort to improve the efficiency of primary collection operations, Ahmedabad Municipal Corporation developed a system that used small community containers, at very convenient locations, so that residents could place their waste directly into these bins rather than walking a long distance to a large container, or depositing their waste on the street. This new system had a number of interesting innovations and implementation techniques, and these are discussed in the last section of this chapter.

A-1.2 SWEEPERS' TOOLS IN MUMBAI

with S A Bargir

a) Brooms

There are two types of brooms - bunch brooms and stock brooms. They are sketched in figure A-1.1.

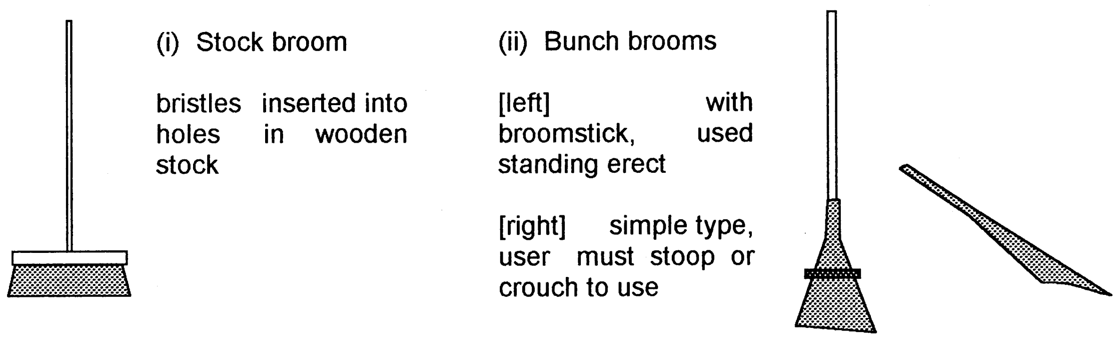


Figure A-1.1 Types of handbrooms

The advantages and disadvantages of these types of brooms are listed in table A-1.1

Table A-1.1 Advantages and disadvantages of different types of brooms

Advantages	Disadvantages
Stock broom	
◊ Can be made wide so that it can sweep a large area in one stroke; ◊ If bristles are stiff they are good for dislodging material that is adhering to the road surface;	♦ Wide brooms are heavy and so tiring to use; ♦ Wide brooms should be reinforced with diagonal stays to prevent the connection between the stock and the stick being broken.
Bunch broom with broomstick	
◊ Cheap and easy to repair	♦ Only a small area is swept with each stroke.
Simple bunch broom	
◊ Very cheap ◊ Can be used to flick light litter on sandy surfaces without collecting all the sand	♦ The user must bend down or crouch so that his/her face is nearer to the ground and the dust that is stirred up by the sweeping.

In Mumbai the bunch broom with a broomstick was in widespread use. A modification was proposed to enable sweepers to loosen hard materials that were adhering to the road surface - a blade made of steel plate was attached to the top of the broomstick as shown in figure A-1.2; the broom could be inverted to use the blade.

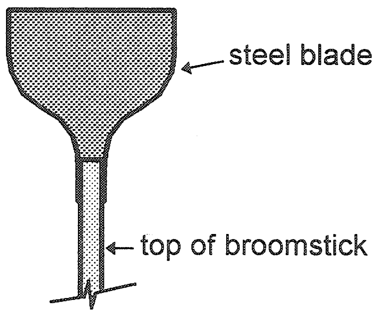


Figure A-1.2 Scraper blade on broom

Though the blade was useful in dislodging adhering deposits, it was not popular with the sweeping staff because the blade was at head height when the broom was being used normally for sweeping, and the blade was sharp - and therefore dangerous - and dirty.

The simple, short bunch broom was in widespread use in many Indian cities, but not Mumbai. Because the user must bend down to use it, back pain may result from prolonged use. The sweeper is also closer to the dust that is being stirred up and so may be more at risk from Tuberculosis and other respiratory infections than a sweeper who has an erect posture. It also appears degrading - and perhaps dangerous - to be stooping or crouching in a crowded street. See figure A-1.3

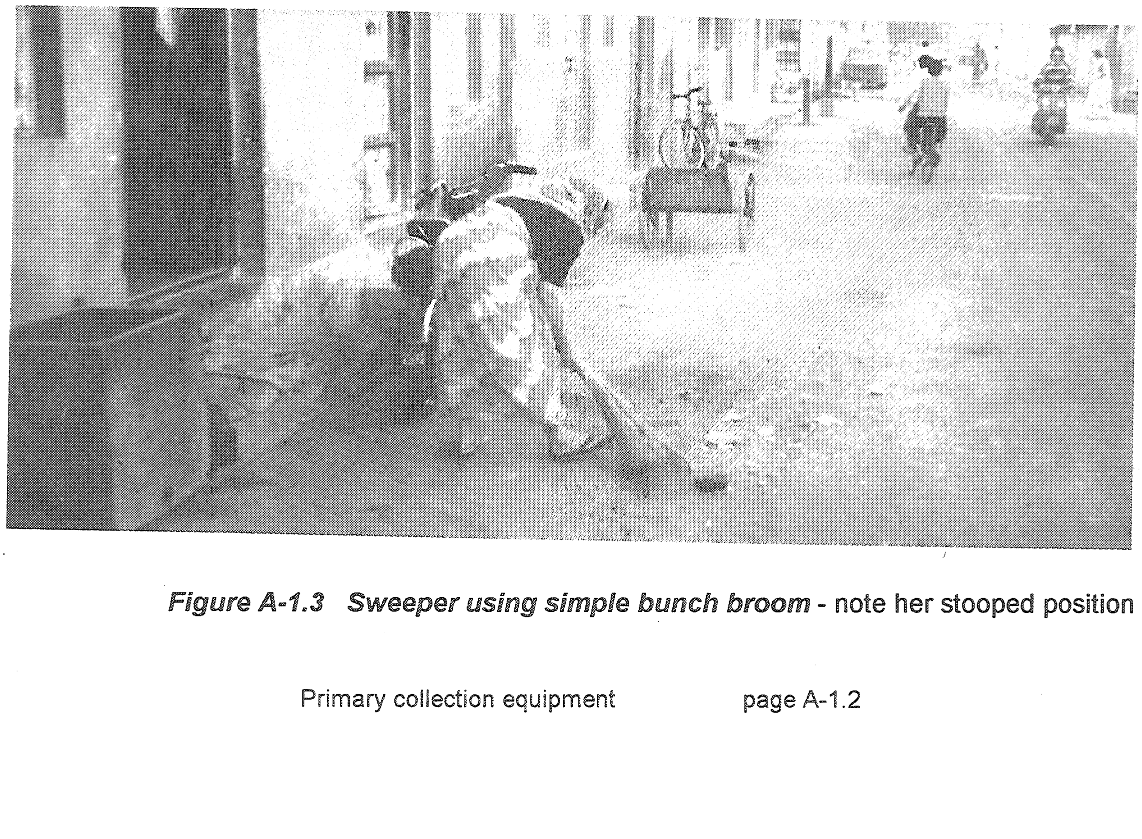


Figure A-1.3 Sweeper using simple bunch broom - note her stooped position

b) Sweepers' bins

In Mumbai sweepers were working in pairs - one would sweep and the other would load the sweepings into baskets or bins (known locally as *handbarrows*) to carry them to the nearest container or storage point. Until 1991 these baskets were made of cane, brought from Assam, but disturbances in that State prevented the continued supply of cane for these baskets. An alternative was sought. Bamboo seemed to be a suitable alternative, and the cost of bamboo baskets was found to be considerably less that the cost of the cane baskets - Rs 30 for a bamboo basket as compared with Rs 200 for a cane basket. Was the crisis in cane supply a blessing in disguise, introducing the cheaper alternative of bamboo? This question is answered in table A-1.3.

Municipal engineers looked at other alternatives. (it is always good to review as wide a range of options as possible before coming to a decision.) One possibility was the use of fibre-reinforced plastic (also known as fibreglass). Such bins could easily be made locally, to any convenient size and shape. They can also be repaired without special equipment. Moulded plastic was also seen as an option, but since polymers such as polyethylene have value as secondary materials in the recycling industry, it was decided that non-recyclable materials should be used to reduce the risk of theft. Fibre-reinforced plastic bins were costed at Rs 650 each. Were they a reasonable alternative? Table A-1.3 provides the answer.

Some basic information about these three types is given in table A-1.2.

Table A-1.2 General description of alternative containers for sweepers

	Cane basket	Bamboo basket	FRP bin
Plan cross section shape	circular	circular	square
Top dimension (diameter or side) mm	440	450	450
Bottom dimension mm	380	350	300
Height mm	360	350	500
Weight kg	4	1.5	4
Capacity litres	50	50	70
Unit cost Rs	200	30	650

Table A-1.3 Cost comparison for alternative containers for sweepers

The cost for the whole of Mumbai for one year's operation is estimated.
There were 3766 beats in Mumbai, and since each beat required two containers, the total number required is in the region of 7600.

	Cane basket	Bamboo basket	FRP bin
Average useful life L days	30	7	270
Number required for one year = 365/L x 7600	92,500	3,96,300	10,300
Total cost Crores of Rs	1.85	1.19	0.67
Annual saving over cane baskets Rs	-	66,00,000	1,18,00,000
Savings as percent	-	36%	64%

If the savings are accurately estimated in table A-1.3, there is clear evidence of the value of investigating even simple items. The item with the highest unit cost appears to be very significantly cheaper for the city. The savings are many times the annual salaries of the engineers required to collect the data so it is financially worthwhile for engineers to spend their time on such matters. It is necessary to check the accuracy of the data - particularly the actual useful service lives. A factor that has not been considered in this simple analysis is the cost of administration and logistics of the provision of the bamboo baskets - organising the supply, storage and distribution of these short-lived items would add to the expense and inconvenience of using this type of container.

More recently moulded plastic bins have replaced the FRP type. They are made from LLDP (Linear low-density polyethylene), were lasting up to two months longer than the FRP bins, and cost a little less (Rs 542 each). The problem of losing the bins to recycling was tackled by requiring that sweepers who wished to have a new bin should "trade in" the old bin.

Figure A-1.4 shows some of these alternatives.

Figure A-1.4 Containers used by sweepers (On the right is a bamboo basket; next to it is a damaged FRP bin, and next to that is a new design of plastic bin.)

In addition to a broom, two containers and a handcart, each pair was provided with two squares of plastic (polypropylene) sheet 200mm x 200mm, for picking up light waste that had been swept into a pile. These sheets were not often employed; most sweepers seemed to use pieces of plywood or card - perhaps the plastic squares were recycled or used for another purpose in the home.

Mechanical sweepers on truck chassis were tried in 1980. They drew fierce opposition from the labour unions who saw them as a threat to jobs, and it was difficult to get the spare parts from abroad. It is certainly advantageous for the nation if more jobs can be provided by employing manual sweepers, rather than cutting the workforce with mechanical sweepers, provided that the cost of the manual method does not become excessive.

In conclusion, the advice of an engineer involved in the provision of equipment for street sweepers is:
- ◊ Keep the systems and tools simple;
- ◊ Use materials and tools that are available locally and without interruption;
- ◊ Train and motivate the staff to use the tools in a proper manner;
- ◊ Preventive maintenance is better than waiting for failures

This advice is often applied to larger and more sophisticated equipment - it is important to realise that it applies to simple street-sweeping equipment also. Perhaps a further recommendation could be added to this list:

◊ Consider a range of alternatives and collect data about each in order to find the most economical and appropriate solutions.

A-1.3 SIX-BIN HANDCARTS IN AHMEDABAD

Handcarts or wheelbarrows are a very important item in solid waste management systems, especially where labour-intensive methods are used and the gradients of the streets are slight. They can be found in almost every country in the world, used by street sweepers and for primary refuse collection. Yet it is amazing how often the carts have been poorly designed. Why have handcarts been neglected by engineers? The answer may lie in the fact that trained engineers may think that their skills should not be used on such simple vehicles, that decision-makers do not want engineers' time to be spent on such things, and that professionals are not prepared to learn from the experience of uneducated manual labourers - a design is rarely adequate at the first attempt; designs should be tested under normal working conditions and refined, in consultation with those who use them. Whatever the reason, it is a fact that there is much room for improvement in the design of most handcarts.

This section describes a handcart that is the exception - it has been designed with considerable thought, and is a much more suitable tool than most types of handcart that can be found around the world. It was observed in operation in Ahmedabad and Rajkot in Gujarat State. It will be referred to as the "six-bin handcart" and can be seen on the cover and in photograph 2. Before this design is discussed, some general points will be made about the design of handcarts, to set the scene for the review of this particular type.

a) Criteria for the design of handcarts

◊ ***How much can it carry?*** In many situations the operator of a handcart wants to carry as large a load as possible. If (s)he is required to move the material some distance - say, over 500 metres - it will be preferable to minimise the unproductive travelling time by maximising the load, so that the journey is made as few times as possible. (If the containers into which the waste is to be put are close together, this argument may not apply since the journey to the unloading point is insignificant.) A simple test of this fact is to observe how labourers use their carts - usually they keep piling waste onto their carts until they are overloaded, indicating that the labourers regard the capacity of the cart as insufficient.

A labourer can push at least 150 kg of waste in a well designed and maintained cart on a reasonable level surface (based on the author's observations in Iran and Chad). If the density of the waste is known, it is possible to calculate the volume of waste that weighs 150 kg. This should be the target capacity for a cart which is to be used for primary collection from houses. If a cart is to be used for street sweeping it may be appropriate for the capacity to be less because:

(i) the waste takes more time to collect than if it is picked up directly from households and so it may not be possible to collect 150 kg during the day's work, and

(ii) there may be community storage containers at frequent intervals so that it is not necessary to carry the waste over a long distance

◊ ***How is the waste transferred?*** Too often one sees labourers tipping the contents of their carts onto the ground and then scooping the waste up into the container or vehicle that will take the waste to the disposal site. (This is shown in photograph 1) This practice is inefficient (wasting time), unhealthy (forcing the labourer to touch or have close contact with the waste), and polluting (often some of the waste is left on the ground or is scattered by the wind). There are two simple ways of avoiding this problem -

⇒ One solution is to have a split level site so that waste can be tipped directly from the cart into the bulk container. An example of such as system is described in chapter A-3. If it is decided to build a ramp for handcarts, one must consider the slope of the ramp - a gentle slope requires considerable space and a steep slope greatly reduces the weight that can be carried in the handcart.

⇒ Another solution is to containerise the refuse in a number of bins that are small enough so that they can be lifted and tipped into the bulk container or transport vehicle, as shown in photograph 2. The maximum weight that can be lifted in this way depends on the strength of the labourer, the convenience of the lifting position, and the height to which the container must be lifted. If there are six containers on a cart, and the weight of refuse collected is 150 kg, then the labourer must be required to lift in each bin 150 / 6 = 25 kg of waste, to which must be added the weight of the container. (This assumes that the weight of refuse in each container is equal, which is unlikely.) If lifting of loads of up to 35 kg is not acceptable, it is necessary to either reduce the total load carried on each trip (increasing unproductive travelling time), or increase the number of containers to eight - unless there is always someone at the unloading point who can help with the lifting and emptying of the containers.

◊ ***General design features*** If the cart is to carry a number of bins, the size on the shape of the bins should be such that the cart is not too wide or long so that manoeuvring it is not difficult. The plan dimensions of the bins should be large enough that big items of waste cannot bridge across the rim and prevent the efficient utilisation of the bin's capacity. Bins that are rectangular in plan may be difficult to pack if the dimensions of large items in the waste are larger than the smaller horizontal dimension of the bin. Square and rectangular bins may be easily deformed and develop dangerous jagged projections at the corners. Bins that are circular in plan do not fit together well - considerable space is lost between the bins, requiring a larger cart and providing more opportunity for waste to fall between the containers.

The pushing handle should be at a convenient height and orientation so that the necessary horizontal force can be provided easily, the labourer's back can be straight, and any lifting is convenient.

◊ ***Wheels*** The wheels of a cart are of great importance. Several features should be considered:

⇒ Number If the cart has only two wheels, the operator is always required to apply a lifting force, adding to the fatigue and perhaps causing back injuries. Therefore at least three wheels are required, but it must be possible to tilt the cart so that only two wheels are in contact with the ground in order to turn the cart. This can be done by having one axle close to the centre of gravity so that the cart can be tilted by lifting or applying body weight. Carts that have three or more wheels may roll by themselves if left on sloping ground, but this is not generally a problem. The advantages of having four wheels are that the cart is more stable and that a wheel can be carried over a hole in the road surface, rather than going down into it.

⇒ Size Large wheels are better on rough surfaces, and, with poor bearings, cause less rolling resistance. On the other hand, large wheels are heavier and more expensive, and may obstruct the removal of containers.

⇒ Contact surface A wide rim is necessary on soft ground. A soft contact surface - such as a pneumatic tyre or solid rubber tyre - reduces the difficulty of pushing on stony or rough ground, but maintenance is considerably more. Manus Coffey recommends the bead section of vehicle tyres because they are made from good quality rubber, and are easy to obtain in good condition from scrapped tyres.

⇒ Bearings Simple journal bearings are rarely lubricated as they should be, so one often sees severely worn wheels at strange angles because of wear between the shaft and the hub. Ball or roller bearings are more expensive and must be protected from dust, and should always be specified for the wheels that carry the main load.

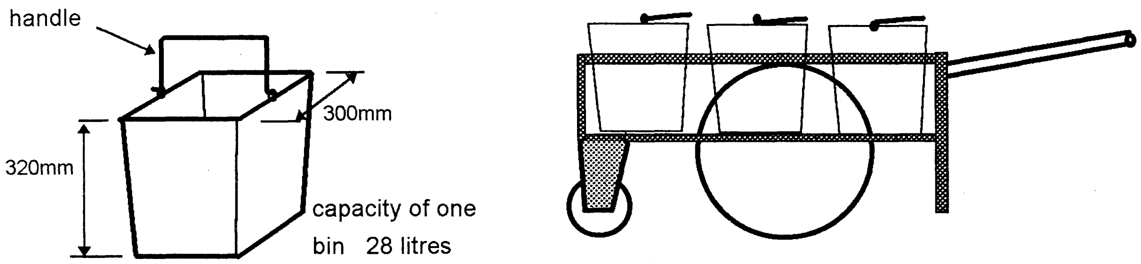
⇒ Durability Bicycle wheels are generally not strong enough for this kind of duty. Motorcycle wheels have proved well suited, but they are likely to be expensive. Prototypes should be thoroughly tested before being implemented on a large scale.

b) General description of six-bin handcart

This design represents a major step forward in handcart design in India. They were designed in 1988 and 5000 were supplied to Ahmedabad Municipal Corporation. The most common previous design had a capacity of only 125 litres and had two large steel wheels. Waste was transferred by tipping it onto the ground or road. The capacity of the new handcart is 6 x 28 = 170 litres, and waste can be transferred directly into large containers without tipping it onto the ground. In 1994 the cost of a six-bin handcart (with its bins) was estimated to be Rs 2000, which is about twice the cost of the previous

type. The life of the handcarts appeared to be more than five years, and the life of a container was said to be about two years.
If the density of the waste is 400 kg/m^3, the payload of the handcart is

$$0.17 \times 400 = 68 \text{ kg.}$$



(a) detail of bin

(b) outline concept of cart

Figure A-1.5 Sketch of six-bin handcart used in Ahmedabad

Table A-1.4 Specification of six-bin handcart

	Large wheels	Small wheel
Diameter mm	500	200
Width mm	40	60
Construction	Steel, 6 spokes	Plastic
Bearing	Ball bearing	Journal
Length of tray mm	970	
Width of tray mm	695	

c) Observations of the six-bin handcart in operation

based on information collected by N H Waghela, R Ramanathan
Dr T M Shantaram, R C Chavan and Dr D C Bhandari

The operation of the six-bin handcarts was studied in Ahmedabad - observations of the operation and condition of the carts were recorded and the operators were asked for their opinions and experiences.

The investigators monitored operations at one bulk container (capacity 10m^3). Most of the sweepers were using the six-bin handcarts and took three to four minutes to transfer their loads to the container. One lady had lost her cart and was bringing waste to the container in a basket. Others did not have all their bins. One sweeper was using the old type of cart, and spent eight minutes transferring the load to the container, having first tipped that waste onto the road.

Some of the incoming bins were weighed. When the sweepers were coming in with the first loads the weights of the bins with their contents were 9.2, 8.9, 11.7, 10.7, 10.5, 10.1, 10.2, and 11.2 kg.

The average full weight was therefore 10.3 kg
An empty bin weighed 5.0 kg.
The net weight of waste was therefore 5.3 kg.
The estimate of the density of the waste from these figures is therefore 5.3 / 0.028 = 190 kg/m^3
The total load carried by the handcart can be estimated as 6 x 5.3 = 32 kg.

The weights recorded when the sweepers returned with their second loads were 6.5, 7.5, 7.5, 7.2, and 6.0 kg. (It was conjectured that the weights were less because the sweepers had wanted to fill their bins quickly to finish the morning's work. Apparently the sweepers were expected to make two trips during the morning shift [06.30 to 11.00].) The estimated load per trip dropped to 12 kg.

In addition to these operational points, fourteen handcarts were observed to monitor their condition. The results are shown in table A-1.5.

Table A-1.5 Observations of the condition of the handcarts

Number of handcarts in sample	14
Number of handcarts without a front wheel	3
Number of handcarts with a broken handlebar	3
Number of bins that were missing	20
so number of bins in sample = (14 x 6) - 20	64
Number of bins without floors [or bottoms]	25

It was also observed that all the handcarts had heaps of waste piled over the tops of the bins, and that ten of them had gunny (sacking) or a net of nylon string tied onto the handlebar frame, to increase the capacity of the carts.

In discussion with the sweepers, the following facts emerged:

- ◊ Several complained about the difficulty of pushing the carts when the front wheel was missing or when the handlebar frame was broken; female staff said this was particularly a problem when they were pregnant or had recently been sterilised. (The problem with the handlebar frame was that welds would break.)
- ◊ No repairs or replacements had been carried out since the introduction of the carts five years before;
- ◊ It was not possible to transfer the waste directly into the bulk container when the bottom of the bin had been lost because of corrosion, or when the handles were missing;
- ◊ Sweepers had hurt themselves when their carts had stopped suddenly when the front wheel hit an obstruction or hole;
- ◊ Eleven out of 14 said that they did not favour having larger carts or larger bins.

It was common practice to thread a chain through the handles of the bins and padlock it so that the bins and cart were not stolen when they were parked overnight near the sweeping area. (The lock and chain were provided by the Municipal Corporation. If a bin were stolen, a sweeper was required to pay Rs 114 for the new one. The investigators were told that damaged bins could be exchanged for good ones, but the number of bins without floors suggested that such exchanges were not always possible. Often handles would be damaged, especially during the rainy season when the waste was much heavier.

<u>Comments</u>

- ♦ The apparent density of the waste is lower than expected. In fact, the use of small containers highlights the wide variation in the densities of wastes, from very low density materials such as leaves and paper to high density construction debris, or wet, partially decomposed organic material. A bin that is sufficiently large to be very heavy when full of construction debris can easily be filled by a kilogram of leaves. In addition, the particle size of the waste becomes important, because a few sticks or twigs can prevent most of the capacity of a small bin from being used. Wastes may not fill the corners of square containers.
- ♦ Maintenance of the handcarts and bins is shown to be of considerable importance. The fact that the carts are still operational after five years testifies to the general quality of their design and construction, but certain features should be designed or fabricated differently - for example the handlebar frame. The reasons why the front wheels failed should be investigated. Materials other than steel should be investigated for the containers, because of the problems caused by corrosion of the floors. However even the best-designed products need maintenance, and provisions should be made for repairing or replacing defective components.
- ♦ The observations that bins were generally overfilled and that sweepers had found a way of increasing the capacity of their carts suggest that a larger capacity would be appropriate. When

asked directly about larger carts the sweepers may have opposed them because of fears that more work would have been required with larger carts.

A-1.4 INTERCHANGEABLE COMMUNITY BINS IN AHMEDABAD

with Dr P K Makwana, Dr D Bhandari and Dr T M Shantaram

a) Introduction

In the late 1980s, solid waste management in Ahmedabad benefited from vigorous leadership (particularly from Mr P U Asnani) and support from the World Bank. A key objective in many of the initiatives was to reduce double handling of waste (that is, once it has been put into a container it should not be deposited again on the ground for a second loading, but should be transferred directly only into a vehicle or larger containers until it reaches the disposal site). Double handling is both inefficient and unhygienic. The six-bin handcarts that have already been mentioned are one result of the developments of this period, since waste can be transferred directly into a $10m^3$ container without it coming into contact with the ground. Another development of this kind is a system of small community bins that were introduced on a trial basis. This system - which can be characterised as primary collection from community bins using specially designed trucks - will be briefly described in this section, and some lessons that might be drawn from this trial will be suggested.

The basic equipment is shown in figure A-1.6. The photograph shows the purpose-built truck which can carry 44 rectangular community bins like that shown in the right foreground. A sample bin was measured and found to be 335 mm deep, 630 mm long and 350 mm wide, giving a capacity of about 75 litres. (The capacity of the bins was normally quoted as being 80 litres, so perhaps the sample bin that was measured was smaller than most of the others.) The system concept was that the bins were distributed on the basis of one container to every 25 families, they were exchanged every day for an empty bin, and the loaded bins were carried on the special truck to a large hook-lift container, into which the contents were tipped. The benefit of exchanging containers rather than emptying them was that no dust or litter were spread in the residential area, as they might be if the waste were transferred at the container location.

Figure A-1.6 The Ahmedabad exchangeable community bin system

The scheme was started in 1988-9, when 2500 bins and 12 trucks were purchased. The trucks were to make two trips in an 8 hour shift, and the crew of each truck was one driver and two labourers. Each container was to be exchanged daily. The containers were painted in the distinctive colours of the Corporation - yellow and saffron stripes.

b) Lessons from experience

The experiences with this system can be divided into two phases.

<u>Problems of Phase I</u>

- ◊ The community was not motivated to make the system function effectively. The system was new to the community and no family took an interest in the scheme. Domestic waste was thrown on the ground as before.
- ◊ Lack of co-operation. No one was responsible for taking care of the community bins so they were moved, stolen, or misused.
- ◊ No replacement procedure The community bins were placed according to the wishes of junior municipal officers and politicians, without considering the local conditions. The bins were not replaced once they disappeared or were damaged. This led to underutilisation of the vehicles, so that they were used with community bins for other purposes, such as transport for supervisors.
- ◊ Misuse by street sweepers The street sweepers found the community bins convenient for depositing street sweepings in order to avoid carting their loads to container sites.
- ◊ Misuse by residents The containers were designed for typical household refuse. However, in addition to kitchen and paper wastes, households also produce heavy wastes like soil and building rubble when alterations are being made to the fabric of the houses, and if there are gardens there are likely to be large quantities of low-density wastes such as leaves and tree cuttings. Construction debris adds greatly to the weight of the contents of a bin, such that a labourer might be unwilling or unable to lift it, and the garden residues from one household would be enough to fill the whole bin - which was intended for 25 households. Often construction debris and garden waste would be left beside the bins because there was no simple way of collecting them.
- ◊ Complaints The bins became an eyesore along the road sides. Residents moved the bins away from their homes. The community bins became storage sites for additional waste, and cows and other animals scattered the contents. Damaged bins were abandoned for long periods of time.

<u>Phase 2 Implementing solutions</u>

The problems that arose in the first phase called for an alternative strategy which would develop a more positive and co-operative attitude amongst the community.

- ♦ Participation of NGOs An NGO which was engaged in some welfare projects for rag-pickers and segregation of recyclable waste joined with the Municipal Corporation in its efforts to improve the use of the bins. Bank union volunteers joined the NGO and selected an area in which to support the introduction of community bins.
- ♦ Community education The NGOs actively moved into the chosen community, identified the leaders in the societies and flats, and explained the advantages of community bins and encouraged groups to take care of them.
- ♦ Interaction between the community and the Municipal Corporation Municipal Corporation officers, NGO representatives and community leaders met and decided on the number of bins and identified the sites where they would be kept. Accordingly, the bins were provided in the project area. The bins were placed at all the identified places, a route was finalised for the collection vehicle, and an adequate number of bins were kept reserved for immediate replacement. of damaged or missing bins.
- ♦ Supervision Community leaders, NGOs and the sanitary supervisors constantly monitored the work on a day-to-day basis during the initial stages, and later the sanitary staff continued to check almost daily and NGOs monitored operations at regular intervals. Complaints were attended to as a priority and resolved within 24 to 48 hours.
- ♦ Extra loads As there was no provision for the disposal of debris and bulky waste, trucks or skips were sometimes deployed. No street sweeper was allowed to dispose of street waste in the community bins.

- Recycling The NGO managed to get big plastic bags as a donation from an industrial house. Households were urged to segregate all recyclable waste and keep it separately in their house. Another NGO known as SEWA (Self Employed Woman's Association) involved lady rag-pickers from the area who visited the houses to collect recyclables twice weekly. These workers were given aprons with a badge. The rag pickers were thus identified to the residents so there was no hesitation in allowing them into the premises. In this way the recycling workers obtained clean recyclable material and thereby earned Rs 25 to 40 per day.

This strategy led to responsible behaviour from the community. People were really involved and felt happy to notice a change in their environment. Instead of complaining to the Municipal Corporation, they showered it with compliments.

c) Survey of residents

A brief survey of the opinions and practices of the residents was carried out in an area where the system was still in operation - an area called Pragatinagar. The housing in this area was mostly three-storey buildings erected by the Housing Board, though there were also some individual houses belonging to a higher income group. The results of the survey are given in appendix AA-1.

It is interesting to note (question 2) that children played a relatively minor role in taking household waste to the bin. (Many types of community bin are too high for children to reach comfortably, but these bins were low enough for children to be able to lift any load they could carry into the bin.) Replies to question 3 suggest that the bins were too small to serve 25 households, because they were frequently overflowing. The majority of people interviewed seemed happy with the system (questions 5 and 6, but the easy access for rag-pickers and animals appeared to cause problems (question 7).

It appeared that there were problems during the monsoon in that the collection of rainwater in the bins caused a foul smell and made the emptying of the bins more difficult.

d) Observations and comments

◊ The exchange concept is good in that it prevents dust and litter from being scattered in the residential area, and could be developed so that damaged bins could be easily exchanged for good bins at the unloading point. The exchange system could also include the option of washing the containers at the transfer point after they have been emptied. However, a major weakness is that if all the containers are, on average, half full, the load carried by the truck is half, because it goes against the principle of operation to distribute extra waste amongst the containers on the truck. Community bins, especially if they are small, should have a generous safety margin in terms of their capacity to cope with fluctuations in the quantities of waste. (If the containers are bigger and serve a larger number of households, there is more chance that the variations will be averaged out, and that one large quantity from one source will have a proportionately smaller effect.) In addition, if the bins are emptied daily, there should be an allowance for one day's collection being missed - because of a particularly important holiday, a strike or a vehicle failure. If containers are normally emptied daily, and one day is missed, there should be sufficient storage for twice the anticipated volume. The following calculation serves as an example:

If the estimated volume of waste to be put into a container is 30 litres (based on the number of people and the per capita generation rate);

- to allow for fluctuations it might be appropriate to provide a 40 litre storage volume,
- and to allow for the collection being missed one day, (i.e. for storage of two days' waste instead of one) the required volume would be

$$2 \times 40 = 80 \text{ litres}$$

- Therefore, the average volume carried by the truck on a normal day might be

$$44 \times 30 = 1320 \text{ litres,}$$

instead of the capacity of

$$44 \times 80 = 3520 \text{ litres}$$

if the bins were all full.

- If the density of the waste is 400 kg/m^3 then a typical load on a normal day might be only

$$1320/1000 \times 400 = 528 \text{ kg,}$$

which very small in comparison with the possible payload of the truck (which is probably considerably more than 3000 kg).

◊ The exchange system requires more work of the labourers, since they must lift each full container twice.

◊ It was estimated that the life of the bins was two to three years. In addition to rust and impact damage, it was thought that the bins might be have been taken for other uses.

◊ When the collection operation was being observed the bins were not being exchanged. It appeared that the truck crew were obliged to keep their containers in good condition and so they did not want to exchange them and leave their numbered bins to be perhaps damaged or stolen. (The bins on the truck all had the truck's number written on them, suggesting that they should remain with the truck.)

◊ Apparently, the trucks did not report to the local ward office, so the sweeping supervisor did not know when the truck was in his area, making co-ordination difficult.

◊ The bins were generally between 10 and 30 metres from the property boundaries. Residents did not want them closer because they feared contracting an illness if the bins were too close.

◊ It appeared that the bins did not have a sufficient capacity for each to serve 25 households. It would therefore be desirable to provide more bins to the area or increase the size of the bins. (In increasing the size one must always consider the maximum weight that the containers may have when full of dense wet waste, and whether the labourers would be able to load them into the truck.)

◊ The blocks each comprised six flats (or apartments). It is often helpful to design a system to harmonise with the existing social arrangements. For example, if each block of flats had its own servant or sweeper, it might be helpful to allocate a container to each building, and make the servant responsible for keeping the surroundings of the containers clean. It might even be possible to keep a cover on the container, so that the container could be kept within the property boundary. (It is usually pointless to provide a community bin with a lid because very few people take the trouble to use the lid properly, and they may be reluctant to touch a lid that has been used by unknown people and may have been fouled by their waste. It is often different if the responsibility for the container is defined.). So an alternative approach would be to allocate a container to each building - the initial cost would be more, but the life of the container might be longer. If this were done it would be necessary to modify the exchange system. If it is possible to make the residents buy their container, the feeling of ownership and responsibility would be very beneficial in terms of extending the life of the containers.

e) Summary and conclusions

* The Ahmedabad Municipal Corporation is to be congratulated on its efforts to investigate new systems and to involve the community in this system.
* No costing of the operation was conducted by the survey team, so it has not been possible to compare this system with others. Though the exchange system has a number of aesthetic advantages, it is thought that its cost may be high. It is likely that the loads carried by the truck were very low compared with the possible payload of the truck, and increasing this load might reduce the operational cost of the system.
* The volume of waste coming from any particular source can fluctuate significantly from day to day, so a small community bin should be considerably larger than the size estimated from average rates. Consideration should also be given to the management of building debris and bulky and garden waste.
* Experiences in Ahmedabad clearly illustrate the importance of involving the community to the greatest possible extent in the preparations and decisions relating to a new system, and in fostering a sense of responsibility for, and ownership of the containers. A domestic waste collection system should never be seen as purely a matter of technology and municipal management, it should be seen also as a question of the behaviour and attitudes of the beneficiary community, and considerable effort is needed to ensure that this aspect of the system is successful. Neither the engineer or the community worker can solve the problem alone.

APPENDIX AA-1 AHMEDABAD COMMUNITY BIN SYSTEM - RESULTS OF QUESTIONNAIRE SURVEY

A small survey was carried out in an area where the community bins were in use, to gain some understanding of the knowledge, attitudes and practices of the residents with regard to this system of waste collection. Two pairs of investigators asked eight questions at 38 households. The questions and an analysis of the replies are shown below.

1. *Is the solid waste from your house put into a community bin?*	Yes	35	92%
	No	2	5%
	Not aware	1	3%

2. *Who carries the waste from your house to the bin?*	Adult member	17	40%
	Children	3	7%
	Domestic servant	10	24%
[Some households gave more than one answer.]	Hired sweeper	12	29%

3. *How often are the bins full or overflowing?*	Every day	21	55%
	More than twice a week	6	16%
	Occasionally	7	18%
	Not aware	4	11%

4. *How often are the bins emptied in one week?*	Daily	33	87%
	4 to 5 times per week	3	8%
	Not aware	2	5%

5. *Are you happy with the present location of the bins?*	Yes	33	75%
	No	4	9%
	Should be nearer	3	7%
[Some households gave more than one answer.]	Should be further	4	9%

6. *Do you like the present collection system? Please give reasons.*	Yes	36	95%
	No	0	
	No opinion	2	5%

7a. *Do rag pickers cause any problems?*	Yes	28	74%
	No	6	16%
	No reply	4	10%

7b. *Do stray animals cause any problems?*	Yes	33	87%
	No reply	5	13%

8. *Do you have any suggestions for improving the system?*

Chapter A-2

Solid waste management in a slum area of Mumbai

by Manfred Scheu, with assistance from N Bandyopadhyay, S A Bargir, B Majhi, VS Rao and K V Ramarao

A-2.1 INTRODUCTION

Slums provide the housing and living environment for a large part of India's urban population. Slums are unplanned and so present many problems for solid waste management. No two slums are exactly the same, so it cannot be expected that the recommendations and solutions proposed in this chapter can be applied without modification to other slum areas, but the approaches and criteria described in this chapter are very relevant to many other slum settlements. The main emphasis of this chapter is on refuse collection; related subjects like sweeping of lanes, drain cleaning and cleaning of public toilets are considered to a lesser extent.

Studies were carried out by two different teams: one was dealing with refuse collection services from a technical, operational and economic point of view, whereas the second team was concerned with social and community aspects related to refuse collection in the same area.

A slum pocket was chosen to study the present refuse collection system, to identify problems and to suggest possible improvement measures. Investigations were based on existing physical conditions including access and housing patterns without considering the possibility of relocation of buildings to realign or widen roads.

In addition, a questionnaire survey was conducted to obtain first-hand information on the residents' needs, opinions and aspirations regarding service improvements.

Information on operations was primarily based on field investigations. Additional data were provided by officers of the Conservancy Section (Ward G-North), and from personnel of the Transport Section (G-North Garage).

A-2.2 SLUM IMPROVEMENT POLICIES IN MUMBAI

Constant migration and population growth led to the development of slums in Mumbai. In 1993 more than 50 % of the city's population was living in such areas (i.e. more than 4 million people).

According to the Maharashtra Slum Areas Act (1971) an area can be declared as a slum in case of dilapidation, overcrowding, faulty design of buildings, narrowness or faulty arrangements of streets, lack of ventilation, light or sanitation facilities or any combination of these factors.

A paper on Slum Improvement Policies in Maharashtra (1992) describes the history of improvement activities as follows:

- Resettlement of slum communities to areas outside the city centre had been practised in the past. This strategy failed because the economic base of people is related to their present location and therefore most slum dwellers were reluctant to move or came back to their original place after being resettled.
- Considering this problem the Government decided to allow the slum dweller to occupy their original place as long as it is not required for urgent public purposes.
- Slum Improvement Schemes were initiated and carried out under the Bombay Housing and Development Board (BHDB) and Municipal Corporation of Greater Mumbai (MCGM). State Government grants, (Rs 250 per person in 1993), were used to improve the living conditions in slum areas by providing basic amenities such as water supply (1 tap per 150 persons), public

toilets (1 toilet per 20-50 persons), drainage, access and street lighting. Service charges were collected at the rate of Rs 18 per resident (probably per year).

- Just prior to the time of writing, a Slum Upgrading Programme was initiated under the World Bank funded Bombay Urban Development Project. This project aimed at providing tenure rights to some 60,000 slum dwellers in 137 slums and to grant home improvement loans (between Rs 5,000 and Rs 14,000) to encourage dwellers to invest in structural improvements to their homes. This programme further aimed at improving infrastructure facilities to higher standards (e.g. one WC for 4-10 households, one water tap for 10 households, provision of hard pathways and lining of drains).

Although refuse collection was not specifically mentioned under any of the programmes, the provision of adequate collection services is likely to be an important component of improving living conditions in slum areas. In the case discussed in this document, a questionnaire survey revealed that the respondents considered refuse collection to be the most neglected service in their community (as will be discussed later in section A-2.6).

A-2.3 DESCRIPTION OF THE STUDY AREA

A slum pocket in Dharavi was selected to carry out the field investigations. Located on the northern fringe of the Island City, Dharavi was originally a peripheral area, but now it forms a central part of Greater Mumbai. About 360,000 people were living in some 60 000 to 65 000 hutments, which made Dharavi the largest slum area in Mumbai.

The study area consisted of four slum communities, namely Sameshwar, Shivashankar, Jagajiban and Mukund Nagar. A location map, including main solid waste management facilities in the area, is provided in figure A-2.1.

Based on census data, the population of the study area was estimated to be about 19,000 people, and the number of hutments was thought to be around 3,800. Considering that the area is about 6.8 hectare (16.8 acres) the population density was around 2,800 persons per hectare.

The majority of buildings along main lanes and a large percentage of buildings inside the slum area had two storeys. They were built from bricks and metal sheets, which were primarily used to construct the upper floor. A wide variety of commercial activities and small scale industries were commonly located on the ground floor whereas the second floor was used for living accommodation. Buildings usually occupied less than 20 square metres.

Access conditions and layout were investigated and are presented in figure A-2.2.

It can be seen from figure A-2.3 that only a few main lanes were wide enough for vehicular traffic and that a few secondary lanes allowed small handcarts to enter the area.

Most pathways were very narrow, usually less than two metres wide, and others became almost impassable because they accommodated ladder type stairs to the first floor or large capacity drums, which were commonly kept in front of premises for water storage as shown in photograph 3.

Almost all pathways were paved with concrete. Open drains, lined with concrete, were located along one or both sides of the lanes and used to convey sullage and rainwater. Drainage was towards Jugelekar Nallah in the centre of the area and Mahim Creek north of the Bandra Sion Road. The Jugelekar Nallah was covered below the main access lane in the direction east-west.

Open spaces were scarce and so pathways were used for various activities like cleaning, washing, bathing and as a playground for children. Therefore the lanes served important functions and people felt responsible to keep them in a clean condition.

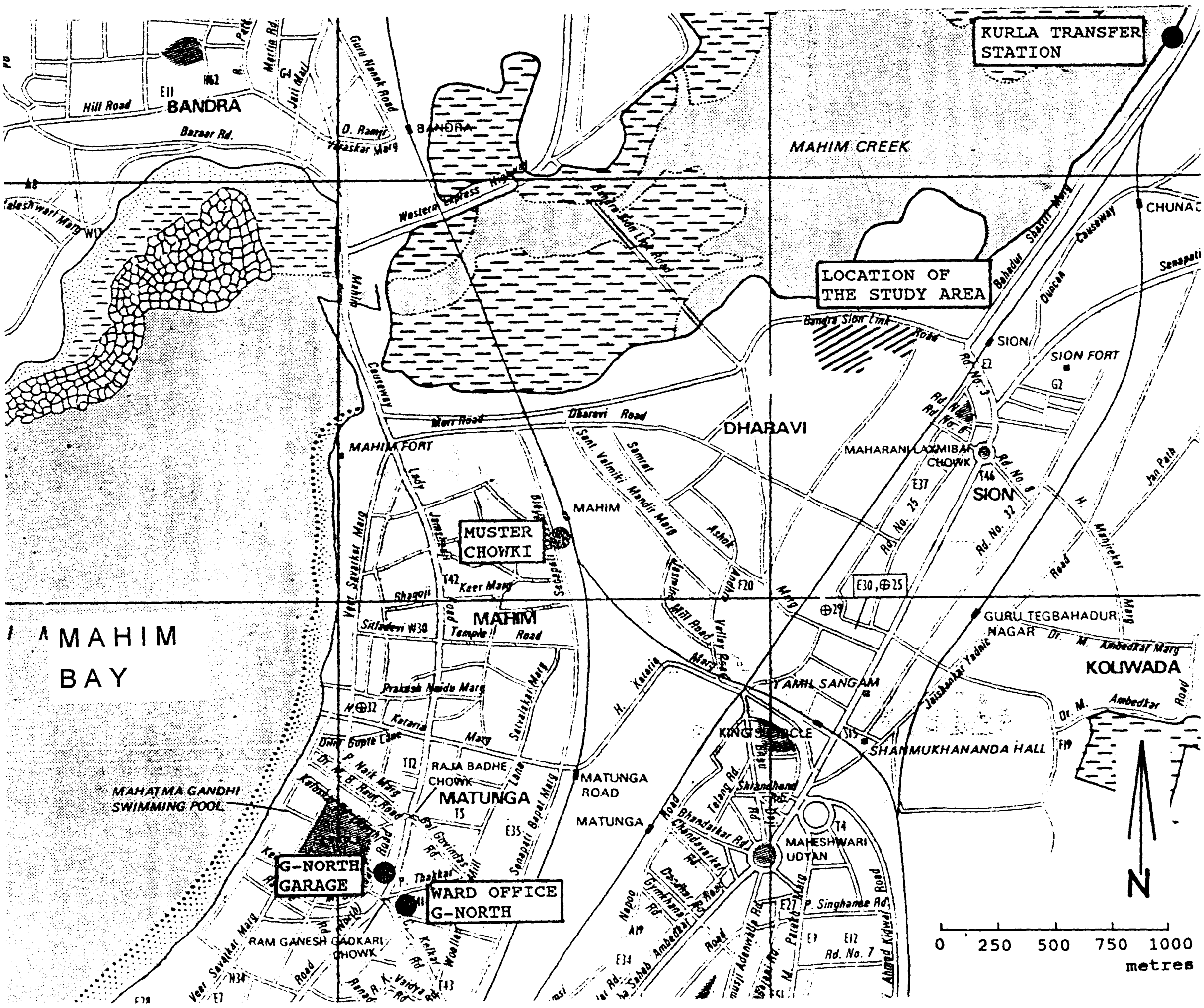


Figure A-2.1: ***Location of the study area***

STUDY AREA:	Sameshwar, Shivashankar, Jagajiban and Mukund Nagar.
MUSTER CHOWKI:	Office of Junior Overseers of the Conservancy Department and place where workers and mukadams met at beginning and end of each shift.
G-NORTH WARD OFFICE:	Offices of G-North Ward, including the Conservancy Section (senior SWM officers: A.H.S. and Supervisor).
G-NORTH GARAGE:	Garage of the Transport Department. Maintenance and repair of MCGM vehicles. Drivers met here at the beginning and end of each shift.
KURLA TRANSFER STATION:	Refuse from the study area was carried to this station. Large capacity trucks were deployed for bulky transport to Deonar dumping ground.

Houses were usually without sanitary facilities and eight public toilets had been installed in the area and were maintained by halalkhores of the MCGM.

Water supply was provided from a central network and connections to individual premises were quite common. However, supply was only for three hours in the morning, from about 6.30 to 9.30 am, and most people kept a drum for water storage in front of their houses. In addition, some handpumps were connected to the pipe network and used to obtain water during times of low pressure in the pipe network.

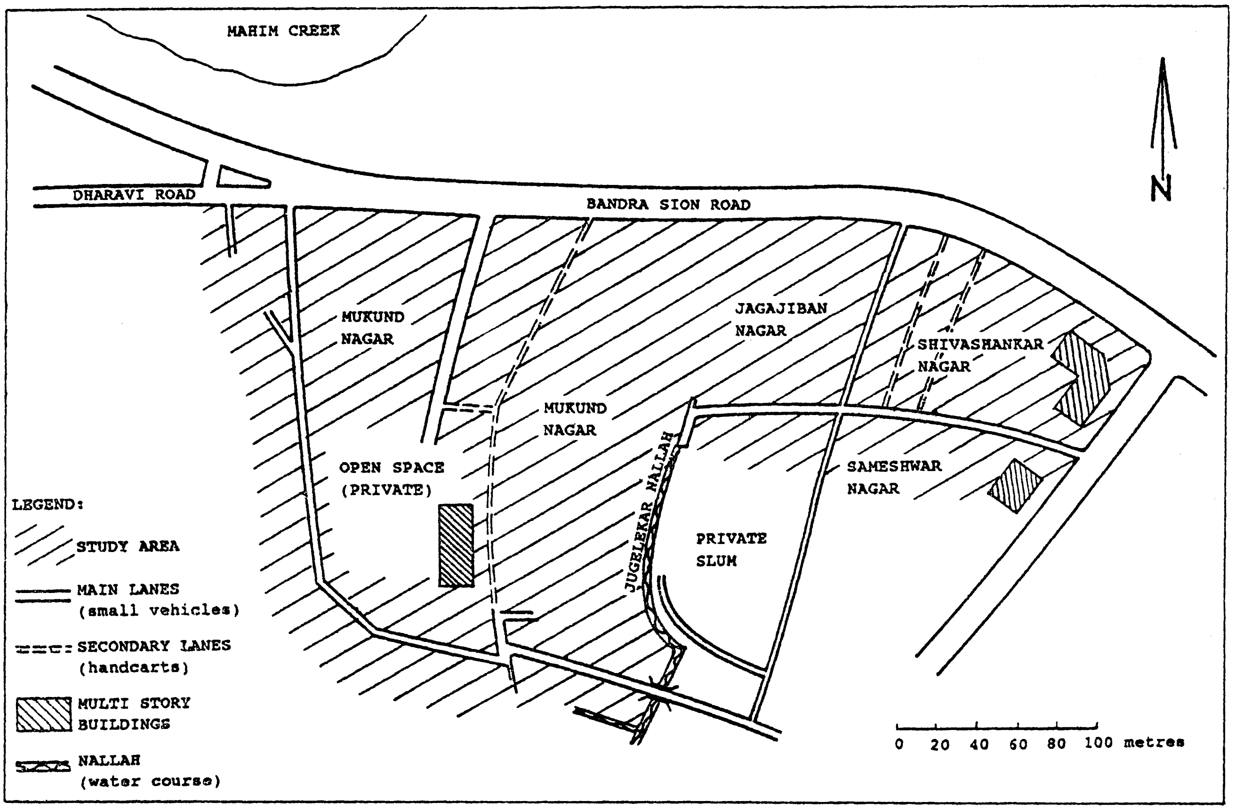


Figure A-2.2: ***Access and layout of study area***

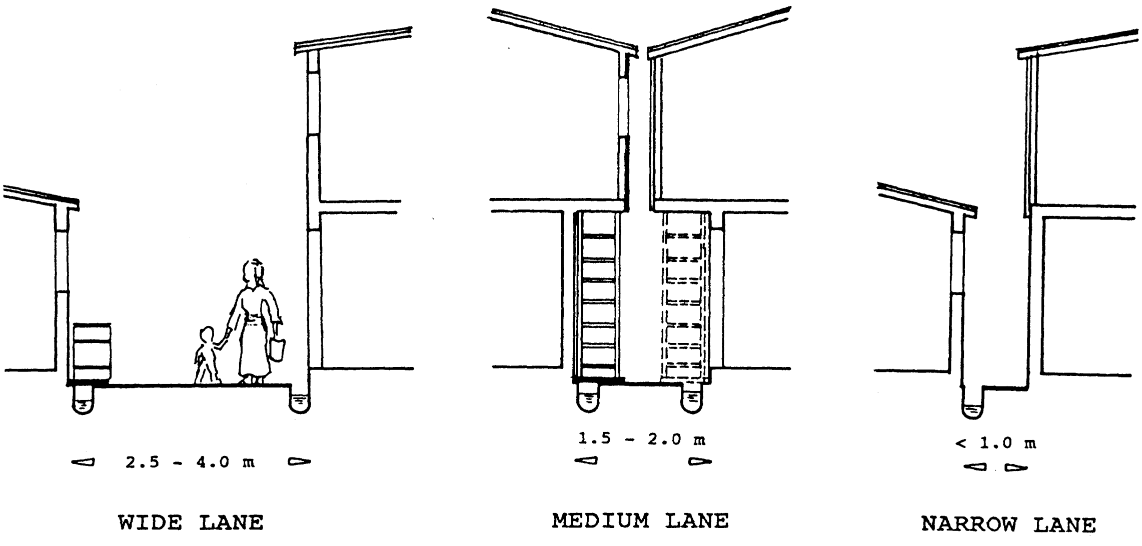


Figure A-2.3: ***Typical lanes in the study area***

Figure A-2.2 also shows the locations of two multi-storey buildings which were provided to slum dwellers under the Prime Minister's Grant Project. Another multi-storey building adjacent to open space is shown in the south-east part of the study area. This area, including the access road, was private property.

A-2.4 SERVICES PROVIDED BY THE CONSERVANCY DEPARTMENT

The Conservancy Department provided the following services: drain cleaning, removal of refuse from community containers along the main road and from refuse collection points in the slum area, sweeping of lanes and roads as well as cleaning of public toilets.

a) Manpower and facilities of the Conservancy Department

Public toilets, community containers and refuse collection points in the study area are shown in figure A-2.4.

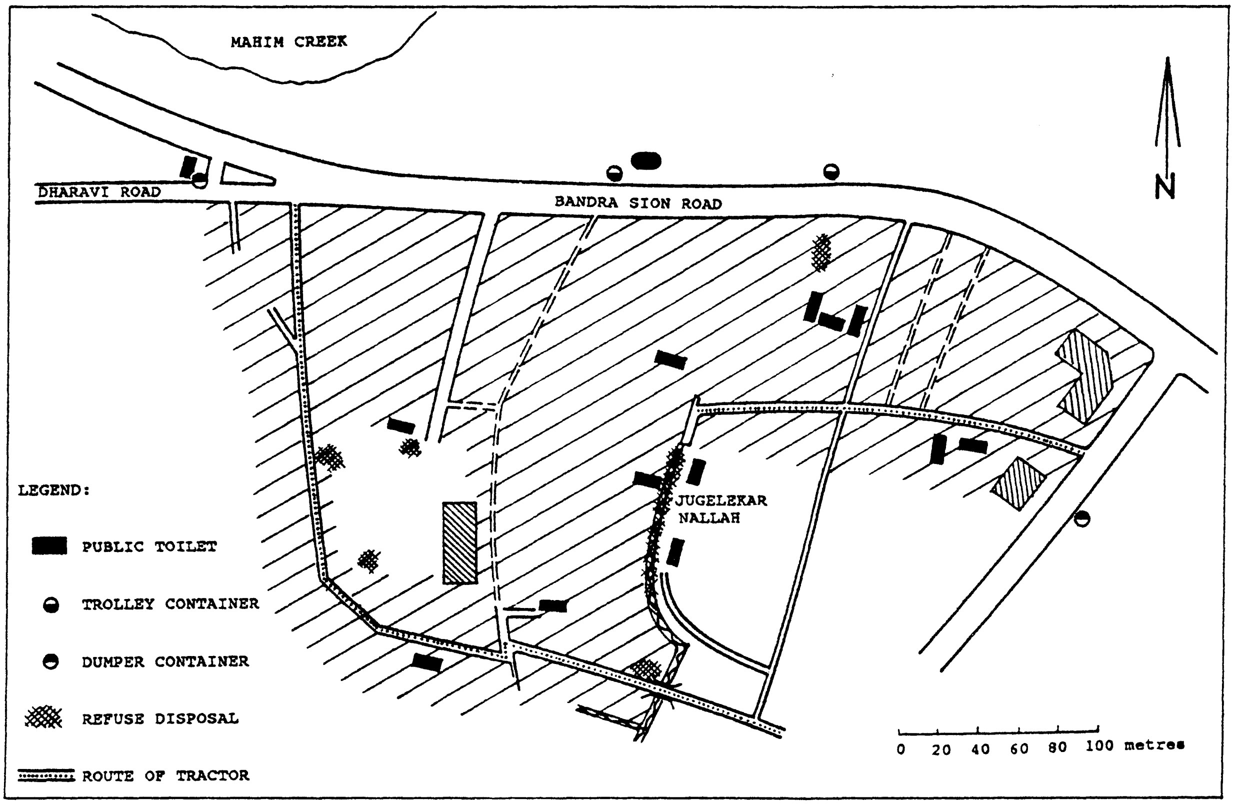


Figure A-2.4: Existing facilities of the Conservancy Department

Four community containers were provided along Bandra Sion Road; two of them were dumper placer type containers (about $4m^3$ each) and the remaining two were trolley bins ($1m^3$ each). In addition, several localities in the slum area were used for refuse disposal, including Jugelekar Nallah. A small tractor, equipped with a container at its rear, was used to transport refuse to Kurla transfer station (see figure A-2.1). The route of this vehicle is shown in figure A-2.4. This figure also shows that most public toilets were located inside the slum area. Spacing was fairly uniform and the distance between toilets was usually about 100 metres, and up to 150 metres in three cases. Most toilets were located along the main lanes, so the walking distance for residents was generally less than 100 metres.

Table A-2.1 shows the assignment of MCGM employees in the study area.

Table A-2.1: Number and tasks of MCGM employees in the study area

3 mukadams [collection]	Supervision of drain cleaners and sweepers
32 drain cleaners	Removal of refuse from open drains and transport to containers (manual, some using handcarts).
5 street sweepers	2 for sweeping of wider lanes in the slum area, 3 for sweeping Bandra Sion Road
8 halalkhores	6 for cleaning public toilets in slum area, 2 for removal of faeces along Bandra Sion Road.
2 mukadams [transport]	One per shift, supervision of motor loaders
10 motor loaders	Five per shift, loading of refuse and drain cleanings to the tractor
2 drivers	One per shift, operation of the tractor.

Personnel for administration and supervision as well as personnel for emptying community bins along the main road are not included.

The number of MCGM employees assigned to the area was 62, which is equal to about one employee per 300 people (estimated population 19,000) or 3.3 employees per 1,000 inhabitants. This is slightly more than the overall labour ratio of the MCGM in Mumbai of about 3.0 per thousand inhabitants.

b) Refuse collection

Table A-2.2 provides an idea regarding the refuse generation in the area.

Table A-2.2: Estimated solid waste quantities in the study area

Refuse generation per capita		population	total refuse generation	
kg/p.d	litres/p.d	(estimated)	tons/day	m^3 /day
0.35 (note 1)	0.88 (note 2)	19 000	6.7	17 (note 2)

Notes (1) This value may be realistic in low income communities.
(2) Assuming that the refuse density is about 400 kg/ m^3

Only a fraction of this quantity was directly carried to existing containers along the main road. These containers provided a capacity of about 10 m^3 and were used by people from both sides of the road and commercial premises. In addition, street sweepers and drain cleaners carried waste to these containers. The facilities were emptied by dumper placer and compactor trucks of the MCGM.

Figure A-2.4 indicates several locations inside the slum area that were used as refuse dumps. Away from the main road there were no storage facilities and refuse was dumped onto the ground and into Jugelekar Nallah. These areas were cleared at very long intervals (up to one year) and posed a threat to public health in the area. Refuse was also dumped in drains and removed by drain cleaners as described in the following section.

c) Drain cleaning

Cleaning of drains was very labour-intensive and more than 50 % of the present manpower was employed for manual removal of refuse from drains by means of tools such as those shown in figure A-2.5.

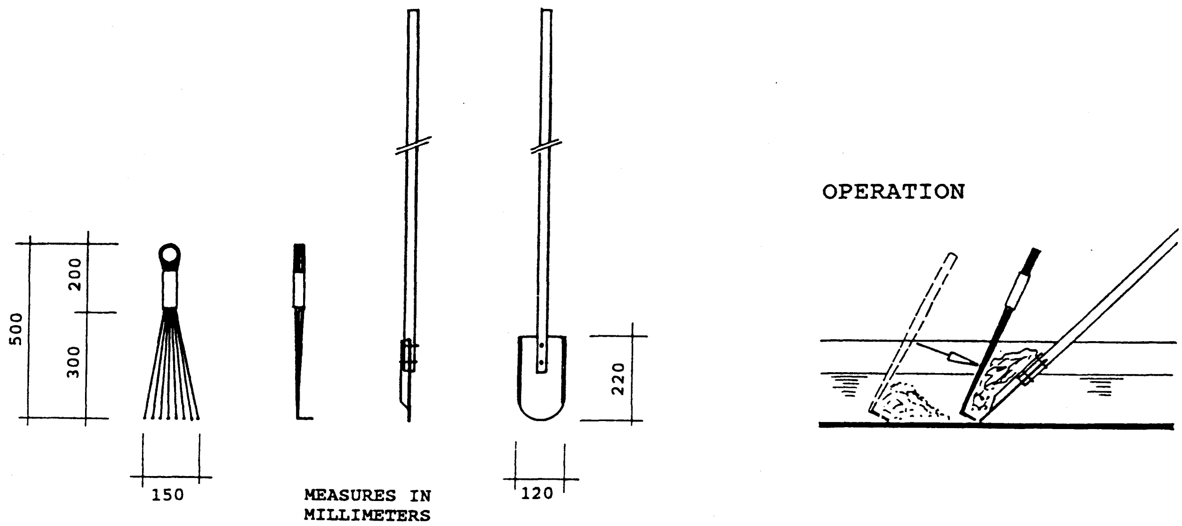


Figure A-2.5 Tools for drain cleaning

The wet material was either directly carried in small bowls to refuse containers along the main road, or loaded into handcarts for transport to the containers, or left along the main lanes for drying until removed by the small tractor.

Transport on handcarts was difficult because the material was wet and heavy. Most handcarts were equipped with two plastic bins which were designed to carry light street-sweeping wastes. When used for transporting silt from drains the bins were soon damaged and were too heavy for lifting and emptying into the containers at the main road. So the contents were usually dumped beside the containers for drying, to be loaded by the motor loaders; this practice caused long waiting periods for the trucks.

When they were dry, piles of silt along the wider lanes were loaded manually into a bin on a small tractor (International B 275) by a crew of five motor loaders. The vehicle was equipped with a container (capacity about 0.8m^3) which was fixed at its rear. Two crews were employed, one in the morning shift (6.00 am to 2.00 pm) to serve Sameshwar, Shivashankar and Jagajiban Nagar, and another in the afternoon (2.00 pm to 8.00 pm) to serve Mukund Nagar. The tractor carried the material to Kurla transfer station, some 3 kilometres north-east of Mukund Nagar along Lal Bahadur Road (see figure A-2.1). There, the container contents were unloaded manually onto the ground and transferred by a front-end loader (JCB) to large tipper trucks for transport to Deonar disposal site. Loading and transport were time-consuming and usually only two trips to Kurla Transfer Station were carried out per shift (based on records obtained from G-North Garage - 107 trips were undertaken in 48 shifts in November 1993). Hence, fourteen persons (see table A-2.1) and one tractor were employed to remove only about 3.5 m^3 of waste per day. Based on appendix AA-2.1, labour costs for this operation were about Rs 2,500 daily, which is equal to more than Rs 700 per m^3. Considering that additional costs for primary collection by drain cleaners, operation of the tractor, transfer at Kurla station and refuse transport to Deonar on bulk carriers are also involved in the system, total costs for refuse collection are extremely high and improvement measures would be highly desirable.

In addition, a private contractor was employed about once a year to remove refuse from Jugelekar Nallah. A layer of some 0.5 metres of floating refuse, which covered the water course completely, was cleared manually. Workers, standing in the nallah without any protective clothing, used small capacity bowls to remove the material and to place it along the banks for drying. There was no access for vehicles and the material had to be picked up again and carried some 50 metres to the truck. Apart from the very high costs involved in this procedure, the working conditions are considered unacceptable.

A-2.5 IMPROVEMENT MEASURES

Inadequate refuse collection services in the slum area are considered to be the main reason for the development of crude dumping areas and for refuse disposal to open drains. This led to unhygienic conditions, blockages of drains and ineffective and costly procedures for refuse removal from the area.

Improvement measures should aim at introducing an appropriate collection system and avoiding refuse disposal to open drains. In addition to public health benefits, the labour force could be reduced and improvements might be cost-effective. Community participation is a vital aspect and will be discussed in section A-2.6.

a) Refuse collection

Refuse collection from individual households was ruled out due to difficult access conditions and high costs. As shown in figure A-2.2 only a fraction of the area is accessible for small vehicles and handcarts.

A collection system which provides a sufficient number of community containers at convenient locations inside the slum area, is considered the most promising way to improve the situation.

Table A-2.3 shows an approximate calculation of the storage requirements in the study area.

Table A-2.3: Estimated storage requirement

Refuse generation		Required capacity of community containers (m^3)		
tons/day	m^3 /day	total required	existing	additional required
6.7	17	18	5	13
(note 1)	(note 1)	(note 2)	(note 3)	

Notes
(1) According to Table A-2.2 above.
(2) Assumptions: 80 % of refuse generation disposed to community bins. Provision of 33 % excess capacity. Clearance once daily.
(3) 50 % of the capacity of facilities along Bandra Sion Road considered (containers are used by people from both sides of the road).

Potential locations for community containers have been identified as shown in figure A-2.6. Ten locations for community containers are suggested in the figure; all locations are accessible for small vehicles and provide sufficient space for manoeuvring during container clearance.

Localities in front of public toilets are considered most appropriate. People are familiar with such localities and the walk to the toilet may be combined with refuse disposal. In addition, they are at some distance from houses and therefore likely to be more acceptable to residents, who are concerned about flies and odour, (which cannot be totally avoided). A small footpath is proposed to link one of the existing dumping areas to container location 2.

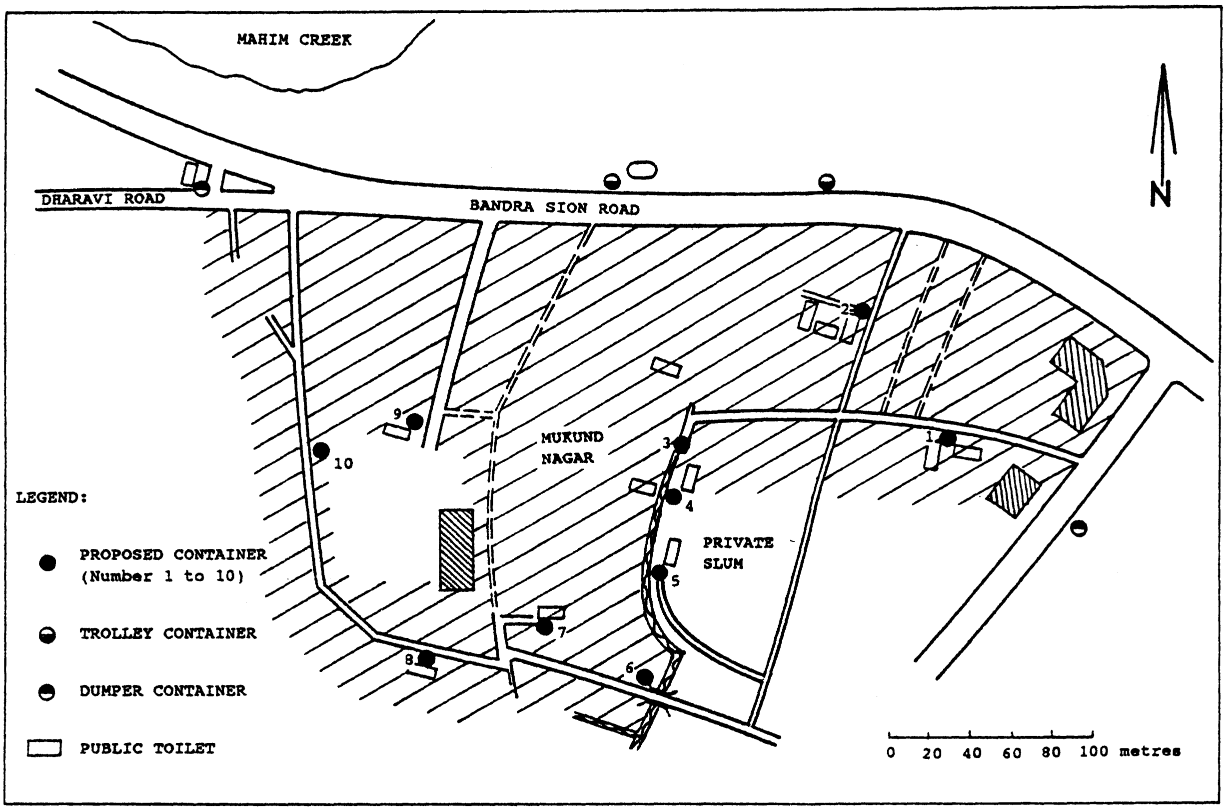


Figure A-2.6: Possible locations for community containers

Three containers (number 3, 4 and 5) are suggested along Jugelekar Nallah to provide a convenient alternative to dumping refuse into the nallah. Two of the proposed locations are east of the nallah, close to the public toilets of a private slum society. Permission of the society is required regarding access to the containers for clearance. However, the private community will benefit from the facilities and this may help to settle this issue. Two pathways crossing the nallah are suggested to provide access to the containers for people from Mukund Nagar.

In addition, a number of locations (number 6 and 10) are proposed at existing dumping areas. These locations are accepted by the people, accessible for small vehicles and provide sufficient space for small containers.

If the suggestions are followed, community containers could be provided to the residents at convenient locations. The walking distance to the facilities is generally less than 100 metres and may be acceptable for the people (see section A-2.6).

In addition, a container handling system is required for clearance and removal of refuse from the area.

b) Container handling and solid waste transport

Access restrictions to the area do not allow the use of large trucks with container emptying devices (such as dumper placers). Therefore a small, manoeuvrable vehicle is required to pick up the containers quickly, to transport them over a short distance and to empty them directly into larger vehicles or containers for long-range transfer to the disposal site. Possible arrangements are discussed in this chapter.

Design of a detachable container The existing tractor is capable of entering the wider lanes of the study area and could be used to carry containers over short distances. However, the existing tractor is not designed for container handling and alternative arrangements are required to make the container detachable. This issue was discussed with personnel of G-North Garage, where the present container was fabricated, and was considered possible. Figure A-2.7 suggests a redesign of the container and the lifting gear of the present tractor to make it suitable for container handling.

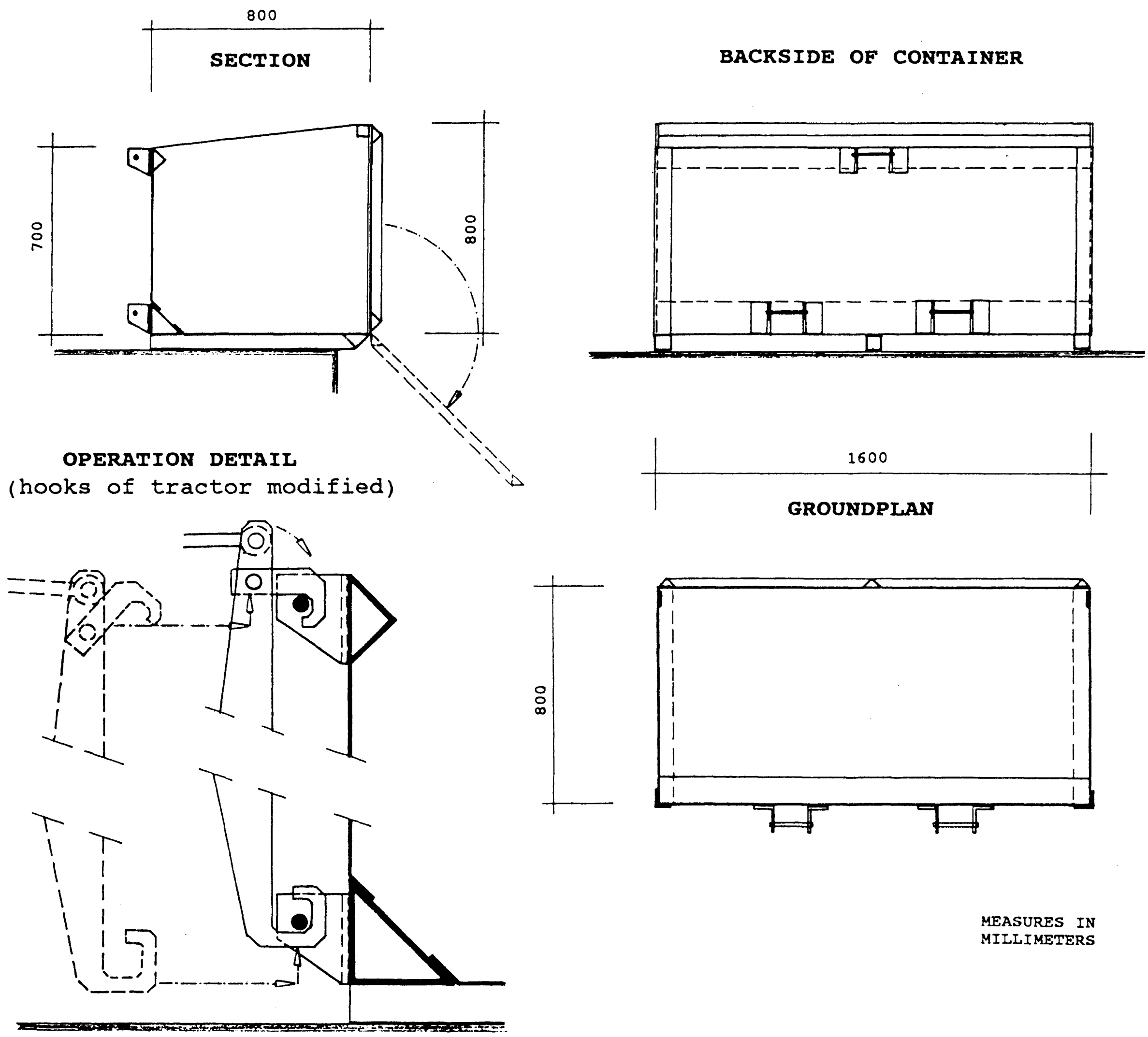


Figure A-2.7 Container design and handling system

Rigid joints (nuts and bolts) at the three supports of the container should be replaced by the proposed hook system, operated by the lifting gear of the tractor. Considering that the tractor will be used to carry refuse rather than wet and heavy drain silt, the container capacity should be increased from the existing 0.8 m^3 to at least 1.0 m^3. It is further suggested to hinge the lid at the bottom of the container. A pilot version should be manufactured and operated for a period of time to further improve the arrangements before the system is introduced on a larger scale. If this suggestion is followed, the existing tractor could be used to handle the detachable containers. One driver and one motor loader are considered sufficient to operate the system.

The distribution of containers to ten locations would provide a storage capacity of about 10 m^3. This is less than the estimated storage requirement of 13 m^3 per day (see table A-2.3) and some containers may need to be emptied twice daily. Monitoring of the system is proposed to establish adequate clearance procedures.

Solid waste transfer Manual container emptying and double handling at Kurla transfer station are inappropriate because they involve long waiting periods for vehicles. In addition, the useful range of the tractor-container system is short and the distance to Kurla is such that using tractors would lead to poor performance and high costs. A small transfer station close to the slum area would be more appropriate. An area along Bandra Sion Road, north of Mukund Nagar, may be appropriate for this purpose and should be investigated. Some minor earth works would be sufficient to construct a split level station at this location and dumper placer containers could be used to receive waste directly from the tractor-container system. Two containers, cleared twice daily, would provide sufficient capacity for secondary storage of refuse from the tractor-container system.

Rapid pick up and unloading in combination with the short distance to the transfer station would allow a substantial increase in the tractor's performance. Time consuming and labour intensive manual unloading of refuse could be avoided and one motor loader would be sufficient to assist the driver during operations.

Performance of the container handling system Time requirements of the proposed container handling and transport system are estimated as follows:

Container pick up in the slum area	about	3 minutes,
Driving to the new transfer station	up to	10 minutes,
Unloading to larger capacity containers	about	3 minutes,
Driving to the next container location	up to	10 minutes.

Hence, less than 30 minutes should be sufficient to complete one round trip, and about 6.5 hours would be required to collect and empty 13 container loads from the study area.

Considering a net working time of 6.0 hours per shift and another hour for driving from G-North Garage to Mukund Nagar and back to the garage (shown in figure A-2.1 to be about 5 kilometres one way) at least ten round trips per shift are realistic.

Therefore the tractor's performance would increase by factor of 5 (ten instead of two trips per shift), the number of motor loaders could be reduced by factor of 5 (one instead of five), and additional localities in the vicinity of the study area could be served by the vehicle (twenty trips are possible per day, only about thirteen are required in the study area).

Daily emptying of containers is required and a rotating labour system (i.e. different labours taking a different day off) would have to be introduced.

c) **Cost comparison**

Costs of the present and proposed systems are estimated in appendix AA-2.2. Both estimates are concerned with primary collection and do not include costs of dumper placer vehicles and bulk transport to Deonar landfill site.

Cost calculations for the proposed system are based on the following assumptions:

- It is expected that the provision of community containers will avoid refuse disposal to drains to a large extent. Therefore ten drain cleaners might be sufficient instead of the current 32. This would also allow a reduction in the number of mukadams from the current four to one or two.
- The suggested container handling system would eliminate manual loading and unloading of containers and one motor loader would be sufficient to assist the driver (instead of the five motor loaders currently employed).
- Calculations assume that the number of sweepers remains at five.
- Costs for the tractor, drivers and motor loaders are reduced by factor 13/20 (13 trips necessary per day, 20 trips possible, remaining time spent to serve other areas in the vicinity).
- Approximate costs for the proposed transfer station at Bandra Sion Road are included.

Results of calculations in appendix AA-2.2 are summarised in table A-2.4

Table A-2.4 Costs of the primary collection system

	Present system		Proposed system	
	Rs/year	percent	Rs/year	percent
Labour costs (drain cleaning and sweeping)	22,64,000	71.8	9,04,000	66.2
Labour costs (loading and transport)	8,18,500	25.9	1,93,000	14.1
Costs of tractor and containers	72,500	2.3	1,07,000	7.8
Publicity	-		1,25,000	9.2
Transfer station and containers	-		37,000	2.7
Total costs	31,55,000	100	13,66,000	100
Costs per inhabitant (19 000 people)	Rs/month		Rs/month	
Drain cleaning/sweeping by MCGM	13.8		6.0	
Drain cleaning/sweeping by residents (note 1)			2.0	
Unit costs of the proposed tractor-container system (note 2)			**365**	Rs/tonne

Notes: (1) If people become in charge for drain cleaning and sweeping along their premises labour costs could be reduced by up to 904,000 Rs/year.
(2) Performance: 13 trips/day x (67 % x 1.0 m^3) x 0.4 tons/ m^3 x 365 d/a = 1270 tons per year. Unit costs without drain cleaners and sweepers.

The comparison shows that the reduction of the labour force would allow the introduction of the proposed system at less than 50 % of the current cost.
Publicity and awareness campaigns are suggested to encourage people to carry out drain cleaning and sweeping of lanes near their premises. Ultimately, with drain cleaning and sweeping entirely carried out by residents, only about Rs 2.0 per inhabitant monthly would be sufficient to operate the primary collection system. This would be about 15 % of the present costs and may be affordable for the majority.

d) Alternative systems

Alternatives to the tractor system may be considered once small container hoist vehicles become available in India. A recent design (by Manus Coffey) is based on a dumper truck chassis and able to carry small capacity containers under difficult road and access conditions. Although smaller than the tractor this vehicle is designed to handle and carry containers with a capacity of about 2 m^3.

Further investigations are suggested regarding solid waste transport to Deonar. Transfer operations at Kurla are very unsatisfactory and should be improved by introducing a split level station. In addition, the proposed system involves two transfer operations, one from the tractor system to dumper placer containers at the suggested Bandra Sion station and another one from dumper placers to bulk carriers at Kurla. This is quite complicated and costly and should be avoided. Larger capacity vehicles could be introduced for direct transport from the proposed transfer station to Deonar. Hook lift container systems or large capacity semi-trailers would be suitable for this purpose and market research is suggested to find out whether such systems are available in India (see also suggestions regarding bulk transfer from Mahalaxmi transfer station in Chapter B-1).

A-2.6 QUESTIONNAIRE SURVEY ON REFUSE COLLECTION

To obtain an idea about the opinions and needs of residents in the study area a questionnaire comprising thirteen questions was prepared and a survey conducted in the area.

The team had become familiar with the locality before formulation of the questionnaire. This helped to identify specific questions, which considered the existing situation, and to include realistic options regarding service improvements.

Conducting a questionnaire survey in slum areas is not an easy task because the communities consist of people from various parts of India, who represent a variety of cultural and religious groups and communicate in at least six different languages (in particular Hindi, Marathi, Kannada, Gujarati and Urdu).

Ideally, a questionnaire survey should include the following:

- Translation of questions into the different languages.
- Multilingual team of enumerators selected to conduct the survey. 50 % of the enumerators should be female to interview female residents.
- Briefing and training of enumerators (including awareness of solid waste management issues).

It was impossible to comply with all these requirements when carrying out the survey. However, although the team had to struggle with language problems it was possible to interview 34 persons from various locations in the study area.

Some of the questions and replies are reproduced below, together with comments on the responses that relate directly to the issues under consideration. The questionnaire sheet including a summary of replies is presented in appendix AA-2.3.

1. Living conditions in slum areas are far from ideal and outsiders may not be able to set the right priorities when planning infrastructure service improvements. Therefore residents were asked to indicate their own perceptions of needs and priorities:

Please rank neglected services in your locality in order of importance:

	Water	Toilets	Flooding	Refuse	Roads	Sweeping	Electricity
First priority	1	12	0	18[53%]	1	1	1
Second priority	1	10	1	14 [41%]	1	7	0
Third priority	4	3	8	2	7	9[26%]	1

Replies clearly indicate that the residents consider refuse collection as the most neglected service in their community. Flooding and sweeping are commonly caused by uncollected refuse and could be combined with refuse collection. Hence, when considering combined replies, 56 % of the responses rank refuse collection improvements as most important, 65 % as second most important and 56 % as the third most important issue.
Considering that there are no individual toilets in the area and that water supply is only three hours in the morning this result is indeed surprising.

2. From a technical and economical point of view community containers are considered most suitable to improve the situation (see section A-2.5).

What do you think about the idea of sharing common bin with several families in your locality if this bin is emptied daily and kept clean?

good 32/94% fair 1 bad 1

The responses indicate that residents like the idea of sharing community bins for storage of refuse.

3. A physical survey in the locality revealed that locations close to public toilets may be most appropriate for community containers (see section A-2.5).

If a community bin would be provided at your public toilet would you be willing to bring your garbage to this place?

yes 29/85% no 2 don't know 3

Replies indicate that residents are willing to carry refuse to community bins at public toilets.

4. Prevention of refuse disposal to open drains would not only improve public health in the locality but also allows a substantial reduction in costs (see section A-2.5).

Do you feel that provision of community bins at suitable locations will prevent people from throwing refuse in drains?

yes 22/65% no 8 don't know 4

Based on the responses the majority believed that the provision of community bins would prevent refuse disposal to open drains. As shown in table A-2.4, the reduction of labour for drain cleaning allows the implementation of the proposed collection system and the reduction of costs for services provided by the MCGM. Publicity and awareness campaigns are suggested to encourage people to carry out sweeping and drain cleaning along their premises.

5. Community support is vital when introducing the proposed collection system.

Is it possible to formulate community action groups in your community to activate people in refuse collection?

yes 9 no 12 don't know 13

Replies indicate that a relatively large number of people may be willing to become actively involved in service improvements. Suitable campaigns may help to motivate additional people to participate in community activities regarding refuse collection.

6. One question has been addressed to assess the willingness of community members to pay for service improvements.

If any new system is introduced by the Corporation for improvement of the existing refuse collection system, are you willing to pay nominal charges?

yes 27/79% no 7 don't know 0

It is significant that a clear majority would be willing to pay for service improvements. Further investigations are required to evaluate affordable service charges and to establish an appropriate system to collect charges. Charges should at least allow the recovery of primary collection costs which could be reduced to a monthly charge of about Rs 2.0 per inhabitant (see table A-2.4).

7. Based on (1) above, toilets have been ranked second regarding improvement needs (35 % rank public toilets as most important, 29 % as second most important). Although not directly related to refuse collection one question was addressed as follows:

Please think about the public toilet in your locality and choose the most serious problem.

Poorly maintained	Place very dirty	Place far away	Lack of water	others
12	9	0	11	2

Lack of water was probably the main reason for poor maintenance and cleanliness of toilets. It was observed that halalkhores were obliged to use sullage from open drains to clean the facilities and that people carried water in buckets from their home for anal cleaning. Further investigations are suggested to establish suitable techniques regarding the provision of water to public toilets.
Results further show that the distance to toilets seemed to be acceptable. This may indicate that people are likely to carry refuse to these facilities, if the community containers are provided at most toilets

A-2.7 CONCLUSION

Replies in the questionnaire survey clearly indicate that residents considered refuse collection as the most neglected service in their community.
The provision of community storage facilities, mostly located at public toilets, is proposed to improve the situation. Responses of people indicate that they liked the idea of sharing community bins and that they were willing to carry refuse to these facilities. The majority of respondents further believed that the provision of community containers would prevent refuse disposal to open drains, which would allow a substantial reduction labour for drain cleaning.

Detachable containers in conjunction with the existing tractor are proposed for refuse storage and collection. In addition, a split level transfer station, located close to the slum area, is suggested. These measures would allow the performance of the tractor to be increased by factor of 5, the number of motor loaders to be reduced by a factor of 5, and the servicing of additional localities in the vicinity of the study area.
A reduction of the labour force is suggested to allow the implementation of service improvements at affordable cost. It is estimated that the proposed system would reduce the present service costs by more than 50 %. It is further suggested that intensive publicity and awareness campaigns be initiated in order to encourage people to carry out drain cleaning and sweeping of lanes adjacent to their premises. Ultimately, with drain cleaning and sweeping entirely carried out by residents, about Rs 2.0 per month and resident would be sufficient to cover the costs of primary collection. This is

only about 15 % of the costs of the present system and may be affordable for the majority. It was significant in the survey that a clear majority seemed to be willing to pay for service improvements. Further investigations are suggested to evaluate affordable service charges and to establish an appropriate system to collect charges.

Alternative collection and transport techniques should be investigated to further reduce costs. Market research is suggested regarding small container hoist vehicles which are suitable to operate under difficult road and access conditions. In addition, hook lift container systems or large capacity semi trailers should be employed to improve refuse transport operations.

APPENDIX AA-2.1 LABOUR COSTS OF MCGM EMPLOYEES

AA-2.1.1 Wage components of MCGM employees

BP: Basic Pay (monthly), increasing annually by certain amount.

Labourers: 1260 - 20 - 1400 - 25 - 1500 - 30 - 1590

Drivers: 1375 - 20 - 1450 - 30 - 1600 - 40 - 1680 - (EB) - 40 - 1880

Mukadam: 1300 - 20 - 1380 - 25 - 1480 - 30 - 1510 - (EB) - 30 - 1660

J. O.: 1590 - 50 - 1690 - 60 - 1930 - 70 - 2350 - (EB) - 70 - 2770

Supervisor: 2190 - 90 - 2550 -100 - 2950 - (EB) -110 - 3500

A.H.S.: 2600 -100 - 2900 -110 - 3450 - (EB) -110 - 3560 - 125 - 4060

E.g. labourer: Minimum Rs 1,260.-, increasing by Rs 20.- per year until BP Rs 1,400.-, increasing by Rs 25.- per year until Rs 1,500.- etc., maximum BP Rs 1,590.- (after 15 years in service).

Note: EB (Efficiency Bar): Possible additional increment to BP, based on performance of the employee, fixed by a committee.

BP in case of promotion to higher grade: One increment in same grade or next scale in higher grade.

DA: Dearness allowance (monthly, all grades), quarterly adjustment according to Mumbai Consumer Price Index, about 50 % to 80 % of BP, decreasing with increasing BP.

DP: Dearness Pay (monthly, all grades), 50% of DA at 30.06.1990, about 15 % to 25 % of basic pay

CA: Conveyance Allowance (monthly, only JO upwards), flat rate for transport during working hours, between Rs 100.- and max. 1,600.-,

WC: Washing Charges (monthly, all staff wearing uniforms, mainly labourers), flat rate of Rs 25.- for laundry services.

UWA: Unclean Works Allowance (monthly, labourers and mukadams only), flat rate of Rs 15.- (labourers) or Rs 25.- (mukadams).

MMA: Municipal Medical Allowance (monthly, all grades), flat rate Rs 70.-,

HRA: House Rent Allowance (monthly, all grades): HRA = 10 % of (BP + DP). If housing is provided by MCGM, HRA = 5 % of (BP + DP)

LTA: Leave Travel Allowance (once every second year, all grades, only provided if staff is min. 240 days per year in service). Rates depend on BP as follows:

BP up to 1,500.- :	LTA 1,250.-
BP 1,501.- to 2,000.-:	LTA 1,550.-
BP 2,001.- to 2,650.-:	LTA 2,000.-
BP 2,651.- to 3,250.-:	LTA 2,450.-
BP 3,251.- to 4,375.-:	LTA 3,250.-
BP 4,376.- to 4,900.-:	LTA 4,150.-
BP more than 4,901.- :	LTA 4,350.-

Ex Gratia: Bonus (once yearly, all grades):

(BP + DP + DA) + Rs 100.- to Rs 500.- (increasing with grade),

Scholarships (all grades): Rs 120.- per year per child, beginning with 5th standard (if marks are above 60 %). Scholarships for college students up to Rs 3,000.- per year.

RG: Retirement Gratuity (single payment, all grades):

15 days x (BP + DP + DA) per year in service

E.g. retirement of sweeper after 26 years in service

RG = 15/30 x 26 x (1,590 + 345 + 1,170) = about Rs 40,400.-.

Maximum Rs 100,000.-, payment to family in case of death of employee.

FP: Family Pension (monthly after retirement, all grades), flat rate

Rs 185.- per month (payment to family in case of death of employee).

AA-2.1.2: Estimated labour costs
(sweepers, motor loaders and halalkhore)

Calculation for employees who have been 5 years in service:

Basic Pay (BP):	1380
Dearness Allowance (DA):	1050
Dearness Pay (DP):	310
Unclean Works Allowance (UWA):	15
Washing Charges (WC):	20
Municipal Medical Allowance (MMA):	70
House Rent Allowance (HRA):	170 (10 % of 1380 + 310)
Leave Travel Allowance (LTA):	50 (1250 two years/24 month)
Ex Gratia:	240 (1380 + 1050 + 310 + 100) / 12
Scholarship:	100 (one child, school)
Retirement Gratuity (RG):	115 (0.5 x 5 x (1380 + 310 + 1050) / 5 x 12
Total	3,520 Rs per month

Annual working days of employees

365 days - 10 days (i.e. 20 days at half payment or 10 days full payment for medical leave) - 33 days (vacation, earned leave) - 20 days (public holidays) - 52 days (weekly day off) - 2 days (optional leave, religious holidays)
= 248 working days per year.

Considering 248 working days per year for municipal workers labour costs per shift are about:

- Workers 3,520 x 12 / 248 = Rs 170 per shift
- Mukadam (estimated) about Rs 190 per shift
- Drivers (estimated) about Rs 200 per shift

APPENDIX AA-2.2 COST ESTIMATES

AA-2.2.1 Estimated costs of the present system

				Rs/year
LABOUR: (1)	32 drain cleaners	32 x Rs 170 x 300	=	16,32,000
	5 sweepers	5 x Rs 170 x 300	=	2,55,000
	3 mukadams	3 x Rs 190 x 300	=	1,71,000
	2 drivers	2 x Rs 200 x 300	=	1,20,000
	10 loaders	10 x Rs 170 x 300	=	5,10,000
	2 mukadams	2 x Rs 190 x 300	=	1,14,000
	Management & Admin.	(10 % of labour costs)		2,80,000
TOTAL LABOUR COSTS			about	30,82,000
TRACTOR: (2)	Diesel	160 ltr/month x 6.65 Rs x 12 months		12,800
	Maintenance and repair as fuel (assumed)			12,800
	Capital	170,000, standby 1.2, interest 12 %		24,500
	Depreciation	(10 years, incl. standby)		20,400
1 CONTAINER:	Capital Rs 9,000, interest 12 %			1,100
	Depreciation (5 years)			900
COSTS OF TRACTOR				72,500
TOTAL COSTS (Rs per year)			about	31,55,000

(1) Labour costs according to appendix AA-2.1, 300 working days per year.
(2) Costs are based on information obtained from G-North Garage.

AA-2.2.2 Estimated costs of the proposed system

				Rs/year
LABOUR:	10 drain cleaners	10 x Rs 170 x 300	=	5,10,000
	5 sweepers	5 x Rs 170 x 300	=	2,55,000
	1 mukadam	1 x Rs 190 x 300	=	57,000
	2 drivers	13/20 x 2 x Rs 200 x 365	=	94,900
	2 loaders	13/20 x 2 x Rs 170 x 365	=	80,700
	Management & Admin. (10 % of labour costs)			99,800
TOTAL LABOUR COSTS			about	10,97,000
PUBLICITY AND AWARENESS CAMPAIGNS (assumed)				1,25,000
TRACTOR:	Capital 170,000, standby 1.2, interest 12 %		= 24,500 x 13/20	16,000
	Depreciation (10 years, incl. standby x 13/20)			13,300
	Diesel 250 ltr/month x 6.65 x 12 (estimated)			20,000
	Maintenance and repair as fuel (assumed)			20,000
10 CONTAINERS:	Capital Rs 9,000 x 10		=	90,000
	Interest 12 %			10,800
	Depreciation (5 years)			18,000
	Maintenance (10 % of capital)			9,000
COSTS OF TRACTOR AND CONTAINERS			about	1,07,000
TRANSFER STATION:	Capital approximately			1,00,000
	Interest 12 %			12,000
	Depreciation (10 years)			10,000
2 DUMPER PLACER CONTAINERS:	Rs 17,500 x 2		=	35,000
	Interest 12 %			4,200
	Depreciation (5 years)			7,000
	Maintenance (10 % of capital)			3,500
COSTS OF TRANSFER STATION			about	37,000
TOTAL COSTS (Rs per year)			about	13,66,000

NOTE: Assumptions are set out in section A-2.5 of the main report.

APPENDIX AA-2.3 QUESTIONNAIRE SHEET AND SUMMARY OF RESULTS

Q-1 Please rank neglected services in your locality in order of importance:

	Water	Toilets	Flooding	Refuse	Roads	Sweeping	Electricity
First priority	1	12	0	18[53%]	1	1	1
Second priority	1	10	1	14 [41%]	1	7	0
Third priority	4	3	8	2	7	9[26%]	1

Q-2 Please think about the public toilet in your locality and choose the most serious problem.

Poorly maintained	Place very dirty	Place far away	Lack of water	others
12	9	0	11	2

Q-3 Are you satisfied with refuse collection in your locality?

yes 7 no 26 don't know 1

Q-4 What are your suggestions to improve garbage disposal in your locality?

Provision of community bins 24
Ringing bell at central location 6
Others 4

Q-5 Do you feel that provision of community bins at suitable locations will prevent people from throwing the garbage in drains?

yes 22 no 8 don't know 4

Q-6 Who is responsible for taking out refuse from your house?

Father	Mother	Children	Other family member	Private scavenger	Others
5	15	6	8	0	0

Q-7 What do you think about the existing locations where most of people in your area bring their garbage?

Garbage not removed	Clearance insufficient	Place very dirty	Location not suitable	Number of points not enough	Blank
15	11	0	0	3	5

Q-8 If a common bin would be provided at your public toilet would you be willing to bring your garbage to this place?

yes 29 no 2 don't know 3

Q-9 What do you think about the idea of sharing common bin with several families in your locality if this bin is emptied daily and kept clean?

good 32 fair 1 bad 1

Q-10 Do you think that people in your locality will bring their refuse to a community bin?

yes 29 no 3 don't know 2

Q-11 Do you feel that people will cooperate in fixing the locations?

yes 25 no 6 don't know 3

Q-12 Is it possible to formulate community action groups within community to activate people in garbage collection?

yes 9 no 12 don't know 13

Q-13 If any new system is introduced by the Corporation for improvement of the existing system, are you willing to pay nominal charges?

yes 27 no 7 don't know 0

Chapter A-3
Tricycle primary collection and small transfer stations

by Manus Coffey and P Roychowdhry, with assistance from B M Desai and J B Kagathara

A-3.1 INTRODUCTION

A study of existing refuse collection, transfer and disposal systems in Mumbai identified many inefficiencies with the existing methods and equipment. Proposals are put forward for an alternative system based on primary collection by means of tricycles bringing the wastes to small transfer stations where the refuse is transferred to large enclosed containers for transport to the disposal site. Outline designs are provided for a typical small transfer station (STS), based on a concept which has proved successful in China. The transfer station will be completely hygienic and odour free and have a capacity of up to 105 tonnes of solid wastes per day, within an overall site area of less than 180 m^2. Thus it is possible for this type of transfer station to be constructed in areas with high population densities.

Costings are included which show that such a system will have operating costs as low as Rs 207 per tonne and capital costs of only Rs 38 per tonne. This is just two-thirds of the cost of existing collection and transfer procedures and this system is also very hygienic and provides a much higher level of service.

Proposals are also put forward for the design of the primary collection tricycles and the container transfer vehicles. Recommendations are made for the setting up of a pilot project based on this system to be used as a demonstration of the small transfer station concept and to remove any fears from the public concerning the location of transfer stations in their localities.

It is considered that this project could have applications in many other cities of India as a hygienic and cost effective system of solid waste management.

Land costs have not been included in the study in line with the policy adopted in a study carried out by NEERI in 1994. In some situations land costs may be a significant factor in choosing sites for the small transfer stations.

A-3.2 BACKGROUND INFORMATION

With the passage of time Mumbai no longer consists of the original seven islands of Colaba, Fort, Byculla, Parel, Worli, Matunga and Mahim, but it has grown into a megapolis with a population of 9.9 million (1991 census) and with a continuing high growth rate. The total area of 438 km^2 is divided into 23 wards according to the density of population and utilisation statistics. The islands are in the form of a peninsula, with the "central" business district at the southern extremity.

At present the MCGM handles and disposes of about four thousand tonnes of solid waste every day at the four existing dumping grounds. For primary collection, transportation and disposal, MCGM deploys 141 refuse vehicles for the city region and 120 for the suburbs and, to keep these vehicles running, 13 garages are provided at different locations within the Greater Mumbai area. The total conservancy staff comprises approximately 33 000 workers, staff and officers. It has been observed that whilst most of the refuse collection vehicles carry the wastes directly from the collection points to the disposal site, a number of vehicles discharge their loads at transfer stations where the wastes are loaded onto larger vehicles for transporting to the disposal sites. There are at present two such transfer stations, situated at Mahalaxmi and Kurla. (see Figure A-3.1 for the locations of existing disposal sites and transfer facilities).

Mahalaxmi Transfer Station This transfer station is located near the Mahalaxmi railway station and serves South Mumbai. Previously the wastes were taken from here to the disposal site by railway, but the facility has since been transformed into a road vehicle transfer station to cater for the wastes of southern Mumbai. The land area taken up by this site is approximately 240 m by 57 m (13,700 m^2.) The transfer facility is of the split-level type, with a central split-level raised platform from which the containers can be directly discharged into bulk refuse carriers standing below and adjacent to the platform at either side. In general, dumper placer trucks bring the wastes in 4.5 m^3 containers and empty them into bulk refuse carriers which, when full, carry the wastes to the disposal site at Deonar. (Operations at this site are described in more detail in section B - 1.) Occasionally loads of sewer silt and offal wastes are also transferred at this site. This transfer station is well maintained but it has been observed that the access to this site through a congested market area causes problems for the movement of the refuse vehicles. The Mahalaxmi transfer station is presently transferring around 300 tons of wastes per day although it is capable of a much greater throughput if fully utilised.

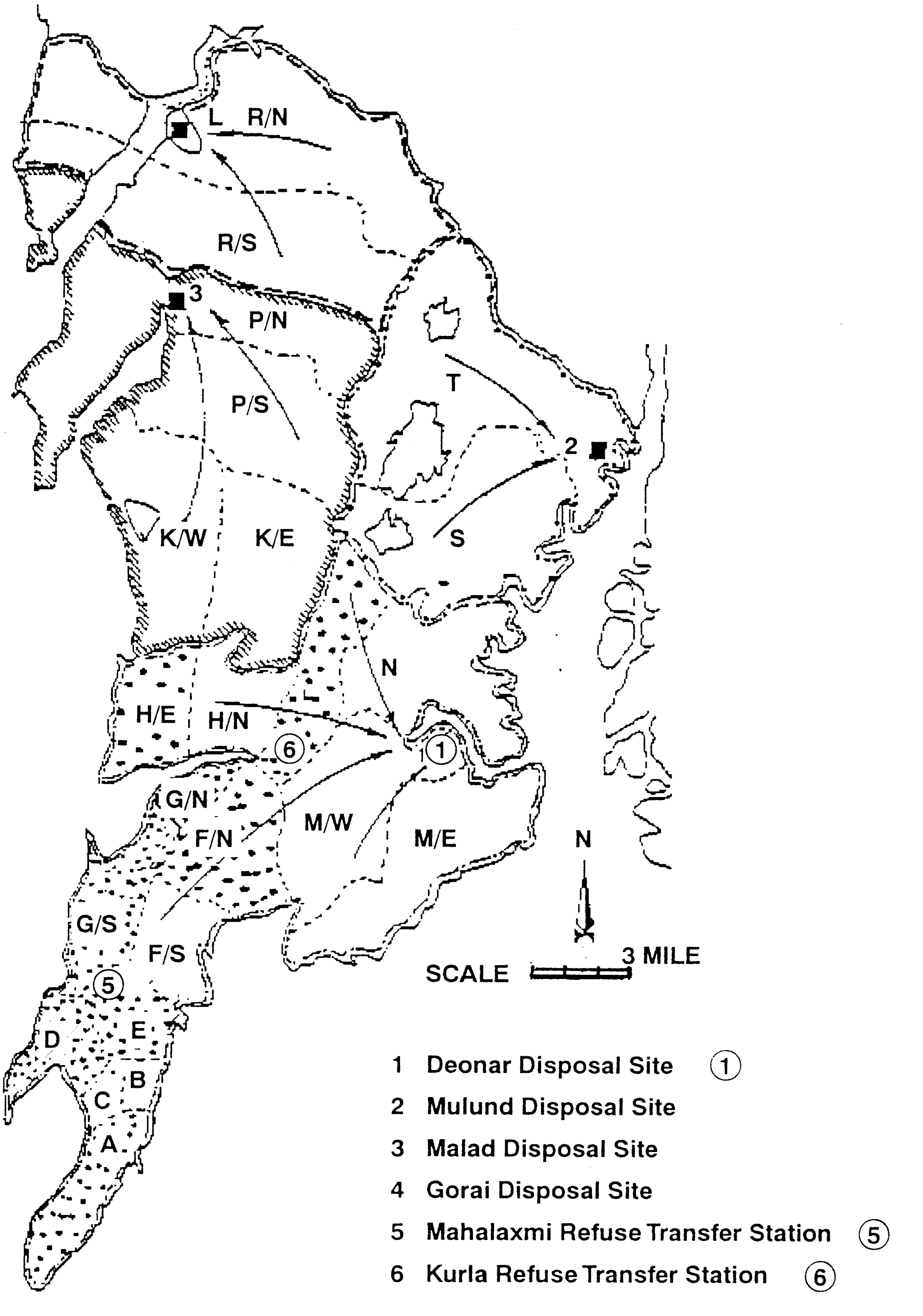


Figure A-3.1 Transfer and disposal sites in Greater Mumbai

Kurla Transfer Station This transfer station is situated in the Central Mumbai area (see figure A-3.1). It has a concrete ramp but it is not usable because of a failure in its foundations, perhaps because it is built on deposited refuse. Municipal vehicles unload the collected refuse from the nearby wards onto the ground from where it is loaded by front-end loaders into contractors' vehicles for transporting to the disposal site. The area of this transfer station is 70 m by 80 m (5,600 m^2).

A-3.3 ASSESSMENT OF EXISTING TRANSFER STATION (MAHALAXMI)

Advantages:

◊ Centrally located with an average haul distance of 5 km from the collection points to the transfer station.

◊ Because of the split level operation, transferring of the wastes avoids secondary handling, resulting in fast turn-around times for the collection vehicles. This means that the collection vehicles are very efficient in clearing wastes from the primary collection points situated in the congested city area.

◊ The gravitational transfer system from the containers on the platform to the bulk refuse carriers standing underneath the platform is a cost-effective and reliable method of transfer.

◊ Operational and maintenance costs (O & M) are low.

◊ The site is clean and easily operated.

◊ The workforce involved directly with the transfer station is small.

◊ This type of transfer station is environmentally acceptable and is suitable for its purpose.

◊ The check post, ramp, split level platform and the bulk refuse bay have enough space to receive, transfer and dispatch the existing total of 23 transfer vehicles during the three shifts. This indicates a daily capacity of 530 tonnes/day based on one load/truck/shift, a body volume of 24 m^3 and a waste density of 400 kg/m^3.

◊ The site has a well-defined area enclosed by a boundary wall with proper recording arrangements and security postings.

◊ All wastes are brought into the site in closed containers and discharged directly into the transfer vehicles. As a result no rag picking is carried out at this site.

Disadvantages

◊ The access road - through a congested market area - causes delays for the incoming and outgoing collection and transfer vehicles.

◊ The total potential of the transfer facility is under-utilised and space requirements are large in an area of scarce and costly land resources. It is estimated that this transfer facility could handle up to four times its present throughput although this might create unacceptable traffic congestion in the adjoining market area and would increase the collection area and the primary collection haul distances correspondingly.

◊ The containers that bring the waste and the bulk refuse carriers that take them out are undersized for the vehicle chassis used. This hampers the cost effectiveness of the transfer station and increases traffic problems.

◊ The space under the platform (if not filled up) could have been utilised for garaging, repairing, storing and other purposes.

◊ The dumper placer containers should be redesigned so that they can be discharged into the bulk transfer vehicles more easily as well as carrying larger loads.

A-3.4 DESCRIPTION OF PROPOSED SMALL TRANSFER STATION (STS).

The remainder of this section describes a more cost-effective transfer system using a number of smaller transfer stations in place of the two large existing facilities.

Figures A-3.2 to 7 show a typical small transfer station which consists of a fully-enclosed transfer room (17 m x 8 m) and toilet and other facilities alongside.

- ◊ There are two pits in the floor of the station into which the 8 tonne capacity refuse transfer containers can be lowered so that the tops of the containers are at floor level. The containers are moved around within the building by means of an overhead gantry (rail-mounted) crane. Rubber flaps are used to prevent wastes falling down between the sides of the pit and the container.
- ◊ There is enough space (6.0 m) between the pits to allow the transfer trucks to pick up one of the full containers without interrupting the filling of the container at the other side of the building by the tricycle collection vehicles.
- ◊ There is sufficient space behind each of the pits to allow two full or empty containers to be stacked for storing waste between transfer collection. In this way there is a total storage capacity of 6 x 8 = 48 tonnes of containerised wastes in the transfer station at any time. This enables the collection and transfer operation to be carried out at different times with all wastes fully containerised at all times.
- ◊ The pits are fitted with simple load cells so that each container can be loaded to its full 8 tonne capacity, thus avoiding overloading of the trucks while maximising the vehicle capacity and minimising the number of loads transferred.
- ◊ The building is tiled throughout and provided with a high pressure wash-down pump for hosing down the containers and the building at the end of each shift. Roller shutter doors prevent rats or dogs entering the building when it is not operating and an electric mosquito/fly killer prevents any insect nuisance (with occasional spraying if required).
- ◊ The overall appearance of the STS may be similar to that of a modern fire station or a 'Mother Dairy' milk booth type building with tiling on the outside for easy hosing down. (The high pressure wash down pump can be used for this purpose).
- ◊ The wastes arrive at the STS on tricycles in plastic containers or in a fully enclosed tipping body. The wastes are transported away in fully enclosed containers, so that at no time should there be any loose waste about or inside the building.
- ◊ The fully enclosed transfer room is provided with air vents at high and low levels for good ventilation and sodium vapour lamps enable operation at any time of the day or night as required.
- ◊ The layout as shown includes an office, canteen for tricycle and STS operators, toilets, repair facilities and parking space for all tricycles serving the station. Quarters are provided for three families above the transfer station. This transfer station covers a total site area of 20.6 m x 15.9 m (328 m^2) and the building as shown has a height of 10.5 m including the overhead staff quarters. In areas where high rise buildings are permitted, further floors with additional staff quarters or rental apartments may be provided.
- ◊ The proposed layout can be modified and adapted to suit any particular site. If the collection service is contracted out or privatised, parking space for the tricycles may not be required. In this case the complete facility can be accommodated within an area of only 17.6 m x 8.6 m (152 m^2).
- ◊ The double pit transfer station illustrated has a daily capacity of 105 tonnes of wastes, if there is two shift working.
- ◊ It will also be possible to provide a single pit transfer station with a capacity of around 50 tonnes/day and storage capacity for 24 tonnes of wastes within an overall site area as small as 9.0 m x 6.0 m (54 m^2).
- ◊ A 15 kW stand-by generator will provide power for the gantry and lights in the event of power failures.

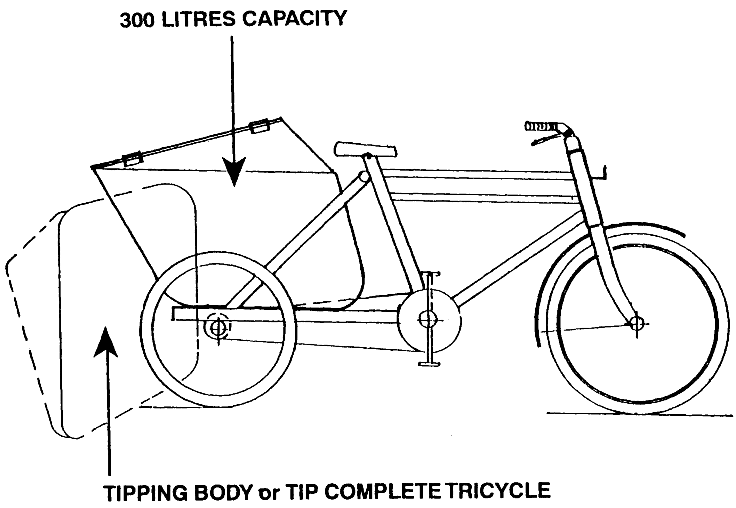


Figure A-3.2 Tricycle for primary collection

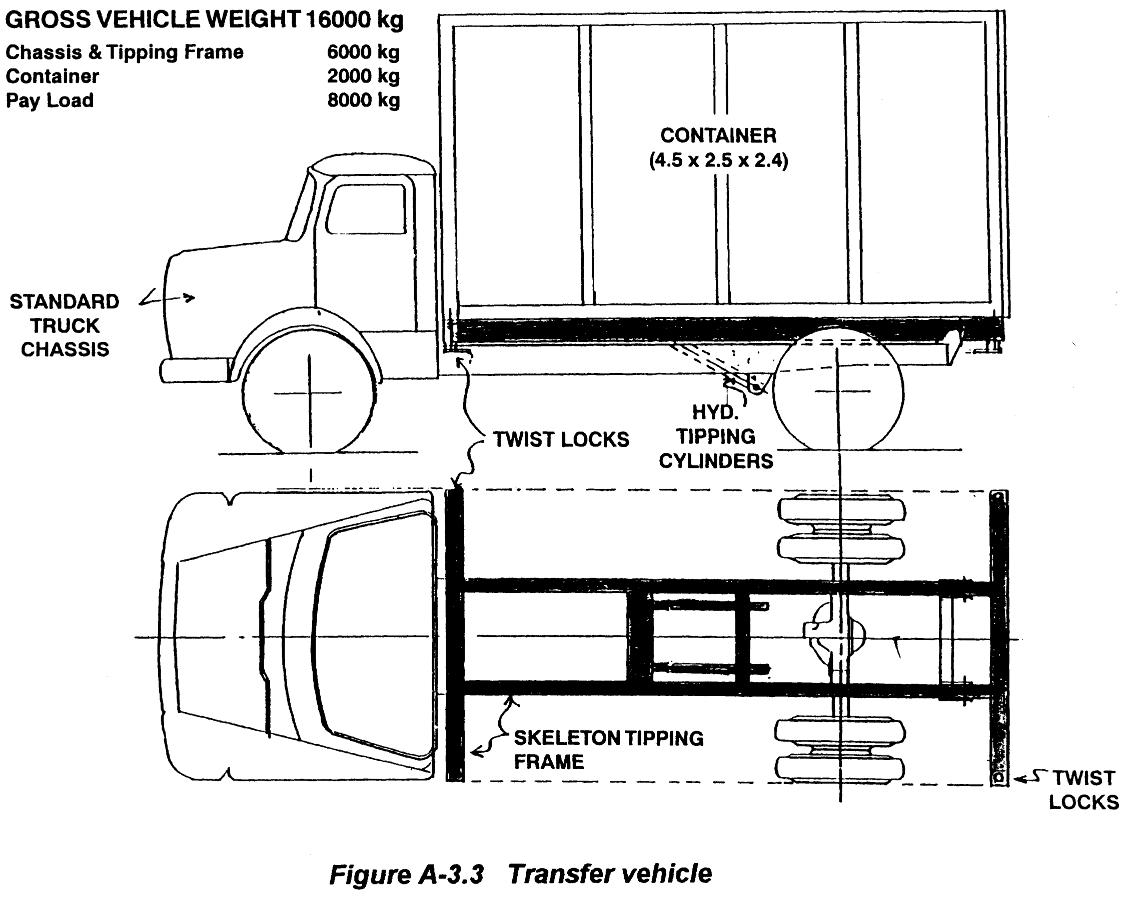
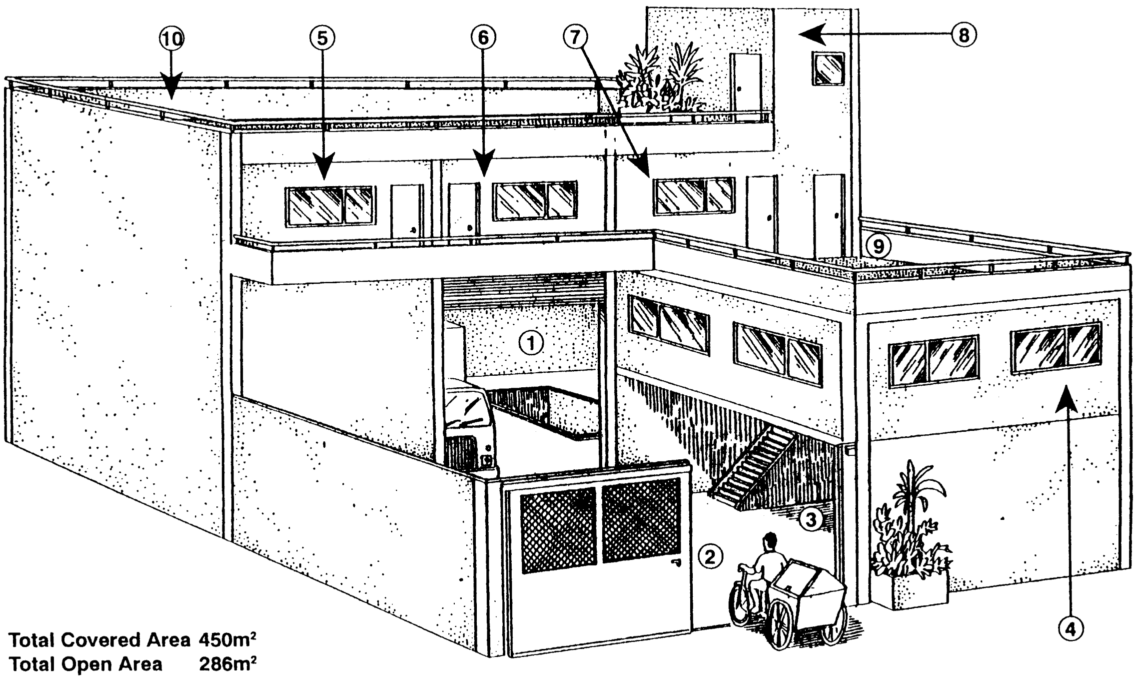


Figure A-3.3 Transfer vehicle



Total Covered Area 450m^2
Total Open Area 286m^2

1	Transfer Room	136m^2	6	Apartment	48m^2
2	Open Tricycle Storage & Access	80m^2	7	Apartment	50m^2
3	Tricycle Repair & Covered Storage	60m^2	8	Stairs/Toilets	60m^2
4	Canteen & Office	56m^2	9	Terrace/Passage	70m^2
5	Apartment	40m^2	10	Roof Play Area	136m^2

Figure A-3.4 Architectural features of small transfer station

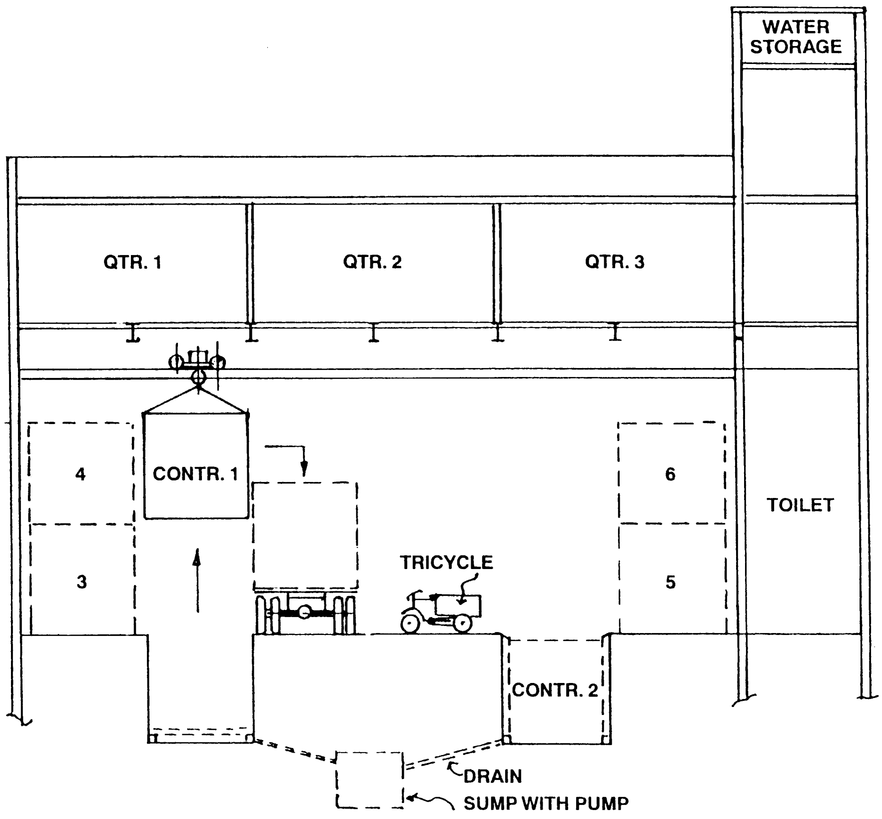


Figure A-3.5 Sectional view of small transfer station

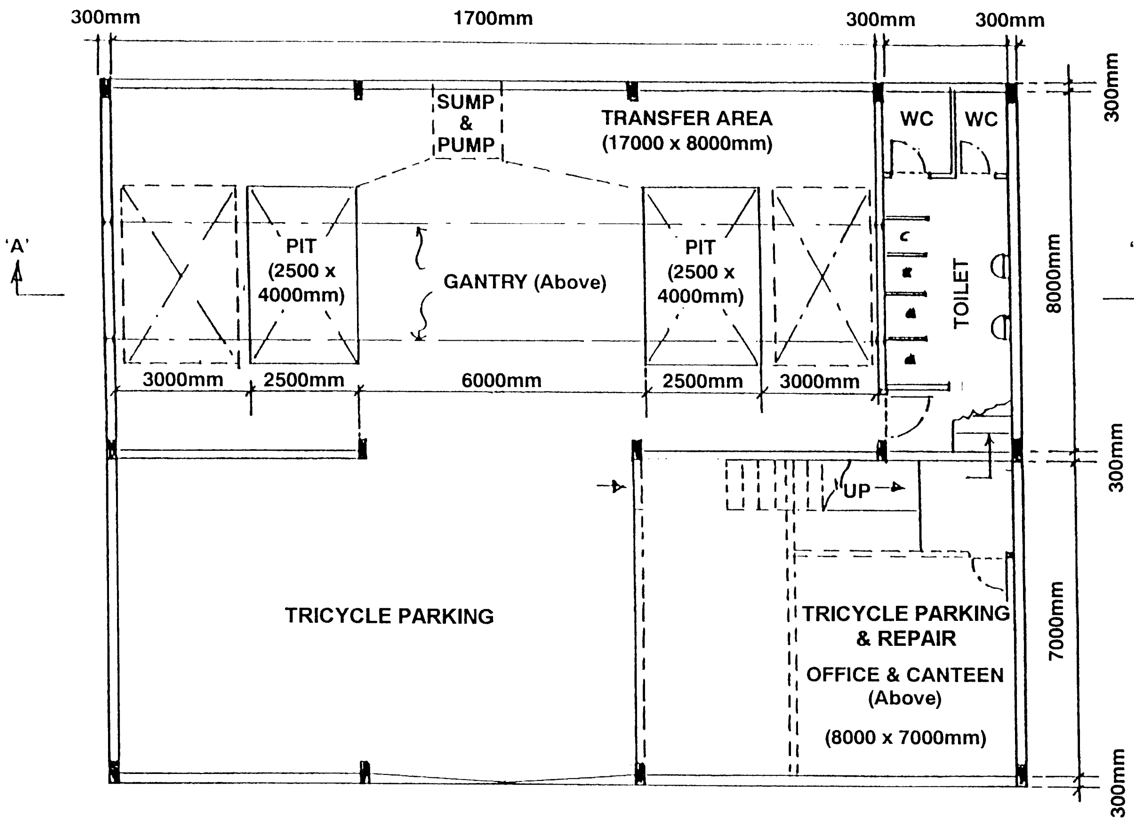


Figure A-3.6 Plan of ground floor of small transfer station

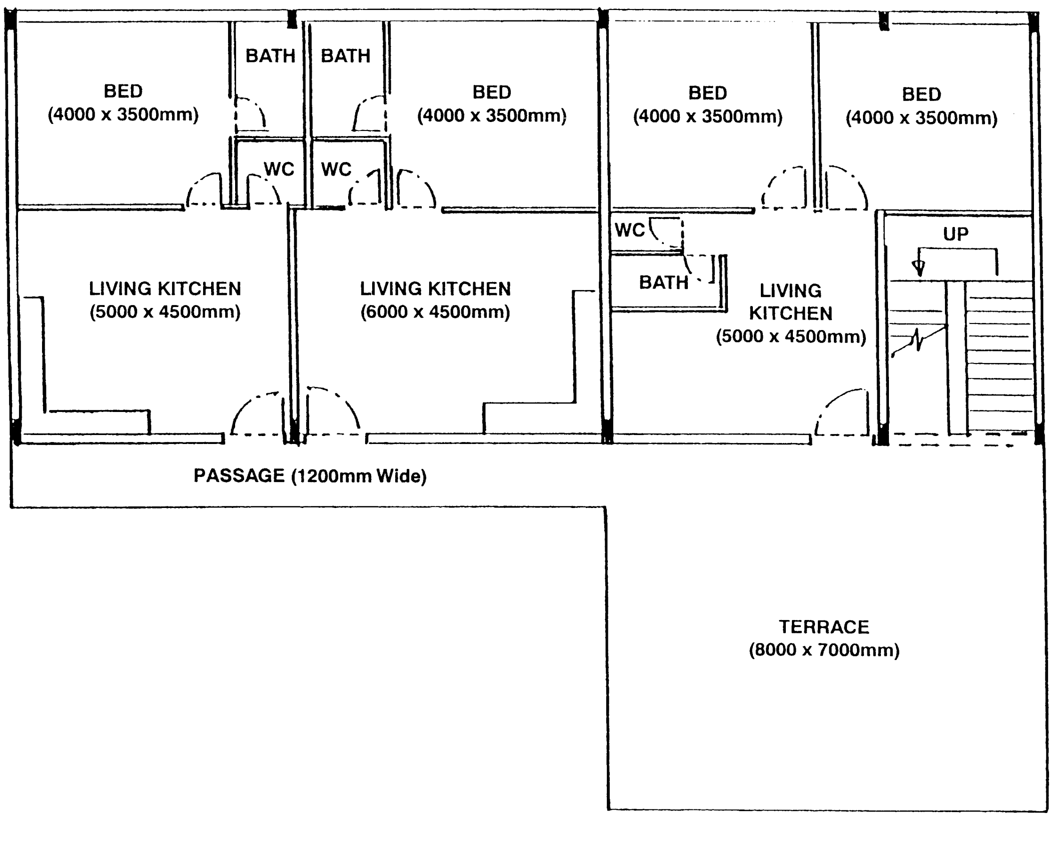


Figure A-3.7 Plan of first floor of small transfer station

A- 3.5 ADVANTAGES AND DISADVANTAGES OF PROPOSED SMALL TRANSFER STATIONS

Advantages

◊ A high level of service is provided by the door-to-door primary collection from individual houses.

◊ Hygiene - all the wastes are covered/containerised from the point of collection to the landfill. Loading heights are low. No one has to lift refuse over his head as is frequently necessary with many existing systems.

◊ No secondary handling - transfer does not require any manual reloading.

◊ Low capital cost and small space requirement for the STS allow them to be located at strategic points thus reducing primary haul distances.

◊ Storage capacity at the STS enables the primary collection and the transfer to take place at different times of the day to suit local traffic conditions. (Primary collection with tricycles may be done during the day, and bulk transfer at night when traffic congestion is less.)

◊ Primary collection by tricycle can work in congested areas and narrow streets.

◊ Traffic congestion will be reduced with the larger haul capacity of the transfer truck resulting in fewer trips.

◊ Optimum loads are carried by the transfer trucks at all times by the use of load cells at the STS to maximise loads without overloading.

◊ The STS uses appropriate technology at low capital cost, using only locally manufactured equipment.

◊ It is a labour-intensive collection system providing local employment.

◊ Both primary collection and transfer are suitable for privatisation where applicable due to the low cost and non-specialised equipment used.

◊ The STS interior specification allows for easy washing and cleaning facilities on a daily basis thus eliminating odours, rodent and insect problems.

◊ Visual impact will be pleasing and very acceptable to the local householders.

◊ No rag-picking will take place at transfer or collection points thus avoiding scattering of waste and fire hazards.

◊ The cost per ton of waste collected and transferred will be a small fraction of that of existing systems of direct haul or large transfer stations.

◊ Space above the STS is used for accommodation and offices.

◊ Due to the de-centralisation concept each supervisor will have a better control over the cleanliness of his locality and his sub-zone.

Disadvantages

◊ To procure land at strategic points may be difficult (although space requirements are small).

◊ The amount of supervision required for primary collectors will be high.

◊ The loading and unloading of containers at the STS is dependent on electricity. (A standby generator must be included to provide power in emergencies).

◊ Truck noise may create disturbance if night haulage is used. (Day haulage only is practical due to the storage capacity of the STS and the small number of truck hauls, but this will require a larger numbers of trucks since each truck will do fewer trips).

◊ It is essential to operate these STS with a very high standard of cleanliness. Failure to keep the stations clean will make them a nuisance to the local residents.

A-3.6 DESIGN CALCULATIONS

Area to be covered by each small transfer station and haul distances for primary collection tricycles. A study was carried out into the wastes generated and the population densities in different wards in Mumbai to determine the area which can be served by each small transfer station based on a throughput of 105 tonnes of wastes per station per day (assuming two shift operation). From this data the average haul distance for the primary collection tricycles can be estimated as well as the number of stations which would be required to serve the total population of each ward. These estimates are set out in table A-3.1.

It can be seen that the maximum straight line haul distance (collection radius) varies between 0.48 km and 1.36 km and the average straight line distance to be travelled by the tricyclist will be between 0.34 km for Ward A and 0.96 km for Ward G/N. Allowing for some deviation from a straight line the average distances travelled by the tricyclists will vary between 0.5 km and 1.4 km.

Table A-3.1 Area to be covered and haul distances for STS

Ward No.	Area (km^2)	Waste generated per km^2 (t/day)	Area to be served by 105 t/day STS (km^2)	Average collection radius (km)	No. of STS needed
A	1.4	145	0.72	0.48	3
D	6.63	32	3.28	1.02	7
E	7.4	31.5	3.33	1.03	7
G/s	10.00	19	5.53	1.33	8
G/n (part)	3.02	18	5.83	1.36	2
				Total No. of STS	27

Daily capacity of each tricycle and number required per STS

For calculating the daily capacity of each tricycle the following assumptions can be made:

- ⇒ Each tricycle will carry a maximum of 125 kg.
- ⇒ Each tricycle can make 8 trips per shift (one hour per trip).
- ⇒ An overall efficiency of 80% is assumed to allow for inefficiencies in the loads carried and the number of trips made.

On this basis each tricycle will collect an average of :

$$\frac{8 \times 125 \times 80}{100} = 800 \text{ kg / shift.}$$

To collect 105 tonnes / day with double shift work will require:

$$\frac{105{,}000}{2 \times 800} = 66 \text{ tricycles.}$$

Assume 75 tricycles per STS to allow 14% for breakdowns and repairs.

Based on the above figures each STS will take in a total of 1050 tricycle loads per day or 525 loads per eight hour shift. During twelve hours each day up to four tricycles can unload at the same time and during the remaining four hours, when the transfer truck is loading or unloading or the containers are being moved, only two tricycles can unload at the same time. On the above basis each tricycle has an average unloading time of 3.2 minutes. This is considered to be more than adequate and the extra time available will help to offset the problem caused by large numbers of tricycles arriving at the transfer station simultaneously at certain times of the day.

Daily capacity of each transfer vehicle

Each transfer container will be sized to hold a minimum of 8,000 kg of wastes and, as load cells are provided at the STS, each container load will be filled to this capacity. (This only applies to high density wastes such as those found in Indian cities - where wastes have low densities it may be difficult to provide containers of sufficient volume to hold 8,000 kg of uncompacted waste.)

The following assumptions can be made to arrive at the daily capacity of each transfer vehicle:

⇒ Average haul distance from transfer station to disposal site 17.5 km. (Based on the distance from the city centre area to Deonar disposal site).

⇒ Average speed of haul vehicle 25 km/hr. (Assuming that most transfers are undertaken during off - peak traffic times.)

⇒ Loading time at the transfer station: 10 minutes

⇒ Unloading time at the disposal site: 10 minutes. (including weighing).

Number of loads to be transferred = $\frac{105,000}{8,000} = 13.125$

Theoretical round trip time:

$$\frac{17.5 \times 2 \times 60}{25} + 10 + 10 = 104 \text{ minutes}$$

If two trucks are allocated to each STS, working two shifts, there will be a theoretical transfer capacity of:

$$\frac{2 \times 2 \times 8 \times 60}{104} = 18.5 \text{ loads per day.}$$

Thus these two trucks will have a surplus capacity of 40% to allow for breakdowns, servicing, tea breaks, etc.

Capital costs for small transfer stations

Construction costs (Based on the designs shown in Figs A-3.4 to 7)

Ground floor covered area.

Transfer area	17.0 m x 8.0 m	136 m^2
Toilet/wash room	2.7 m x 8.0 m	22 m^2
Tricycle repair	7.0 m x 8.0 m	56 m^2
Total covered ground floor area		214 m^2

Second floor area.

3 staff quarters	158 m^2
Office & canteen area	56 m^2
	214 m^2

Building costs

Ground floor 214 m^2	2,306 ft^2 @ Rs 600	Rs 1,383,600
First floor 214 m^2	2,306 ft^2 @ Rs 350.	Rs 807,100
Total building cost		Rs 21,90,700 or Rs 22 lakh

Depreciation on building @ 4% 0.8 lakh

Note: This does not include the value of the land which must depend upon location and availability. Some of the land value can be offset against the rental value of the three staff quarters included in the above costings.

Equipment at transfer station

	cost: Lakh Rupees
Gantry crane	3.0
High pressure wash down pump	1.5
Gates, roller shutter door, fencing	2.0
Electrical installations	1.5
Stand by generator	1.5
Load cells	2.0
	11.5

Depreciation on plant @ 10% 1.2 lakh

Transport costs

Two 16 tonne GVW trucks with skeleton tipping bodies.

Table A-3.2 Capital and annual depreciation for vehicles and containers

	Capital cost: Lakh Rupees per truck		Capital cost: Lakh Rupees for whole system	Economic life (years)	Depreciation cost (Capital cost/life), Lakh Rupees per year
Chassis	7.0				
Hydraulic system	2.0				
Tipping frame	0.5				
Total, (x 2 since two trucks)	9.5	x 2 =	19.0	8.0	19.0/8.0 = 2.38
Ten containers @ Rs 60,000			6.0	3.5	6.0 / 3.5 = 1.71
75 tricycles @ Rs 6,000			4.5	5.0	4.5 / 5.0 = 0.90
Small tools etc.			0.5		
		Total	**30.0**		**4.99**

Annual costs

Table A-3.3 Calculation of annual costs

Item	Explanation or calculation	See note	Costs, Lakh Rupees	Total costs, Lakh Rupees
Fixed costs				
Depreciation	Buildings (calculated above)		0.80	
	Plant (calculated above)		1.20	
	Vehicles (Table A-3.2 above)		4.99	
Interest on capital	Buildings 22.0 x 12%	1	2.64	
	Plant 12.0 x 12%	1	1.44	
	Vehicles 30.0 x 12%	1	3.60	
	TOTAL FIXED COSTS			14.67
Maintenance costs				
Trucks:	assuming 10% of cost		1.9	
Containers:	assuming 5% of cost		0.3	
Tricycles:	assuming 15% of cost		0.7	
Buildings	assuming 2.5% of cost		0.55	
Plant	assuming 5% of cost		0.6	
	TOTAL ANNUAL MAINTENANCE			4.05
Energy and water				
Fuel	13.125 loads x 35 km x 365 days @ 4 km/litre @ Rs 4 per litre			3.4
Electricity & water	Guesstimate			1.0
Overheads	Guesstimate			3.0
Labour costs				
Tricycle operators	193 operators @ Rs 2,500 per month	2	57.9	
Truck crew	9 drivers @ Rs 4,000 per month	3	4.3	
	9 helpers @ Rs 2,500 per month	3	2.7	
STS staff	3 attendants @ Rs 2,500 per month	4	0.9	
	3 mechanics @ Rs 3,000 per month	4	1.1	
	3 cleaners @ Rs 2,000 per month	4	0.7	
	TOTAL LABOUR COSTS			67.6
	TOTAL ANNUAL COSTS			**93.72**

Notes for table A-3.3

1. A NEERI study used a 12 % rate for this purpose.
2. [66 tricycles x 2 shifts x 365 collection days per year] / [250 working days per man per year] = 193
3. [3 trucks x 2 shifts x 365 collection days per year] / [250 working days per man per year] = 9 drivers and 9 helpers
4. One of each category (attendant, mechanic and cleaner); STS works two shifts but three of each category are needed to allow for holiday periods etc.

Cost per tonne of waste collected and transported

One small transfer station, working two shifts, can handle 105 tonnes of waste per day.
Therefore, waste handled per year = 105 x 365 tonnes, and cost per tonne is

93,72,000 Rs per year 105 x 365 tonnes per year	=	**Rs 245 per tonne**

Note: This figure can be compared with the estimate provided in the NEERI report at Rs 378 per tonne for the existing system of collecting wastes from community containers and transporting them to the disposal site. It can be seen that the proposed STS system will provide a much higher level of service in a hygienic manner at less than two-thirds of the cost of the existing system.

A-3.7 CONCLUSIONS AND RECOMMENDATIONS

The economics and hygiene advantages of this proposal suggest that this method of waste collection and transport merits serious consideration. It is recommended that a potential site in an urban area be identified and that a research and development grant be awarded for the construction and operation of such a system. It is unlikely that the initial design will be perfect, so time and money must be allocated to allow improvements to be made to the prototype before a decision is made as to the viability of this system. Operational data will need to be verified before a definitive costing of the system can be obtained. A similar approach in China has been successful, so it is worth investing money and skill into the introduction of this system in India.

If the waste is collected directly from houses, and is kept containerised all the way to the disposal site, there is very little opportunity for rag pickers or recyclers to separate materials that can be reused or reprocessed. Such a system could be operated in conjunction with household separation - each tricycle having two compartments for two types of waste (such as wet and dry) - or the waste could be sorted by the collector at each house, so that the value of the recyclable materials and the opportunities for employment (which are provided by resource recovery) are not lost.

A-3.8 EXERCISES

A sensitivity analysis could be conducted on the calculated cost per tonne. For example, it may be that the average speed used for the transfer vehicles in the analysis above is too optimistic, and that a lower speed should be used if two-shift operation is specified. The effect of a lower average speed on the number of vehicles and the collection cost per tonne would show how sensitive the results are to traffic conditions. Another variable that could be considered is the time allowed for each tricycle to collect its load. By using different times, the sensitivity of the final results to the number of tricycle trips undertaken in a day could be investigated. Such sensitivity analyses can be used to indicate which items of data are most influential on the final result, so that extra effort can be concentrated on obtaining accurate values for these key items.

Chapter A-4

Private Sector Primary Collection in Rajkot

by Dr Gracie Mihsill, Dr S P Kulkarni and A K Gurung

A-4.1 INTRODUCTION

Much emphasis is laid these days on the role of the private sector. In Rajkot, Gujarat, three systems of street sweeping and primary collection are in operation in parallel - (i) direct labour (municipal workforce), (ii) private sector contractors and (iii) a system of subsidising housing associations. These three systems are compared and discussed in this chapter.

The Bombay Municipal Corporation Act, 1949 (BPMC Act) is followed by municipal corporations of Gujarat State. This Act has laid down the rules and regulations for local bodies. The Act has specified obligatory functions. Conservancy and sanitation are amongst these basic obligatory duties to be performed by municipal corporations. All the local bodies have adopted different systems to maintain hygienic conditions for their citizens by employing sweepers and various forms of transport to collect the solid waste and take it for disposal. It is often observed that the collection and disposal services are inefficient and unsatisfactory. Public and press usually have negative impressions of these services.

Rajkot Municipal Corporation has sought to improve its delivery of these services by engaging the private sector to undertake some of this work. This chapter describes how contractors have been involved in primary collection and street sweeping.

In 1995 Rajkot Municipal Corporation (RMC) had a budget of about Rs. 120 crores, of which Rs. 8.5 crores was allotted to the Health Department, which was responsible for solid waste management. The Health Department spent about Rs. 6.5 crores (over 75%) on conservancy and sanitation functions. More details of the budget and workforce of the Health Department are given in Appendix AA-4.1. The RMC employed about 4000 staff, of which about 2530 (63%) were employed in solid waste management. The population of Rajkot was about six lakhs (0.6 million).

The rapid growth of the urban area created a demand for sanitation services that the RMC was not able to meet with its own workforce and financial resources. So the RMC introduced a scheme of subsidising housing societies to provide their own services in 1989, and then introduced contract sweeping in 1990, so that now there are three systems operating in parallel. The demand for contracted sweeping emerged as a result of

- Increasing establishment costs,
- Labour problems,
- Indiscipline among workers, and
- Decreasing levels of performance.

Each ward has been divided up into a number of sweeping units or beats by the RMC. The area of each unit is based on a strip on each side of each street - the centre of the street is not included because the passage of vehicles keeps this part reasonably clean and prevents the sweeping of this part. The area of each unit is nominally 30 000 ft^2 ($2800m^2$).

A-4.2 DESCRIPTION OF THE SYSTEMS

a) Municipal system

In each ward where the primary collection and sweeping services are still provided by the municipal labourers, there is one Sanitary Inspector (SI) and one Sanitary Sub-Inspector (SSI). The SI and the SSI concentrate their efforts on sanitation and conservancy work. Above them, the Chief Sanitary Inspector, Zonal Officer and Medical Officer of Health also inspect the sanitation work from time to time, and they are also responsible for food and water sanitation, immunisation and control of epidemics. Below the SSI are peons, each of whom is in charge of 20 to 25 sweepers.

The SSI is responsible for:
- ◊ Attendance of sweepers at 6.30 am, 10.30 am, 3.00 pm and 6.00 pm;
- ◊ Arranging for daily waged sweepers to cover leave vacancies and absentees;
- ◊ Attendance of part-time sweepers;
- ◊ Maintenance of sanitary and conservancy stores, and issuing implements and uniforms to workers;
- ◊ Preparation of the muster list;
- ◊ Supervision of payment of salaries;
- ◊ Receiving and attending to complaints from the public;
- ◊ Supervision of the work of the sweepers; and
- ◊ Arranging vehicles for the collection of the solid waste

The RMC provides the following implements to its sweepers:
- Hand broom - made from coconut leaves, about 80 to 100 cm long and weighing about 300g. These are provided at the rate of one a month. (Municipal sweepers usually are obliged to purchase extra hand brooms themselves from the market at a cost of Rs. 8 to 10 each, because the life of such brooms is less than one month.)
- Cycle fan - this is a part of a bicycle mudguard and is used for scooping up silt from open drains. One is provided every three months; they cost about Rs.5 in the market.
- Scoop - this is made from a tin container and provided with a handle to facilitate picking up waste from the ground.
- Handcart or wheel barrow - either the old two-wheel design (photograph 1) or the six-bin design (photograph 2).

b) Subsidies to housing societies

Sweeping within the areas owned by the housing societies is not technically the responsibility of the Municipal Corporation, but if waste is scattered indiscriminately in these areas it is difficult for the municipal employees to collect and remove the waste. For this reason the housing societies have been urged to engage their own sweepers. To encourage this the RMC started giving subsidies of Rs.600 per sweeping unit - the actual subsidy depending on an assessment of the size of the area to be swept. (In the 13 societies that receive this benefit, the subsidy payable varies from Rs. 300 to Rs. 1600.) The RMC also provides a handcart at no cost., and undertakes to repair it. A list of the grants made to different housing societies is given in appendix AA-4.3

The RMC does not supervise the work of sweepers employed in this way by the housing societies, though a Health Department supervisor checks from time to time that the area is being kept clean. The housing societies are responsible for paying the sweepers and providing the necessary implements. This system provides a direct benefit to the municipality in that solid waste is taken by the sweeper to the appointed collection point or container, so that the work of the collection labourers working with the trucks is reduced.

c) Contract sweeping

A pilot scheme for contract sweeping was introduced in 1990 when 25 sweepers were engaged. An evaluation was conducted after 3 months by sending out a questionnaire to the residents of the areas where these sweepers had been working. More than 90% expressed approval of the new scheme. This led to the implementation of the scheme in Wards 7 and 10 - wards that are on the outskirts of the city. The numbers of sweepers needed for each ward was assessed in terms of the 30000 ft^2 sweeping unit, and the RMC invited separate tenders for each ward. Initially only two or three tenders were received, but in 1994-5 RMC received six tender quotations. In the first year, the rate for one unit was Rs. 1200, and in 1995 it was Rs 1396 for Ward 7 as Rs 1390 for Ward 10. The contractor for Ward 7 was Hetal Construction, with 89 sweepers, and Ward 10 was served by Krishna Construction with 64 sweepers. Both contractors had held the contracts for five years.

Under this arrangement the RMC supervisors are no longer concerned with supervision of labour, but are only responsible to monitor the contractors' performance, and report on it to their superiors. The contractors engage their own staff to supervise the sweepers, record attendance etc.. The municipal supervisors in these wards have more time to devote to other public health duties.

The contractors claimed that they supplied handbrooms, cycle fans and scoops, but the sweepers themselves said that they were obliged to buy their own implements.

According to the terms and conditions of the contracts (appendix AA-4.2) the contractor is responsible for providing implements (and the Municipality should provide the handcarts), and the sweepers should be paid at least the official minimum wage. Each employee should be a member of the Provident Fund, and have an ESI (Employees State Insurance) number. The contractor is responsible for providing a service every day, including holidays.

The conditions of contract also specify that a penalty of Rs. 100 per day is payable if any area is found not cleaned. The penalty for non-attendance of a sweeper is Rs. 50 per day. If the performance of the contractor is found to be below standard, the contractor is to be issued a written warning, and the contract can be terminated and the deposit paid by the contractor is forfeit. The decision of the Municipal Commissioner is to be final in any dispute.

d) Further comments about the provision of implements

Since the life of a handbroom in such conditions is less than a month, new brooms should be provided more frequently. Brooms with long handles or broomsticks [figure A-1.1 (ii)] are not issued because the sweepers are not accustomed to them. As mentioned in chapter A-1, longer handled brooms can reduce back complaints and exposure to dust.

A deduction is made from the wages of the sweepers for the purchase of equipment. This practice should stop since the wages of the sweepers are already low.

Twelve of the sweepers working for housing societies refused to use the handcarts provided because they were concerned that the handcarts would be stolen and they would be held responsible. Those without handcarts either carried the waste to the containers in very small quantities - an inefficient practice - or they burned the waste in small piles, causing air pollution. The RMC should compel the societies to solve the problem of security of the carts or provide an alternative method of carrying the waste that is hygienic and effective.

A-4.3 ADVANTAGES OF THE PRIVATE SECTOR SYSTEMS

The following advantages apply to the contracting system, and also in most cases, to the subsidy system:

◊ **Administrative burden reduced** - The RMC is not responsible for payment of salaries, issuing implements and uniforms, and other administrative functions. All the supervisors with whom this was discussed mentioned the reduction of administration with great relief.

◊ **Other functions benefit** - Health Department supervisors were able to devote more time to other public health functions.

◊ **Financial savings**. A municipal sweeper in 1995 was paid between Rs 1700 and Rs 1800 per month, and there are many other expenditures relating to municipal employees such as the provision of implements, chemicals and uniforms, and the payment of benefits such as leave travel concessions, medical benefits, housing etc. [In appendix AA-2.1 there is a summary of the benefits payable to municipal employees in Mumbai.] Thus there is a considerable saving if the total payment to the contractor is only Rs. 1390 per month for each sweeper's beat.

◊ **Reliability** - The contractor was required to pay a security deposit of Rs 30 000 and provide a solvency certificate before he could start work. This discouraged the contractor from unilaterally terminating the contract.

◊ **Advantages to labourers** - Sweepers working for contractors said that they would prefer to work for the Municipal Corporation because of the better job security, wages, and benefits. Many contract sweepers expressed the belief that the position as a contract worker was a way in to a municipal job. (It is not known whether there is any substance in this belief, or whether perhaps it is a story circulated by the contractors to help recruitment and retention of their workers.) The contractors provided some assistance to individuals in their workforces in the form of emergency loans.

◊ **Effect on municipal sweepers** - The RMC sweepers saw the contract system as a potential threat to their own jobs and so were motivated to work harder.

◊ **Disciplinary action** - The lengthy procedures for taking disciplinary action against a municipal employee are avoided in the contract system, so reducing the load on the municipal labour officer and other management staff. An example of a common disciplinary problem is given in a box below.

◊ **Financial simplicity** - The calculation of individual salaries with their different increments is avoided, so the work of the finance section of the Municipal Corporation is much simpler

◊ **Control of recruitment** - Labour laws require that a person who has worked for 90 days on a daily wage basis is entitled to an establishment post. This requirement is no longer of any concern under the contract system, so there is no need to monitor the employment records of casual workers, as in the past.

◊ **Reduction of complaints** - Municipal supervisors in contracted wards estimated that there had been a 80 to 90% reduction in complaints from residents, so that their work had become considerably easier.

◊ **Political acceptance** - Municipal councillors expressed approval of the contractor system and wished to see it extended to other parts of the city. Cost savings that reduce the need to increase taxes are always welcomed by politicians.

> *A common labour dispute among sweepers*
>
> *It has often been observed that a sweeper posted permanently to a particular beat (or sweeping unit) claims that it is his right to continue at the same place, resisting attempts to change the location of his working place. In some cities sweepers have made informal arrangements with householders to carry their waste to the storage point or sweep their private premises. The income from such informal arrangements is often considerably more than the wage from the municipality. If a sweeper is ordered to move he may enlist the help of his labour union, and fight to keep his present location.*

A-4.4 DISADVANTAGES OF THE PRIVATE SECTOR SYSTEMS

a) Disadvantages to the Administration

- If the contract system were èxtended to other wards, a situation may arise in which the contractor had sufficient power that he could dictate the terms of the contract and demand an increase in the fees.
- If a proper balance is not maintained between the contract system and the municipal system, a dispute may paralyse the sanitation work.
- If the labour laws are modified, it could become obligatory for the Corporation to absorb the private sector contract sweepers since, by its nature, the work they do is permanent (that is, it is not just meeting a temporary need).

b) Disadvantages relating to supervision

- There may be a lack of flexibility in the contract system. In the past, when there had been an emergency - such as a crash programme to clean an area of the slums and other nuisance points during the plague epidemic - it had been possible to divert municipal sweepers from other areas. Such moves might be difficult if all of the sweepers are working under contracts which do not allow for this kind of flexibility.
- Supervisors cannot instruct the sweepers directly, but must pass requests through the contractor.

c) Disadvantage affecting residents

The only disadvantage appears to be the lack of rapport between the residents and the sweeper working in a particular area. Under the municipal or direct labour system, residents would get to know the sweeper working in the area, and this relationship would assist co-operation and satisfaction in the service. For example, in the past , if there was a complaint related to some other department (such as roads, water, electricity etc.) the sweeper would pass on the complaint to the local ward office. The contractors frequently changed their staff to avoid the legal commitments to pay provident fund and insurance benefits to their staff, and so there was little time for any relationship to be built up between sweepers and residents.

d) Disadvantages to the labourers

- The contractor was required to pay his labourers as per the Minimum Wage Act at a daily rate of Rs 42. In interviews only two of the labourers admitted that they were being paid less than this, but it was possible that the others were told to say that they were being paid the minimum wage, and did so because they were afraid of losing their jobs - if the contractor discovered that they had said this or if the contractor was obliged to face legal action. Perhaps some simple arithmetic is appropriate here:

Contract rate per sweeping unit		Rs 1390	
Monthly pay according to minimum wage (30.4 days/month)	Rs 30.4 x 42	1277	
Balance to pay for supervision and tools and to provide profit		113	or 8%

- There was some evidence that the sweepers were required to purchase the implements they needed for the work from their own salaries.
- There was no security for the labourers, so they were always under the fear of losing their jobs.
- The contract sweepers did not receive the benefits that were given to the municipal workforce, such as quarters, uniforms, medical benefit, travel allowances, and even the obligations for Provident Fund and insurance payments were not being met by the contractors.

A-4.5 DISCUSSION

A permanent sweeper employed by the Municipal Corporation earned about Rs 1800 per month in 1995. In addition to this (s)he was eligible for a number of benefits such as paid leave, medical leave, medical expenses reimbursement, quarters, death and disability benefits, and uniforms. (The total cost of a municipal labourer in Mumbai was estimated in appendix AA-2.1.2 to be Rs 3520 per month.) In contrast, the contractors were being paid about Rs 1390 per month for each labourer, and out of this amount, in addition to paying the sweeper's salary, the contractor was supposed to pay for implements, social insurance, provident fund contributions, and to pay the wages of supervisors (at about Rs 1700 to 2000 per month). Some sources indicated that contract sweepers were being paid at the rate of only Rs 30 to 35 per day, and there was the suggestion that provident fund contributions were made in fictitious names so that the entitled person never received the amount due to him or her.

The Rajkot Municipal Corporation paid its employees through a bank, and it is suggested that contractors be required to do the same so that it would be possible to verify that all relevant laws are being complied with. It would be possible to prevent other abuses by modifying the terms and conditions of the contract. This would lead to an increase in the rate quoted, but it would be of great help to the people who are engaged in this type of work.

An alternative view of this situation is that there was no shortage of workers to do the work of contract sweeping, so such a position must be attractive to an unskilled person in the face of alternatives. This view leads to the conclusion that the labourers who were working for the RMC were being paid too much, and that recruitment should be frozen and no further increments paid until there is some form of parity between the public and private sector. Alternatively, an investigation could be carried out as to how productivity could be raised, perhaps by providing more efficient tools or by a concerted campaign to reduce the depositing of waste on the ground so that daily sweeping in most areas was no longer necessary.

The privatisation experiment of Rajkot Municipal Corporation over its first five years is a success story because satisfactory services have been provided at lower public cost. (Or it could be argued that municipal administrations over a long time had failed to keep the costs of municipal labour within reasonable bounds, and so the failure of one sector led to the success of the other.) A balance needs to be struck between economy and avoiding exploitation, and labour laws should be respected. The RMC system should be replicated after taking new precautions to avoid exploitation.

The subsidy system that encourages housing societies to make their own arrangements for sweeping is an excellent idea since it encourages the housing societies to take responsibility, and the feedback loop for complaints is very small - if residents are unhappy the sweeper hears about it very soon and action can be taken quickly. In such situations supervisors have little to do.

APPENDIX AA-4.1 BUDGET AND STAFFING OF RAJKOT MUNICIPAL CORPORATION

a) Budgetary provision for solid waste management 1995-6

	Lakhs Rs
General Conservancy salary expenditure	550
Equipment, uniforms etc.	7
Special conservancy	
Special conservancy staff salary	65
Equipment, and maintenance of community bins	1.5
Contract base removal of solid waste	30
Contract base cleaning of toilets	5
Housing society grant for sweeping	3
Cleaning of urinals	0.5
	662

b) Conservancy staff

General conservancy	
Medical Officer of Health	1
Deputy Medical Officer of Health	1
Zonal Officer	3
Chief Sanitary Inspector	1
Sanitary Inspector	24
Sanitary Sub-Inspector	20
Peon	35
Sweepers	1554
Daily waged sweeper	142
Part-time daily waged sweeper	580
Establishment clerk	10
	2371
Special conservancy	
Conservancy inspector	1
Clerk	2
Medical supervisor	1
Driver	42
Helper	104
Cleaner	5
Peon	1
	156

APPENDIX AA-4.2 TENDER DOCUMENTS FOR SWEEPING CONTRACTS

RAJKOT MUNICIPAL CORPORATION

(HEALTH BRANCH)

TENDER

Tender fees Rs. 150/-

Sweeping of Roads, Open Drains. etc. in Ward No. 7, 9 and 10. In response to above I/We quote the rates as below for cleaning of Streets as decided by the Corporation, in Ward No. ...., as per the Terms and Conditions attached herewith.

SrNo.	Particulars of work	Ward No.	Monthly Rate For One Street
	Rate for cleaning of 30,000 Sq. Ft. of Areas of Roads, Roads, Gutters, etc. and all types of Cleaning and Collecting the Solid Waste in the Stand (Dust- Bin) as per the Terms and Conditions of this work		

Contractor shall have to submit the following Details:-

1) Registration No. Of The Contractor
2) Provident Fund No.
3) ESI No.
4) Copy of Income-Tax Completion Certificate
5) Experience Certificates
6) Copy of Solvency Certificates
7) Demand Draft amounting to Rs. 4000/- in favour of Rajkot Municipal Corporation, along with the Tender.

Name of the Contractor ....

Address ....

....

Date : ...... / .... / 1995

Place: ....

Signature of Contractor

Administrative Officer
Rajkot Municipal Corporation

Medical Officer of Health
Rajkot Municipal Corporation

RAJKOT MUNICIPAL CORPORATION

HEALTH DEPARTMENT

YEAR 1995-6

Terms and Conditions for Cleaning Works on Contract base in ward No. 7, 9 and 10.

TERMS AND CONDITIONS

1) The Contractor shall have to arrange at its own cost the materials related to cleaning i.e., Box, Brooms, Fan, Bamboo, Trikum, all sizes of shovels, Phenyle, Acid etc. All materials shall have to be provided by the Contractor. The Corporation shall provide B.H.C. Powder and Cost of the B.H.C. Powder will be deducted from the Bill of the Contractor.
2) The Contractor shall have the list of Sweepers.
3) The Sweepers shall be paid their Wages as per minimum Wages and as and when declared by The Labour Department of Government. The Contractor should have Provident Fund Number and E.S.I. Number.
4) The Contractor shall have to maintain, regularly, The Attendance Register and Attendance Card.
5) The Contractor have to get the work done for half day on Holidays declared for the Sweepers, i.e., on Thursdays and Sundays and on Holidays as and when declared or published by the Government.
6) The Contractor shall get done, the work of cleaning of areas as well as cleaning of gutters from each sweeper for not more than 30,000 Sq. Ft. area.
7) Daily, twice a day, cleaning of areas and gutters shall be carried out by the sweeper in the area distributed.
8) The solid waste shall be collected at prescribed places and solid waste box.
9) The Areas of cleaning shall be as decided by the Survey Deptt. of R.M.C.
10) Penalty of Rs. 100/- per day will be imposed for each area if any area is found uncleaned.
11) The Bill Of Sweeper shall be submitted by deducting Rs. 50/- per sweeper those found unattended.
12) The Contractor shall have to get the work done for cleaning on the days on which the Government declares holidays for Festivals and Public Holidays as and when declared by The Government.
13) The Rules and Regulations of Labour Department and the Rules related to Sweepers should be followed fully. The Rules and Regulations are subjected to change from time to time.
14) A daily Report of the daily taken attendance shall be submitted next day at 11.00 a.m. in the Health Department.
15) The Working hours and attendance of sweepers shall from 6.30 in the morning to 10.30 a.m. and from 3.00 p.m. to 6.00 p.m. respectively. The attendance timing for morning and afternoon shall be 6.30 a.m. and 3.00 p.m. to 3.15 p.m.
16) 20% more sweepers can be kept in addition to the total sweepers.
17) If the entrusted cleaning work is not found satisfactory or if not done properly as per the standards, the Contractor will be issued a Notice by the Competent Authority and the Contract will be terminated, as well as the deposit paid by the Contractor will be forfeited.
18) Cleaning of Manholes main gutter, closed gutters, as well as Public Toilets and Public Urinals in the entrusted area shall be carried out regularly.
19) Payment shall be made on submission of bill every month.
20) R.M.C. reserves the right to accept or reject the rates without assigning any reason thereof.
21) The decision and order of the Municipal Commissioner will be final in case any dispute arises.

22) An agreement shall have to be executed within 7 (seven) days and on amount of Rs........../- shall have to be deposited in the Accounts Department of R.M.C. against Security Deposit.

23) The Contractor shall have to arrange to lift the demised Dogs, Pigs, Goat, Cat, etc. whose weight is about 20 kg or below 20 kg.

24) The Competent employee of Corporation will Supervise the daily work and the instructions given by the employee shall have to be followed scrupulously.

25) The place for attendance shall be the respective ward.

26) The Rates shall be quoted for the period of one month for the work in question, and agreement shall be executed for one year on the basis of rates quoted for one month.

27) Earnest money deposit should be paid by way of Demand Draft amounting to Rs ..../- in favour of Rajkot Municipal Corporation and the said Demand Draft should be enclosed alongwith the Tender.

28) The copy of Registration Certificate registered for the respective class, Solvency Certificate, Income-Tax Completion Certificate as well as Experience certificates should be enclosed alongwith Tender.

29) The corporation shall arrange for Wheelbarrows.

Medical Officer of Health
Rajkot Muni. Corporation

APPENDIX AA-4.3 GRANTS TO HOUSING SOCIETIES

GRANT IN AID TO PRIVATE SOCIETIES FOR SWEEPING AND CLEANING OF SURFACE DRAINS

Sr. No.	Name of the co-operative housing society	No. of areas of 30000 sq.ft. to be swept	No. of sweepers to be employed	Amount of grant given by RMC Rs/month
1	Shree Colony	1	1	600
2	Chotunagar	2	2	1200
3	Rel Nagar	1.5	2	900
4	Shanti Niketan	1	1	600
5	Income tax	1	1	600
6	Anjani	0.5	1	300
7	Aviation	0.5	1	300
8	Sijitra Nagar	0.5	1	300
9	Mochinagar	1	1	600
10	Purnakutir	2	2	1200
11	Gunalit	2	2	1200
12	Anupama	1	1	600
13	Nutan	3	3	1600
14	Gramyalaxmi	0.5	1	300

Chapter B-1

Performance of transfer system in Mumbai

by Manfred Scheu, with assistance from
S A Bargir, and K V Ramarao

B-1.1 INTRODUCTION

The centre or main business district of Mumbai is at the southern end of the peninsula, and traffic conditions are very congested during the daytime. From many parts of the city a refuse collection truck could make only one journey to the disposal site in one shift. It follows that, for the sake of economy, the vehicles that make this long and slow journey each day should be carrying the largest possible volume of waste. Large vehicles are not suitable for collecting waste in a congested city centre, so transfer is necessary, transferring waste from the smaller collection vehicles to the large bulk transport vehicles that take the waste to the disposal site. This chapter is concerned with the way this transfer and transport system was working in Mumbai in 1993.

Three different types of vehicles were employed for refuse collection in Central Mumbai:

◊ Compactor trucks, operated and owned by the MCGM, in conjunction with trolley containers. Some compactors were deployed for house-to-house collection.

◊ Dumper-placer trucks, operated and owned by the MCGM, for clearance of large capacity community containers.

◊ Open trucks, mostly operated by private contractors and rented to the MCGM for refuse collection.

All dumper-placers and some compactors delivered refuse to a transfer station at Mahalaxmi where the loads were transferred to large capacity trucks for bulk transport to Deonar dumping ground, some 21 kilometres north-east of Mahalaxmi.

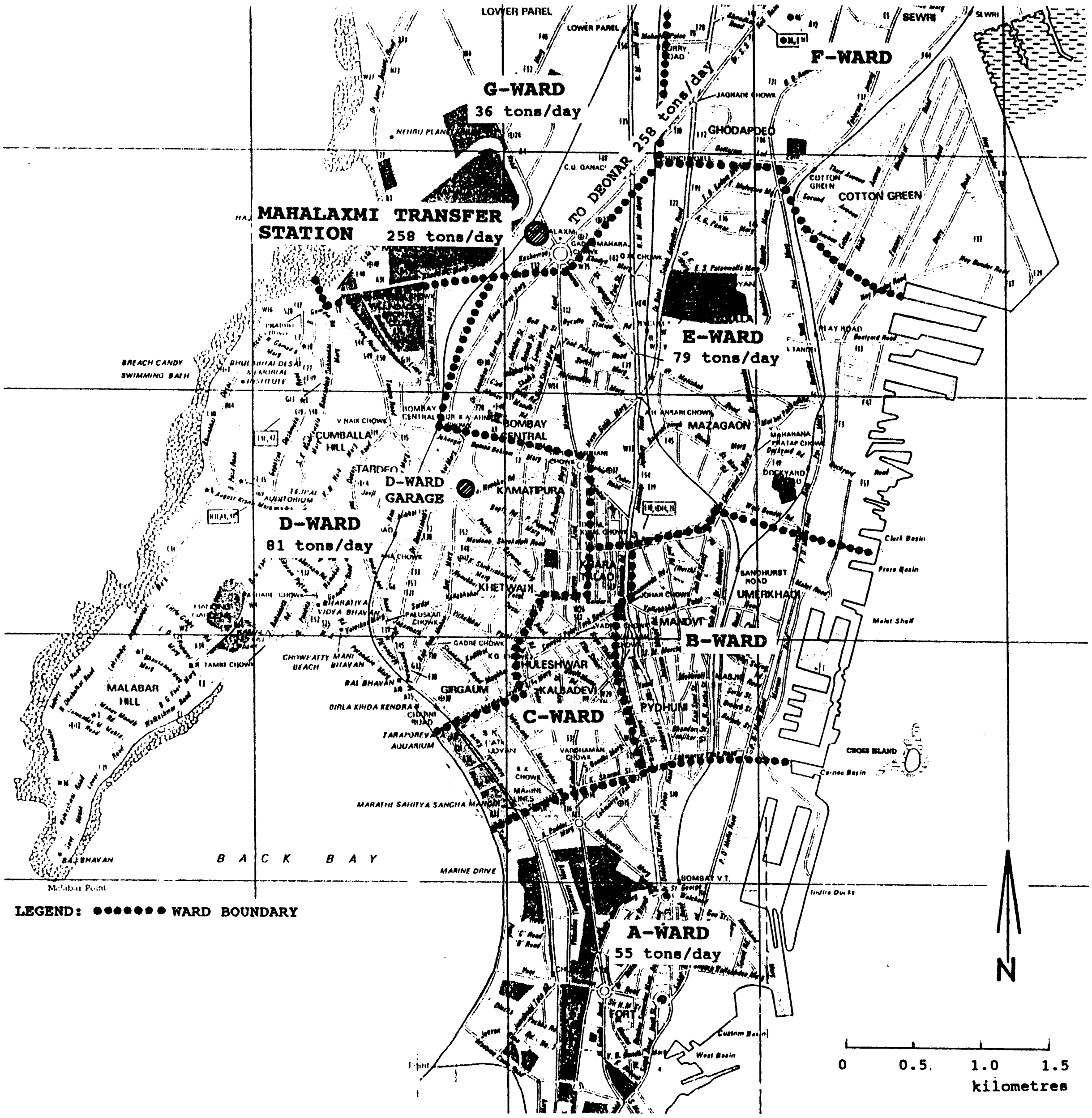
Trucks and drivers were under the Transport Department of the MCGM, and operated, maintained, and repaired through garages of this department. The vehicles were provided to the Conservancy Department on a rental basis and assigned to particular areas. Workers and mukadams of vehicles were under the Conservancy Department and supervision was through motor loader chowkies of this department. (See appendix 1 at the end of the report for explanations of Indian terms.)

Data on operations were obtained from records maintained at the transfer station and by observing operations. This information has been used to estimate costs for primary collection, bulk transport and transfer operations and to estimate total costs of the combined system. In addition, the information has been analysed to suggest possible improvements and to compare costs of alternative arrangements with the present system.

B-1.2 MAHALAXMI TRANSFER STATION

Solid waste transfer at Mahalaxmi has been practised for decades. Transfer is necessary because of the heavy traffic in Central Mumbai and the long distances to disposal sites. Until 1973, a rail transfer system was used to carry refuse from Mahalaxmi to Deonar. Operations were relatively complex because the refuse wagons had to change tracks three times - at Dadar, Kurla and at the junction to the Deonar landfill. With increasing passenger transport the railway became more and more congested and a road transport system had to be introduced in 1976. Mahalaxmi station was modified to allow for refuse transfer to large capacity trucks. The transfer station was extended to its present capacity between 1990 and 1992.

Figure B-1.1 shows the location of the transfer station in relation to other important features. It is clear that a very appropriate location was chosen to accommodate the transfer station - located north of the highly congested city centre, along the road to Deonar, and linked to the road network from the city and to the landfill. The station received waste from four different wards, namely A, D, E and G. Haul distances for primary collection vehicles were usually less than five kilometres, with a maximum of about ten kilometres from the A-South area. Refuse from Wards B and C was mainly collected by compactor trucks which carried their loads directly to Deonar.



Note Values in tons per day refer to solid waste delivered to Mahalaxmi transfer station. In addition most compactor trucks and all private contractors deliver solid waste directly to Deonar landfill site. All waste from Wards B, C, and F is hauled directly to Deonar.

Figure B-1.1: Location map

Based on records maintained at Mahalaxmi (see appendix BB-1.1) it is estimated that about 260 tons of refuse were passing through this station each day.

Table B-1.1 Refuse quantities at Mahalaxmi Transfer Station

Shift	Dumper-placers (a)	Open trucks (b)	Compactors (c)	Total
Morning	86.1 x 1.1 = 95 tons	7.3 x 2.4 = 18 tons	4.7 x 5.0 = 24 tons	137 tons (53%)
Afternoon	65.3 x 1.1 = 72 tons	7.4 x 2.4 = 18 tons	0	90 tons (35%)
Night	27.8 x 1.1 = 31 tons	0	0	31 tons (12%)
Total [tons/day]	179.2 x 1.1 = 198 (77%)	14.7 x 2.4 = 36 (14%)	4.7 x 5.0 = 24 (9%)	258

Notes: Data according to Appendix BB-1.1, one week considered.
(a) Number of trips per shift x estimated average load 1.1 tons per trip
(b) Estimated average load 2.4 tons per trip
(c) Estimated average load 5.0 tons per trip

It is shown that the largest proportion of the refuse was being delivered by dumper-placer vehicles (77%). Open trucks of the MCGM contributed about 14 % and compactor trucks some 9 %. These compactors were exclusively employed for house to house collection (in D-Central) whereas other compactors (those collecting refuse from trolley containers) as well as open trucks of contractors carried their loads directly to Deonar landfill. (The reason why the compactors collecting house-to house went to the transfer station was probably that this collection process took longer than other methods and so there was insufficient time to go to the disposal site.)

The transfer station consists of a very substantial structure, comprising a platform with a length of about 140 metres. Up to 14 bulk refuse carriers (BRC) may be parked at either side of the platform and the elevated part (width 18.5 metres) provides sufficient space for manoeuvring of primary collection vehicles during unloading to either side of the station. Slopes of the ramp are moderate (about 6.0 %) and easy to climb for full vehicles. Space is no problem and only one side of the platform was being utilised, while still leaving sufficient space between BRCs to allow individual vehicles to move in or out. In addition, parts of the platform were used to store old containers.

The organisation of transfer operations was closely linked to the primary and bulk transfer system. Primary collection by dumper-placer vehicles and refuse transfer by bulk refuse carriers are discussed in sections B-1.3 and B-1.4 respectively, before the transfer system at Mahalaxmi is analysed in section B-1.5.

B-1.3 PRIMARY COLLECTION BY DUMPER-PLACER VEHICLES

Dumper-placer trucks are designed to load, carry and unload a single container (capacity about 4 m^3). This type of vehicle has been employed in Central Mumbai since about 1987. At the time of the study, 18 dumper-placer vehicles were being used to deliver refuse to the transfer station.

a) Dumper-placer trucks

Most of the dumper-placer trucks were maintained at D-Ward Garage. Out of 17 vehicles, 14 were in service and 3 were kept as standby. This is equal to a standby factor of 1.21 (17 / 14), which seems adequate for this type of vehicle. Two different chassis were employed -TATA (6 trucks, purchased 1987) and Ashok Leyland (11 trucks, purchased 1991). [Maintenance records for this type of vehicle are shown in appendix DD-1.2.]

Maintenance and repair of the vehicles seemed to cause few problems. According to information obtained at D-Ward Garage, the hydraulic systems were very reliable and had not failed so far. Some problems with the power takeoff units of the Leyland vehicles had been experienced. It is clear from Appendix BB-1.1 that the number of trucks in service was very constant throughout the week and that only in one out of 286 trips (morning shift, A-South, 30.11.95) were operations short of a single vehicle.

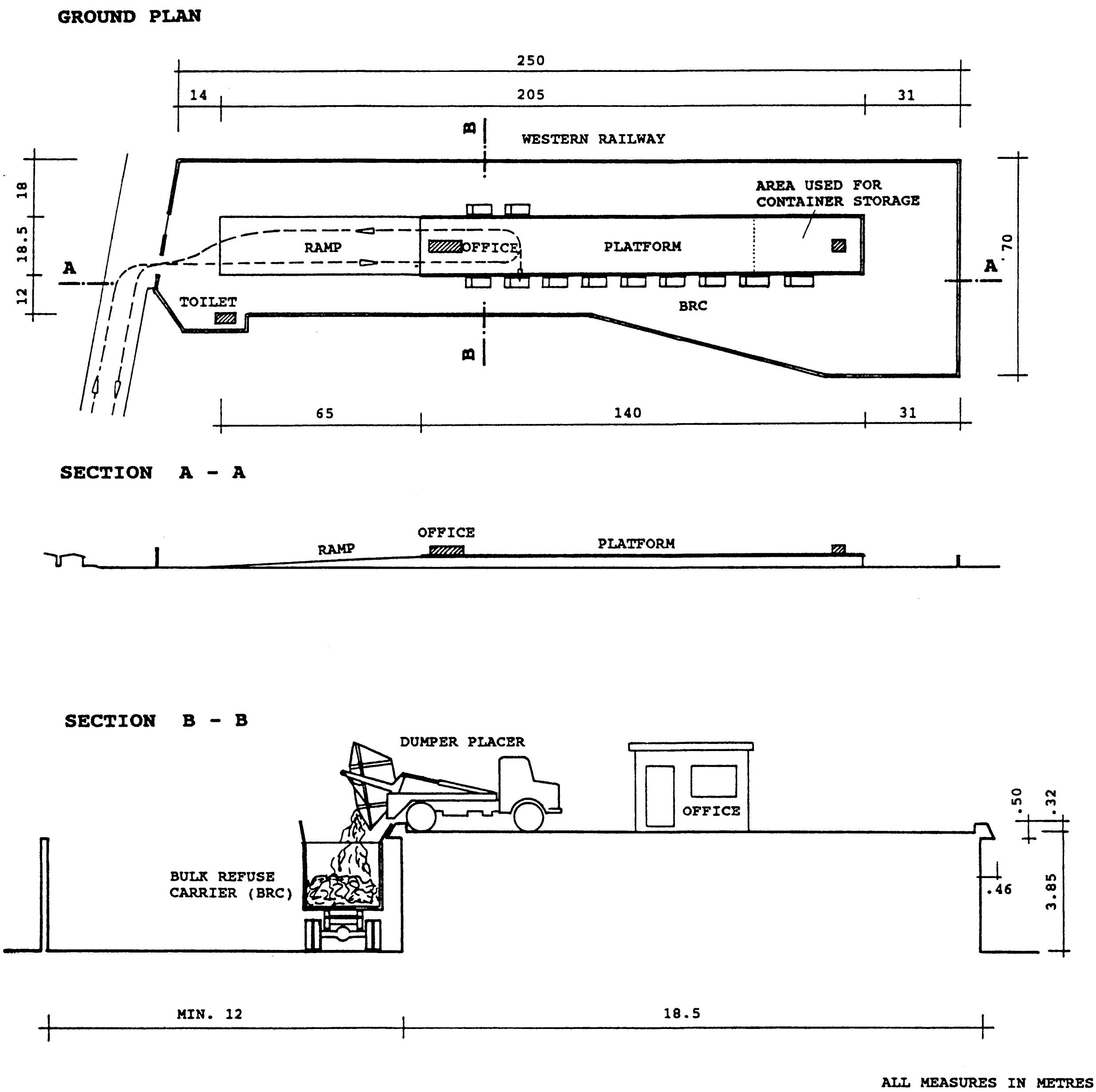


Figure B-1.2: Layout of Mahalaxmi Transfer Station

Dumper-placers were originally designed to collect containers from construction sites, handling heavy material like debris. Refuse is much lighter and therefore only a fraction of the permissible payload can be utilised if this type of vehicle is employed for solid waste collection.

Table B-1.2 indicates that even very heavy refuse with a density of 0.5 tons/m^3 (e.g. during monsoon) would only allow about 60 % of the vehicle's permissible payload to be utilised, and that common loads are well below 50 % of the payload capacity. This leads to relatively high vehicle costs because a large chassis and engine are used to collect small quantities of refuse. Therefore long range transport by dumper-placer vehicles is ruled out on grounds of economics and, in the case of Mumbai City, refuse transfer is a basic requirement.

Table B-1.2 Payload capacity of dumper-placer vehicles

Permissible GVW	tons	12.0	(note 1)	
Chassis and engine weight	tons	6.5	(note 2)	
Body weight	tons	1.5	(note 3)	
Container weight	tons	0.5	(note 3)	
Permissible payload	tons	3.5		
Container capacity	m^3	4.0		
Refuse density	tons/ m^3	0.3 - 0.5		
Actual payload	tons	1.2 - 2.0		

Notes

1. TATA chassis 1210 (GVW 12 tons, 100 HP). GVW according to weights written on cab 15.7 tons. This seems too high and is not considered
2. Empty weight written on cab of TATA chassis type 1210. It is assumed that the body weight is not included.
3. Estimated values

Suggestions: One option for improving the performance of dumper-placer vehicles would be to increase the container capacity by about 50% from about 4.0 m^3 to at least 6.0 m^3. However, major alterations of the body would be required and containers with higher sides are probably not desirable.
It may be more appropriate to use a smaller chassis to carry a similar body arrangement. For instance, the new (1993) TATA 0608 chassis (GVW 06 tons, 80 HP) could be employed for this purpose.
Alternatively. roll-off container trucks may be more suitable because this type of vehicle is capable of carrying larger containers (since the container can be as wide as the chassis, whereas the width of a dumper-placer container is limited by the space between the lifting arms). Market research is suggested to find out whether suitable vehicles are available in India.

b) Organisation and records

As with other vehicles of the MCGM, records of dumper-placer trucks were being maintained by the Garage (on behalf of the Transport Department) and drivers were obliged to keep log sheets requiring the following information

Name - licence plate - working area - containers attended - time out - time in - /mileage

Personnel at the D-Ward Garage were well aware of typical vehicle operational data such as average mileage, working hours and fuel consumption.

All trucks stopped at the motor loader chowki at the beginning and end of each shift and log books were stamped by the Junior Overseer (Conservancy Department). He was responsible for organising the clearance of containers. Locations to be attended were written on the back of the log sheets at the beginning of each shift and confirmed by the mukadam of the vehicle after clearance of individual containers. Log sheets were further used by the depot attendant at Mahalaxmi transfer station for keeping the tip register.

Suggestion: It is proposed to record additional information regarding the degree of filling of containers (e.g. 50%, 75%, 100%) on log sheets. This would help to adjust the clearance frequency of individual locations according to requirements. Provided that this suggestion is followed the log sheet system seems appropriate for controlling and monitoring operations. Further investigations are suggested regarding organisation, supervision and control of container clearance by the Conservancy Department.

c) Crew size

Crews of dumper-placer vehicles consisted of one driver, one attendant to assist the driver (e.g. fitting of lifting chains), and one mukadam to guide the vehicle and to supervise container clearance according to daily orders of the conservancy department.
In addition, six workers were assigned to each vehicle and responsible for cleaning the locations of the containers in the vehicle's area of operation. Depending on the haul distance, three to seven containers were cleared per shift, hence one to two workers were employed per container. There was not sufficient space in the vehicle's cabin to accommodate the workers and so they remained in the area and were supervised by the mukadam during container pick-up operations.
It has been mentioned that the crew size was based on the Union's policy that six motor loaders should be employed per truck, regardless of the type of vehicle. As a result, a simple and manually loaded truck was being operated by the same number of loaders as a dumper-placer vehicle equipped with a fully mechanised loading system.

Suggestions: It does not seem appropriate to assign workers for cleaning container locations to the vehicle. More than one person per container was employed full-time for cleaning. This is considered excessive and not justifiable. Street sweepers, who were also assigned to the localities, should be in charge of cleaning container locations (similar to the trolley container system) and mukadams based in the locality should be in charge of supervising labour. Further investigations are suggested to study whether existing sweepers are capable of taking over additional work or whether some additional sweepers are required to keep container locations tidy.

Another arrangement, which appears very promising, was observed in D-Ward - some container locations were handed over to rag pickers for cleaning. The rag-pickers were given an exclusive right to collect recyclable material from the containers and, in return, they were required to keep the locations in a clean condition. This proved successful and the locations were being kept very tidy at no cost. It is therefore suggested that this arrangement be extended to as many areas as possible. This would allow a very significant reduction in the costs of the dumper-placer system [see section B-1.3 (g) below].

In addition, there seems to be no need to assign one mukadam to each vehicle. The driver and his assistant would be sufficient to carry out the orders obtained from the J.O. at the motor loader chowki.

d) Working time of vehicle crews

Time records of a dumper-placer vehicle (morning shift, dumper-placer MH-X) are analysed in Appendix BB-1.2.1. The vehicle was employed in A-North Ward and carried four container loads to Mahalaxmi transfer station. Results are summarised in table B-1.3.

Table B-1-3 Time requirements of dumper-placer MH-X

Time, a.m.	Duration of trip, minutes				Time a.m.	Working time
Garage	1st trip	2nd trip	3rd trip	4th trip	Garage	(hours, min.)
7.06	38 (a)	43	50	89 (b)	10.58	3 h 51 m

Notes Time requirements are average values, based on records obtained at Mahalaxmi Transfer Station (tip register), one week considered (30.11.93 to 06.12.93).
(a) including time to report at A-Ward motor loader chowki.
(b) including time to report at A-Ward motor loader chowki and tea break.

The data indicate that the time to complete one round trip is constantly increasing from 38 minutes (first trip) to ultimately 89 minutes (last trip). To some extent this may be due to increasing traffic in Central Mumbai. In addition, the last trip includes about 30 minutes for a tea break. The results also show that the average working time of the crew was slightly less than 4 hours. Considering that the morning shift was from 6.00 am to 2.00 pm (8 hours), the crew were spending less than 50 % of the shift on the job.

Appendix BB-1.2.1 also shows time values which are based on measurements made when following the vehicle on 8 December. Perhaps because they were being observed, the crew spent more than five hours to complete their usual daily programme (four round trips). One reason for the longer period was that the vehicle was being driven extremely slowly, whereas the vehicle's mileage did not vary significantly from a normal day. When arriving at the motor loader chowki at 11.46 am, the building was already locked and the vehicle had to leave without clearance from the J.O..

However, only one vehicle was studied like this in more detail, and results may be not representative of other cases. Therefore additional data from the tip register at Mahalaxmi Transfer Station were analysed in Appendix BB-1.2.2. Results are summarised below:

Morning shift:	82 out of 100 trips between 7.25 and 11.00 am (less than 4 hours, official shift until 2.00 pm)
Afternoon shift:	69 out of 75 trips between 2.25 pm and 6.00 pm (less than 4 hours, official shift until 10.00 pm)
Night shift:	26 out of 28 trips between 10.30 pm and 2.00 am (less than 4 hours, official shift until 6.00 am).

The data indicate the bulk of the work (87 %), whether in the morning, afternoon or night shift, is completed within the first four hours of the shift.

***Suggestions*:** Based on the data obtained the performance of vehicles could be increased by a factor of about two by extending the working time of crews to 8 hours (including tea breaks). However, this is probably not realistic. Working for six hours per shift may be acceptable if, in return, crews are permitted to leave the job earlier. Shifts could be adjusted to 6 hours as follows:

Morning shift	6.30 am to	12.30 pm.
Afternoon shift	12.30 pm to	6.30 pm.
Evening shift	6.30 pm to	0.30 am.

Drivers would have to be asked to attend 10 minutes earlier in order to leave the garage on time.

If this suggestion were followed, the performance of the system would increase by about 50 %. In addition, shorter shifts would lead to more balanced vehicle arrivals at Mahalaxmi as shown in Appendix BB-1.2.3. This is of particular importance when planning bulk transfer operations and will be further discussed in section B-1.4 (b).

e) Comparative performance of different shifts

Records presented in appendix BB-1.1 are employed in table B-1.4 to compare the performance of dumper-placer vehicles in the morning, afternoon and night shifts.

Table B-1.4 Comparative performance of different shifts

	morning shift		afternoon shift		night shift	
	vehicles	trips	vehicles	trips	vehicles	trips
total number	17.9	86.1	17.0	65.3	6.0	27.8
trips per vehicle	4.8		3.8		4.6	

The data indicate that the afternoon shift achieves about one trip less than the morning and night shift.

Suggestions: Although time did not allow a study of the afternoon arrangements, it seems not acceptable that the performance is 20 % less than the morning and night shift. Further investigations are suggested to evaluate and adjust afternoon assignments. Either more containers should be assigned to each crew or, if the number of filled containers would not allow an increase in the total workload, the number of afternoon crews should be reduced.

Table B-1.5 provides an idea regarding what could be achieved if a 50% increase in workload were assigned to the crews and if all shifts were to perform an equal number of trips.

Table B-1.5 Alternative assignment of vehicles and crews

		morning shift		afternoon shift		night shift	
Present	Trips per vehicle	4.8		3.8		4.6	
	Total no. of trips	86.1		65.3		27.8	
	Total no. of vehicles		**17.9**		**17.0**		**6.0**
Proposed	Trips per vehicle	7.2		7.2		7.2	
	Total no. of trips	86.1		65.3		27.8	
	Total no. of vehicles		**12.0**		**9.1**		**3.9**

Table B-1.5 indicates that the proposed system would allow:

- ◊ a reduction in the number of vehicles from 18 to 12.
- ◊ a reduction in the number of crews from 41 to 25.

f) Container design

The capacity of containers varied between 4 and 4.5 m^3, depending on who had manufactured the container. The containers were fabricated from welded mild steel sheet. Corrosion was severe and containers were phased out after about five years in service.

Most containers were covered by a metal sheet and lids as shown in figure B-1.3.

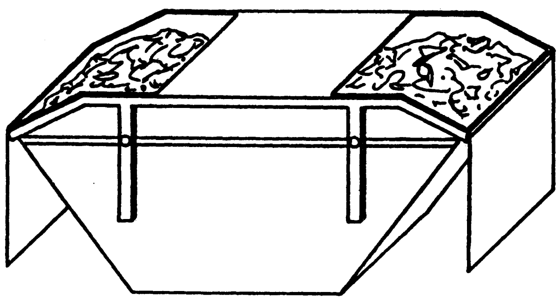


Figure B-1.3 Container with cover and lids
[Note Dumper-placer containers are also discussed in Chapter C-2]

It was observed that this arrangement causes significant problems during operations, in particular:

◊ Most lids had been removed because they were damaged during transfer operations. Only two containers were observed that were still equipped with lids, and in both cases the lids were left open during transport. When following different vehicles littering was significant and even large items - such as a cane basket - were blown off at normal speed.

◊ The covers caused severe problems during unloading. In nine out of twelve unloading operations that were observed, refuse became wedged in the containers during tipping. Different emptying techniques had been developed by the drivers. One was to drive eight times back and forth against the concrete upstand, with the container still lifted, until the container was finally empty. Other drivers lowered the container back onto the truck, drove forward, stopped suddenly to loosen the blockage, then drove back to the edge and repeated the tipping procedure. Up to three of these operations were required before containers were empty. Not only do these blockages cause delays, but they also lead to excessive wear of vehicles and containers.

◊ It was further observed that a void develops below the cover while the containers were being filled, so that the container capacity was not fully utilised. In addition, once the container was almost full, people placed refuse on top of the cover and it was necessary for an attendant to remove this material before the container could be taken away. A wooden stick was employed to fill the void and obtain sufficient space for the material from the cover. This procedure caused long waiting periods for the vehicles and should be avoided.

Suggestions: It is generally considered doubtful whether suitable solutions for covering this type of container can be developed. In theory, close fitting lids would reduce fly breeding and bad smells. However, this only applies if lids are kept closed. Considering the size of dumper-placer containers it is hardly possible to design lids which are durable and yet light enough to be easy to open and close, so that the public, in particular women and children, would be able to open and close them conveniently.

Therefore the only reasonable purpose for covers is to prevent littering during container transport. In addition to the risk that covers remain open during transport (which seemed to be the practice during the observations) there are much simpler means of avoiding littering. It is proposed that all covers should be removed and that simple nets should be used to cover the waste during transport. Four hooks, one at each corner of a container, may be used together with rubber tubes to fix and remove the net quickly.

Regarding corrosion of containers, it is suggested that some containers should be manufactured, on a pilot basis, from galvanised or corrosion-resistant steel. In particular CorTen type steel, if available in India, may allow a doubling of the life span of containers. Special rods are required for welding such steels and the cost of using this steel would be about 30% more than if standard mild steel were used. (The subject of dumper-placer container design is discussed further in chapter C-2.)

g) Costs of the dumper-placers system

Data and information provided in this chapter are used to calculate unit costs of the present system and to compare costs with two modified systems (Proposals A and B). The proposals are based on the following assumptions:

◊ The crew size of vehicles will be reduced to one driver and one assistant. Both proposals operate without motor loaders and mukadam [see B-1.3.(c) above].

◊ Proposal A includes the provisions that two more street sweepers per vehicle crew will be assigned to the collection area to clean container locations, and that mukadams of districts become responsible for the supervision of these personnel.

◊ In Proposal B, containers are handed over to rag pickers who are given the exclusive right to collect recyclables and who, in return, are expected to keep the locations in a tidy condition.

◊ Additional work will be assigned to the crews to increase their performance by 50 %, and, in return, shifts are reduced to 6 hours (as mentioned in B-1.3(d) above).

◊ Vehicles of all shifts will achieve a similar performance [see B-3.(e) above].

Costs of the different systems are estimated in Appendix BB-1.2.4 and summarised in table B-1.6.

Table B-1.6 Costs for primary collection by dumper-placers

		Present system	[%]	**Proposal A**	[%]	**Proposal B**	[%]
Capital costs - vehicles	Rs/yr	1,58,000	[8.4]	1,58, 000	[13.1]	1,58,000	[17.9]
Capital costs - containers	Rs/yr	28,000	[1.5]	42,000	[3.5]	42,000	[4.8]
Operation and maintenance	Rs/yr	2,50,000	[13.3]	3,74,000	[30.9]	3,74,000	[42.3]
Labour costs per vehicle	Rs/yr	14,40,000	[76.8]	6,35,000	[52.5]	3,09,000	[35.0]
Costs per vehicle	Rs/yr	18,76,000	[100]	12,09,000	[100]	8,83,000	[100]
Performance per vehicle	t/yr	4,015		5,980		5,980	
Costs per ton	Rs/t	467		202		148	
Total daily costs (a)	**Rs/d**	**92,500**		**40,000**		**29,300**	

Note (a) Based on table B-1.1, about 198 tons per day collected by dumper-placers.

The results indicate that only 43 % of the present costs are required to operate Proposal A and that this could be further reduced to 32 % if container locations were cleaned by rag pickers. Potential cost savings for the MCGM are between Rs 52,500 per day (Proposal A) and Rs 63,000 per day (Proposal B).

It has been suggested that making an arrangement with rag-pickers could lead to large numbers of them claiming to be employees of the Municipality and therefore having the right to all the benefits of this position -pay, leave, pensions etc., thereby adding a huge expense to the wages bill of the MCGM which is already very high. There are a number of possible arrangements that could be made with rag-pickers, such as treating them as contractors or employing them for limited periods of time. It is obviously important to consult with experts in employment legislation and to keep the trade unions informed so that such consequences do not arise.

Another issue that might need to be checked is whether there is already an informal "franchise" system in operation among rag-pickers to allocate rights for picking over specific accumulations of waste. If the right of access to a particular dumper-placer container has already been allocated by an informal system - a system set up by rag-pickers and not by the Municipal Corporation - it may be difficult for the Municipality to give the rights to that container as an incentive for someone else.

***Suggestions*:** Considering the present collection costs, the dumper-placer system is probably more expensive than using compactors in conjunction with trolley bins. This is primarily due to the excessive labour costs which could be reduced without negative impacts on the service. Negotiations with vehicle crews and labour unions are suggested to evaluate acceptable conditions to implement the proposals. If negotiations fail, privatisation of the dumper-placer system should be seriously considered. This privatisation could take many forms, such as hiring drivers, leasing vehicles or even selling the vehicle fleet to private contractors.

B-1.4 BULK TRANSFER OF SOLID WASTE

Bulk transfer vehicles are primarily employed to reduce refuse transport costs to a minimum and to increase the performance of primary collection vehicles. Large capacity trucks, operated without motor loaders, allow for low cost haulage of refuse over long distances.

a) Comments on bulk transfer vehicles

Two different types of vehicles - namely rigid body bulk carriers and semi-trailer type vehicles - are employed for bulk transfer of refuse from Mahalaxmi to Deonar disposal site. The haul distance is about 21 kilometres (one way) and vehicles operate three shifts per day.

Bulk refuse carriers (BRC) have a body capacity of 22.5 m^3 and are capable of carrying up to 15 tons per load (GVW about 26.0 tons, empty weight 11.1 tons). However, when one of these trucks was weighed, the load was found to be only 9.9 tons. Loads were probably higher when the loads contained high proportions of construction debris or wet organic waste, and perhaps when the bulk carriers were carrying waste that had previously be compressed in a compactor truck. They were equipped with an ejector plate and hydraulic cylinders to open the tail gate. The top of the body was open but could be partially closed during transport since they had two flaps, fitted to the side walls and operated by one hydraulic cylinder each.

Figures B-1.4 and B-1.5 show the two types of bulk carrier that were in use.

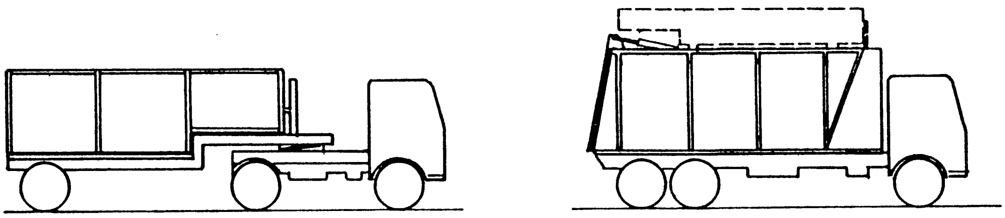


Figure B-1.4 Kirla semi-trailer ***Bulk refuse carrier***

Figure B-1.5 Bulk refuse carrier at Mahalaxmi

Fifteen of these vehicles were maintained at Worli Garage, some 3 kilometres north-west of the transfer station. Between eight and ten were available during the morning shift, up to eight in the afternoon and three during the night shift. Maintenance problems with the hydraulic systems were quoted as the main reason for poor availability.

In addition, two Kirla semi-trailer units, each consisting of two trailers and one engine, were employed for bulk transfer of refuse. The trailer capacity was about 18.5 m^3 and could carry up to 10 tons. Each trailer was equipped with a tipping device and the tailgate was opened manually. One unit was permanently parked at Mahalaxmi to act as a standby. According to information obtained at Mahalaxmi, the Kirla company had stopped producing this type of vehicle.

In addition to the vehicles already mentioned, open trucks with high side walls were also employed during the morning shift (see appendix BB-1.3.1).

Suggestions: Further investigations are suggested to evaluate maintenance and repair problems with BRCs and to propose ways of improving the availability of these vehicles.
A larger body with a capacity of 28 to 30 m^3 would be desirable in order to utilise the permitted payload of the trucks more effectively. Although redesign of the rigid body trucks might be possible (i.e. longer chassis plus larger body), semi-trailer or roll-off type container systems would be more suitable and should be preferred in case this design is available in India. They avoid the need for the power unit and the driver to wait during loading so releasing more time for transport operations. In addition, these systems are more flexible because one engine unit is able to handle several body units. Market research is suggested to find out whether semi-trailer or roll-off type container systems are available in India (with a body capacity of about 30 m^3, and a GVW of about 26 tons). Another aspect that should not be forgotten is that, during the day time, the trucks spend most of their time in very congested traffic, and drivers may need special training before they feel confident to take such large vehicles onto busy and narrow streets.

b) Performance of the bulk transfer system

At the time of the study, transfer vehicles were performing only one trip per eight hour shift. Records from log books were used in appendix BB-1.3.1 to analyse time requirements for solid waste transfer. The results are summarised in table B-1.7.

Table B-1.7 Time requirements for bulk transfer of refuse

Elapsed time in minutes					
Waiting at transfer station	Driving to disposal site	Unloading at disposal site	Driving back to Worli garage	Time for one round trip	Working time
157	65	12	78	155	302

Note: These are average values for nine vehicles, taken from appendix BB-1.3.1

Results indicate that the waiting period at the transfer station was longer than the round trip transport time to the disposal site. Considering that only about 2½ hours were required for one round trip to Deonar it should be possible to carry out two round trips per vehicle in each shift. However, the waiting period at Mahalaxmi would have to be reduced to provide more time for transport operations. Two different options may be realistic:

1. Semi-trailer or roll-off type vehicles could be employed instead of rigid body BRCs. Containers or trailers would remain at the station for loading while the power units would carry a full load to the disposal site. On returning to the transfer station, a filled trailer or container is replaced by an empty one from the vehicle which leaves again for the disposal site. This would be the most elegant solution and will be discussed in more detail below (Scenario B).
2. Alternatively, existing BRC trucks may be employed in a similar way. Empty trucks remain parked at the transfer station for loading while full vehicles drive to the landfill. Coming back, drivers

change to full trucks, which have been loaded during their absence, and leave for a second trip to the landfill. As will be shown below (Scenario A) this option is not easy to organise and requires more vehicles than the semi-trailer or container option.

As has already been mentioned in section B-1.3.(d), bulk transfer operations are far easier to organise if primary collection vehicles deliver waste at a uniform rate to the transfer station. Appendix BB-1.2.3 shows that improvements to the primary collection system would allow vehicle arrivals at Mahalaxmi to be balanced to a large extent.

***Suggestions*:** Two alternative options for bulk transfer are set out in Appendix BB-1.3.2 (scenario A) and BB-1.3.3 (scenario B) respectively. Both options assume that the primary collection system will be improved as proposed in section B-1.3 and that the duration of shifts is reduced to 6 hours. Existing BRC trucks are deployed in scenario A, whereas scenario B is based on a roll-off or semi-trailer system. Vehicle and manpower requirements are compiled in table B-1.8.

Table B-1.8 Comparative manpower and vehicle requirements (bulk transfer)

	Duration of shifts	Required number of crews			Required number of trucks		
		service	standby	total	service	standby	total
Existing	8 hours	24	1	25	13	3	16
Scenario A	6 hours	12	2	14	9	3	12
Scenario B	6 hours	12	1	13	7	2	9

Table B-1.8 shows that both scenarios would allow a substantial reduction in the number of crews and trucks. The organisation of scenario A is more complex (see appendix BB-1.3.2) than scenario B and higher standby resources are recommended. Both options assume that vehicle crews will accept different working hours as shown in appendix BB-1.3.4, while the working time of drivers and attendants, although performing two trips per shift, would be only about 6 hours. To allow for some flexibility the operations are scheduled for teams of two crews in both cases (see Appendix BB-1.3.2 and BB-1.3.3).

It should be further mentioned that both suggestions require significantly less parking space at the transfer station. Whereas the existing system involved parking of up to twelve vehicles, this could be reduced to maximum of seven vehicles (scenario A) and to five containers or trailers in case of scenario B.

c) Costs of bulk transfer

Suggestions discussed in the previous section are employed to estimate and compare costs of bulk transfer. Calculations are presented in appendix BB-1.3.5 and summarised in table B-1.9 below.

Table B-1.9 Solid waste transfer costs

		Present system	[%]	**Scenario A**	[%]	**Scenario B**	[%]
Capital costs - vehicle	Rs/yr	209 000	[29.3]	230 000	[28.7]	262 000	[26.8]
Operation and maintenance	Rs/yr	229 000	[32.1]	341 000	[42.5]	439 000	[44.9]
Labour costs per vehicle	Rs/yr	275 000	[38.6]	231 000	[28.8]	276 000	[28.3]
Total costs per vehicle	Rs/yr	713 000	[100]	802 000	[100]	977 000	[100]
Performance per vehicle	t/yr	7 250		10 500		13 400	
Costs per ton	Rs/t	98		76		73	
Total daily costs (a)	**Rs/d**	**25 400**		**19 800**		**18 700**	

Note (a) According to table B-1.1, about 258 tons are delivered to Mahalaxmi transfer station each day

Results indicate that bulk transfer costs could be reduced by 22% (scenario A) and 26% (scenario B). Compared with primary collection the potential savings are less significant. It should be noted that real costs of the existing system were high for a number of reasons such as the very poor availability of BRC vehicles and the utilisation of small capacity open trucks. Unit costs of scenario B may vary slightly depending on the purchase price of the semi-trailer or roll-off container system. However, this system is likely to remain cheaper than scenario A and it would certainly be easier to manage and to operate.

Suggestions: It is proposed to introduce a second round trip for BRC vehicles and to adjust the working hours of the primary collection system as discussed in section B-1.3.(d).

In addition, BRC vehicles should be gradually replaced by roll-off or semi-trailer type vehicles. Market research is proposed to find out whether such vehicles are available in India. It is further suggested to employ larger capacity vehicles with a capacity of about 30 m^3 (see section B-3.1).

Both systems - scenarios A and B - could operate in parallel for a period of time until the entire BRC fleet is replaced.

Involvement of the private sector should be considered if MCGM drivers were not willing to accept alternative arrangements. A variety of arrangements should be considered, including hiring drivers, leasing vehicles and selling the vehicle fleet to private contractors. It might be best if a single contractor were responsible for transporting all the waste from the transfer station; the contract period should be at least five years to allow him to replace the fleet by roll-off or semi-trailer vehicles.

B-1.5 TRANSFER OPERATIONS AT MAHALAXMI

Results and suggestions regarding the primary collection and bulk transfer system are combined in this section in order to analyse the operations at Mahalaxmi and to suggest which possible improvements should be examined further.

a) Utilisation of Mahalaxmi Transfer Station

Figure B-1.2 above shows that the design of the transfer station at Mahalaxmi provides sufficient space for parking and loading up to 28 BRC vehicles at one time. The greatest space requirements for bulk transfer operations are as follows:

- Existing system: 12 BRC vehicles at 6.30 am.
- Scenario A: 7 BRC vehicles (8.00 to 8.30 am).
- Scenario B: 5 trailers or containers (8.00 to 8.30 am).

Hence, less than half of the structure would be sufficient to operate the present system and only a small proportion would be needed if alternative operations were introduced. Reasons for the large size of the facility include that the transfer station was designed to handle all waste from the island city, including waste from compactor trucks. However, less waste than this was passing through the site and only four compactor trucks, which are employed for time-consuming house-to-house collection, deliver waste to Mahalaxmi, and the remaining compactors, which operate in conjunction with trolley bins, deliver refuse directly to the Deonar disposal site. It was mentioned "off the record" that compactor crews, supported by powerful unions, were generally not willing to load more than one truck per shift, even if loading in conjunction with trolley bins takes less than three hours.

Suggestions: The transfer station is poorly utilised and capable of handling at least twice the present throughput. Efforts to increase its utilisation may include the following suggestions:

◊ Compactor trucks should be obliged to carry two loads per shift to the transfer station whenever possible. One BRC is able to carry at least two compactor loads. Hence, assuming two round trips of bulk transfer vehicles per shift, one additional truck would be sufficient to serve two compactor trucks. This would allow a 50% reduction in the number of compactor vehicles and crews with significant cost savings. Further negotiations with MCGM drivers and crews are suggested before operation of compactors by private contractors is considered.

◊ Transfer services should be offered to all private contractors operating in the island city. Charges should be set to provide some surplus and could be levied according to the amount of refuse delivered to Mahalaxmi.

b) Records

Three tip register books were maintained at Mahalaxmi, one for each shift. Records were neat, complete and kept in a very reliable manner. They were compiled by the depot attendant, who observed the vehicles from his office while they were unloading at the station. Records in the tip register comprise the following:

No. - Ward - Licence plate - Name of driver - Time in - Time out - Total trips

The number of total trips per vehicle was calculated towards the end of each shift and records were summarised daily as set out below:

Ward - Total - Vehicle loads - Number of D-P vehicles - Number of D-P loads

Filled register books were handed to the Cleansing Department (D Ward). However, the employees at Mahalaxmi were not informed whether any analysis of data was carried out and never received any feedback on their records.

***Suggestions*:** Although a good system of record keeping had been developed, the data seemed to disappear in the Cleansing Department without further analysis.
It is suggested that one officer in the Cleansing Department should be made responsible for analysing data, monitoring the system and co-ordinating operations with the Transport Department. Discussions with personnel at Mahalaxmi may help to improve the system and to motivate personnel to work more effectively. This will be of particular importance during implementation of improvement measures.

c) Staffing at the transfer station

Staffing at Mahalaxmi transfer station was as shown in table B-1.10.

Table B-1.10 Staffing at Mahalaxmi Transfer Station

	Morning shift 6.00 to 14.00	Afternoon shift 14.00 to 22.00	Night shift 22.00 to 6.00
Cleaner [levelling BRC loads, cleaning]	8	5	2
Mukadam [supervision of labour]	1	1	0
Junior overseer [responsible]	1	1	0
Depot attendant [record keeping]	1	1	1
Inspector of Transport Department		1 (from 10.00 to 17.00)	

The assignment of labour and supervisory staff was not studied in detail. Further investigations would be required to establish the number of employees required to operate the transfer station.

***Suggestions*:** Further investigations are suggested regarding the assignment of labour as detailed below:

◊ Cleaners: Only about two vehicles per hour were loaded at one time during peak periods. Hence, at least four cleaners were assigned to each truck for levelling the load and cleaning. Further investigations are proposed to evaluate whether the number of cleaners could be reduced.

◊ Supervision: It seems to be doubtful whether one mukadam and one junior overseer are both required at the station. One person, probably a J.O., may be sufficient to supervise transfer operations.

◊ Inspector: The tasks of the inspector were unclear and should be evaluated. As already outlined in B-1.5.(b) above, one officer of the Cleansing Department should be responsible for analysing records, monitoring the system and to co-ordinating operations with the Transport Department.

It is further proposed to adjust the working hours at the transfer station to co-ordinate with the primary collection system, from eight hours at present to six hours. This could be used as an incentive if the number of cleaners were reduced.

d) Operation costs of the transfer station

Operation costs at Mahalaxmi primarily consist of labour costs as shown in table B-1.11.

Table B-1.11 Operation costs of the transfer station

	Labourers	Mukadams	J. Overseer	Attendant	Inspector	TOTAL
Number	15	2	2	3	1	23
Costs / capita Rs/d	170	190	210	170	210	
Total Rs/d	2 550	380	420	510	210	4 070

Note: Labour costs are estimated in appendix AA-2.1

Considering that about 258 tons of solid waste are handled at Mahalaxmi each day the unit costs for transfer operations are about:

Rs 4,070 per day / 258 tons per day = Rs 15.8 per ton.

This includes neither investment costs for the facility nor the very high value of land in Central Mumbai (about 3.5 acres are occupied by the station). Hence, total costs for solid waste transfer are likely to be considerably higher.

***Suggestions*:** There are basically two options to reduce costs for transfer operations:

◊ Better utilisation by increasing the amount of waste handled at the transfer station [see B-1.5(a) above]

◊ Reduction of labour employed to operate the transfer station [see B-1.5(c) above].

Both options should be investigated and may be combined if appropriate.

B-1.6 SUMMARY AND CONCLUSIONS

Suggestions outlined in this chapter are summarised and combined in this section.

a) Combined unit costs for refuse collection

Estimated costs of the system components - primary collection, bulk transfer and transfer station - are combined in table B-1.12. Costs of the present system are compared with alternative arrangements according to suggestions outlined in this chapter.

Table B-1.12 Combined unit costs for refuse collection

	Primary collection	Bulk transfer	Transfer station	TOTAL [Rs/ton]
Existing system	467	98	16	581
Proposal A & scenario A	202	76	16	294
Proposal B & scenario B	148	73	16	237

Note:: Proposals A and B refer to the primary collection system.
Scenarios A and B refer to the bulk transfer system.

These estimates suggest that it should be possible to operate the system at less than half of the present costs. The main potential saving lies with the primary collection system where costs could be reduced by more than 2/3.

It should be mentioned that additional measures are considered possible to reduce costs still further, in particular:

◊ A smaller chassis size for primary collection vehicles would allow more effective utilisation of the vehicles and reduce capital and operation costs.

◊ Larger capacity bodies for bulk transfer would allow a further reduction in transfer costs.

◊ Better utilisation of the transfer station would reduce costs for transfer operations.

In addition, the involvement of the private sector would be likely to reduce costs considerably.

b) Primary collection

- **Records**: Log sheets of dumper-placer vehicles should include filling rates of containers to monitor and adjust the clearance frequency according to requirements.
- **Crew size**: The assignment of motor loaders to dumper-placer vehicles for cleaning container locations is considered not appropriate. Street sweepers, who are already assigned to the localities, should be made responsible for cleaning container locations (proposal A). A less costly approach consists of handing over responsibility for cleaning around containers to rag-pickers in return for an exclusive right to collect recyclable material from the containers (proposal B).
- In addition, there seems to be no need to assign one **mukadam** to each vehicle. A driver and his assistant should be sufficient to operate vehicles according the orders of the Conservancy Department.
- **Performance**: The performance of vehicles should be increased by 50% by extending the working time of crews from 4 hours at present to 6 hours. It is further suggested that the duration of each shift should be reduced to six hours (morning 6.30 to 12.30, afternoon 12.30 to 18.30, night 18.30 to 0.30). In addition, afternoon crews should be obliged to work as much as their colleagues on the morning shift.

  If these suggestions are followed the number of vehicles could be reduced from the existing 18 to 12, and the number of crews from the current 41 to 25.
- Container design: It is proposed to remove all covers of containers and to employ simple nets to avoid littering during transport. Corrosion resistant steel may be considered on a pilot scale to increase the life span of the containers.

c) Bulk transfer

Waiting periods of BRC vehicles at the station should be reduced to allow the introduction of two round trips to the disposal site per shift.

1- In scenario A, the existing BRC trucks are deployed and empty trucks remain parked at the station for loading while full vehicles drive to the landfill. Coming back, drivers change to full trucks, which have been loaded during their absence, and leave for a second trip to the landfill.

   This would allow a reduction in the number of vehicles in service from the existing 13 to 9, and the number of crews from 24 to 12.

2- Semi-trailer or roll-off type vehicles are employed in scenario B to improve the performance of vehicles. Containers or trailers remain at the station for loading while trucks carry a full load to the landfill. When coming back, a filled trailer or container is replaced by the empty one from the vehicle, which then leaves again to the disposal site.

   This would allow to reduce the number of vehicles in service from the existing 13 to 7 and the number of crews from 24 to 12.

It is recommended that the arrangements described as scenario A should be introduced as soon as possible and that the BRC vehicles should subsequently be gradually replaced by roll-off or semi-trailer type vehicles (if such vehicles are available in India).

d) Transfer operations

◊ **Utilisation**: The transfer station is poorly utilised and capable of handling at least twice the present load. Compactor trucks should be obliged to carry two loads per shift to the transfer station and transfer services should be offered to private contractors on a payment basis.

◊ **Records**: One officer in the Cleansing Department should be in charge of analysing data, to monitor the system and to co-ordinate operations with the Transport Department.

◊ **Staffing**: Further investigations are suggested to evaluate whether the number of labourers at the transfer station could be reduced.

APPENDIX BB-1.1 SOLID WASTE TRANSFER OPERATIONS AT MAHALAXMI

Records are based on the tip register at Mahalaxmi transfer station

MORNING	30.11.93		01.12.93		02.12.93		03.12.93		04.12.93		05.12.93		06.12.93		AVERAGE
SHIFT	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P only
A-South	2/08 *		3/10		3/09		3/12		3/12		3/11		3/10		2.9/10.3
A-North	3/12		3/12		3/12		3/12		3/10		3/12		3/11		3.0/11.6
D-East	2/11	1/1 o	2/10	1/2 o	2/09	1/2 o	2/10	1/1 o	2/11	1/2 o	2/10	1/2 o	2/09	1/1 o	2.0/10.0
D-Central	1/07	1/1 o	1/07	1/1 o	1/07	1/1 o	1/04		1/05	1/1 o	1/06	1/1 o	1/06		1.0/6.9
D-West	1/04	4/4 c	1/05	4/4 c	1/02	4/4 c	1/04	4/4 c	1/05	3/3 c	1/05	4/4 c	1/05	4/4 c	1.0/4.3
E-East	2/11		2/09		2/12		2/11		2/11		2/12		2/10		2.0/9.1
E-Central	3/15	2/4 o	3/16	2/4 o	3/17	2/4 o	3/12	2/3 o	3/15	2/3 o	3/17	2/4 o	3/15	2/4 o	3.0/15.3
G-South	3/19		3/19		3/19		3/19		3/19		3/16		3/14		3.0/17.9
LGP		1/1 o						1/1 o		1/1 o					
Offal		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o	
BV		2/2 c		1/1 c		1/1 c		1/1 c		1/1 c					
D-P	17/87		18/88		18/87		18/84		18/88		18/89		18/80		17.9/86.1
Trucks		6/8		5/8		5/8		5/6		6/8		5/8		4/6	5.1/7.3
Compactors		6/6		5/5		5/5		5/5		4/4		4/4		4/4	4.7/4.7
TOTAL	29/101		28/101		28/100		28/95		28/100		27/101		26/90		

Notes

* 2/08 means 2 trucks, making a total of 8 trips per shift.

D-P = Dumper-placer truck   Other trucks: o = open truck;   c compactor truck

LGP = Waste from Lowground pumping station; Offal = fish and chicken waste from markets; BV = breakdown vehicle

SOLID WASTE TRANSFER OPERATIONS AT MAHALAXMI (continued)

AFTERNOON	30.11.93		01.12.93		02.12.93		03.12.93		04.12.93		05.12.93		07.12.93		AVERAGE
SHIFT	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P only
A-South	3/06		3/06		3/06		3/06		3/06		3/06		3/07		3.0/6.1
A-North	3/09		3/09		3/09		3/09		3/08		3/08		3/09		3.0/8.7
D-East	1/04	2/2 o	1/05	2/2 o	1/04		1/04	2/2 o	1/04	2/2 o	1/04	2/2 o	1/04	2/2 o	1.0/4.1
D-Central	1/06		1/06		1/04		1/06		1/04		1/04		1/04		1.0/4.9
D-West	1/04	1/1 o	1/05		1/04	1/1 o	1/02	1/1 o	1/03	2/3 o	1/03	2/2 o	1/07	1/1 o	1.0/4.0
E-East	2/10		2/09		2/09		2/10		2/09		2/08		2/09		2.0/9.1
E-Central	13/12	2/2 o	3/14	2/4 o	3/14	2/2 o	3/14	2/2 o	3/14	3/3 o	3/13	2/4 o	3/15	2/4 o	3.0/13.7
G-South	3/15		3/15		3/14		3/15		3/15		3/13		3/15		3.0/14.6
LGP										2/2 o					
Offal		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o		1/1 0	
BV															
D-P	17/66		17/69		17/64		17/66		17/63		17/59				17.0/65.2
Trucks		6/06		5/07		4/04		6/06		10/11		7/09		7/09	6.4/7.4
TOTAL	23/72		22/76		21/68		23/72		27/74		24/68		24/79		

Note: 06.12.93 was a bank holiday so there was no afternoon shift; data from 07.12.93 are considered instead

NIGHT SHIFT - only dumper-placer trucks in use

	30.11.93	01.12.93	02.12.93	03.12.93	04.12.93	05.12.93	06.12.93	AVERAGE
A-South	2/09	2/08	2/09	2/08	2/08	2/09	1/04	2.0 / 8.5
A-North	1/05	1/05	1/05	1/05	1/04	1/03	1/03	1.0 / 4.5
D-West	2/10	2/10	2/10	2/10	2/09	2/10	2/05	2.0 / 9.8
E-Central	1/05	1/05	1/05	1/05	1/05	1/05	1/04	1.0 / 5.0
TOTAL	6/29	6/28	6/29	6/28	6/26	6/27	6/16	6.0 / 27.8

Note: 06.12.93 was a bank holiday, so it was not considered in the average values

APPENDIX BB-1.2 PRIMARY COLLECTION BY DUMPER-PLACER VEHICLES

BB-1.2.1 Time requirements of dumper placer MH-X

Times days	30.11.93	01.12.93	02.12.93	03.12.93	04.12.93	05.12.93	06.12.93	Average	08.12.93 **
Leaving D Ward garage	7.00	6.55	7.05	7.15	7.15	7.05	7.25	7.06 *	7.23
Interval, minutes	15	15	15	15	15	15	15		14
Reporting to chowki	7.15	7.10	7.20	7.30	7.30	7.20	7.40		7.39
Interval, minutes	30	20	15	15	15	25	40	23	36
First transfer	7.45	7.30	7.35	7.45	7.45	7.45	8.30		8.15
Duration of trip, minutes (1)	40	40	40	50	55	35	40	43	66
Second transfer	8.25	8.10	8.15	8.35	8.40	8.20	9.10		9.19
Duration of trip, minutes	60	50	55	40	45	50	85	50 *	76
Third transfer	9.25	9.00	9.10	9.15	9.25	9.10	10.35		10.35
Duration of trip, minutes	80	100	95	115	75	70		89 *	115
Fourth transfer	10.45	10.40	10.45	11.10	10.40	10.20			12.30
Interval, minutes	15	15	15	15	15	15	15		15
Arrival at D Ward garage	11.00	10.55	11.00	11.25	10.55	10.35	10.50	10.58 *	12.45
WORKING HOURS	4.00'	4.00'	3.55'	4.10'	3.40'	3.30	3.25	3.51' *	5.22'
DISTANCE PER SHIFT km	42	67	47	55	55	63	39	55 *	61

Notes (1) Estimated time. * 06.12.93 being a bank holiday, was not included in average values

: Data for morning shift, based on records obtained at Mahalaxmi Transfer Station (tip register), dumper-placer MH-X, Ward A-North.

** Data at 08.12.93 are based on measurements when following the truck (same vehicle, same shift).

BB-1.2.2 Present vehicle arrivals at Mahalaxmi

(01.12.1993)

MORNING SHIFT (6.00 to 14.00) Period	Vehicles	AFTERNOON SHIFT (14.00 to 22.00) Period	Vehicles	NIGHT SHIFT (22.00 to 6.00) Period	Vehicles
7.25 to 8.00	11	14.25 to 15.00	10	22.30 to 23.00	5
8.00 to 8.30	17	15.00 to 15.30	15	23.00 to 23.30	4
8.30 to 9.00	9	15.30 to 16.00	9	23.30 to 24.00	4
9.00 to 9.30	15	16.00 to 16.30	12	0.00 to 0.30	3
9.30 to 10.00	11	16.30 to 17.00	12	0.30 to 1.00	5
10.00 to 10.30	9	17.00 to 17.30	6	1.00 to 1.30	2
10.30 to 11.00	10	17.30 to 18.00	5	1.30 to 2.00	3
11.00 to 11.30	6	18.00 to 18.30	4	2.00 to 2.30	1
11.30 to 12.00	3	18.30 to 18.55	2	2.30 to 3.00	1
12.00 to 12.30	4				
12.30 to 13.00	3				
13.00 to 13.30	2				
Total morning 100		Total afternoon 75		Total night 28	

NOTE: Data based on the tip register, Mahalaxmi Transfer Station.

BB-1.2.3 Scenario of vehicle arrivals at Mahalaxmi

ASSUMPTIONS: Shifts will be reduced from 8 hours at present to 6 hours.
The performance of crews will increase by about 50 %.
All shifts achieve an equal number of trips per vehicle.

NOTE: Vehicle arrivals at the transfer station are approximate. Monitoring of actual operations would be required to determine more accurate values.

MORNING SHIFT (6.30 to 12.30) 12 crews instead of 18 Period	Vehicles	AFTERNOON SHIFT (12.30 to 18.30) 9 crews instead of 17 Period	Vehicles	NIGHT SHIFT (18.30 to 00.30) 4 crews instead of 6 Period	Vehicles
6.55 to 7.30	8	12.55 to 13.30	6	19.00 to 19.30	2
7.30 to 8.00	11	13.30 to 14.00	8	19.30 to 20.00	3
8.00 to 8.30	11	14.00 to 14.30	8	20.00 to 20.30	4
8.30 to 9.00	11	14.30 to 15.00	8	20.30 to 21.00	4
9.00 to 9.30	10	15.00 to 15.30	8	21.00 to 21.30	4
9.30 to 10.00	8	15.30 to 16.00	8	21.30 to 22.00	3
10.00 to 10.30	8	16.00 to 16.30	8	22.00 to 22.30	3
10.30 to 11.00	10	16.30 to 17.00	7	22.30 to 23.00	2
11.00 to 11.30	10	17.00 to 17.30	6	23.00 to 23.30	2
11.30 to 12.00	8	17.30 to 18.00	5	23.30 to 24.00	1
12.00 to 12.30	5	18.00 to 18.30	3	24.00 to 00.30	0
Total morning	100	Total afternoon	75	Total night	28

BB-1.2.4 Costs for primary collection by dumper-placer vehicles

PRESENT SYSTEM:

Crew: 1 driver, 1 attendant, 1 mukadam, 6 motor loaders.
Working time of crew about four hours per shift.
Three shifts, based on table B-1.5 about 2.27 shifts per vehicle daily (18 morning + 17 afternoon + 6 night / 18 vehicles).
Average performance of vehicles according to table B-1.5 about 10.0 round trips per day (86.1 morning + 65.3 afternoon + 27.8 night / 18 vehicles).

PROPOSAL A:

Reduced crew: 1 driver, 1 attendant, no motor loaders, 2 additional sweepers per shift to clean container locations.
Working time of crew 6 hours per shift.
Three shifts, based on table B-1.5 about 2.08 shifts per vehicle daily (12 morning + 9 afternoon + 4 night / 12 vehicles).
Average performance of vehicles according to table B-1.5 about 14.9 trips per day (86.1 morning + 65.3 afternoon + 27.8 night / 12 vehicles).

PROPOSAL B:

Reduced crew: 1 driver, 1 attendant, cleaning of container locations by rag pickers.
Working time of crew 6 hours per shift, 2.08 shifts per vehicle daily, performance as proposal A.

	Present	Proposal A	Proposal B
VEHICLE CAPITAL COSTS			
Unit price of vehicle [Rs]	6,00,000.-	6,00,000.-	6,00,000.-
Unit price including standby (factor of 1.2) [Rs]	7,20,000.-	7,20,000.-	7,20,000.-
Depreciation (life span 10 years) [Rs/yr]	72,000.-	72,000.-	72,000.-
Interest on capital (12 % per annum) [Rs/yr]	86,400.-	86,400.-	86,400.-
TOTAL CAPITAL COSTS PER VEHICLE [Rs/yr]	1,58,000.-	1,58,000.-	1,58,000.-
CONTAINER CAPITAL COSTS			
Unit price of container [Rs]	17,500.-	17,500.-	17,500.-
Round trips per vehicle, day (average, 3 shifts)	10.0	14.9	14.9
Containers per vehicle (average clearance twice daily)	5.0	7.5	7.5
Container capital costs per vehicle [Rs]	87,500.-	1,31,000.-	1,31,000.-
Depreciation (life span 5 years) [Rs/yr]	17,500.-	26,300.-	26,300.-
Interest on capital (12 % per annum) [Rs/yr]	10,500.-	15,800.-	15,800.-
TOTAL CAPITAL COSTS CONTAINERS [Rs/yr]	28,000.-	42,000.-	42,000.-
OPERATION AND MAINTENANCE COSTS			
Mileage per round trip [km]	15	15	15
Round trips per vehicle, day	10.0	14.9	14.9
Mileage per day [km/d]	150	224	224
Fuel cost per year (0.3 l/km, 6.65 Rs/l, 365 d) [Rs/yr]	1,09,000.-	1,63,000.-	1,63,000.-
Maintenance and repair (estimated 2.5 Rs/km) [Rs/yr]	1,37,000.-	2,04,000.-	2,04,000.-
Container maintenance (5 % of capital costs, year) [Rs/yr]	4,400.-	6,600.-	6,600.-
TOTAL OPERATION AND MAINTENANCE COSTS [Rs/yr]	2,50,000.-	3,74,000.-	3,74,000.-
LABOUR COSTS (1)			
Driver [Rs/shift]	1 x 200 = 200.-	1 x 200 = 200.-	1 x 200 = 200.-
Attendant [Rs/shift]	1 x 170 = 170.-	1 x 170 = 170.-	1 x 170 = 170.-
Loaders [Rs/shift]	6 x 170 = 1,020.-	2 x 170 = 340.-	0
Mukadam [Rs/shift]	1 x 190 = 190.-	1/4 x 190 = 50.-	0
Total labour costs [Rs/shift]	1,580.-	760.-	370.-
Shifts per vehicle, day	2.27	2.08	2.08
Labour costs per year [Rs/yr]	13,10,000.-	5,77,000.-	2,81,000.-
Management & Admin (10 % of labour costs) [Rs/yr]	131,000.-	58,000.-	28,000.-
TOTAL LABOUR COSTS [Rs/yr]	14,40,000.-	6,35,000.-	3,09,000.-
COSTS PER VEHICLE [Rs/yr]	18,76,000.-	12,09,000.-	8,83,000.-
PERFORMANCE (trips/d x 1.1 tons/trip x 365 d) [tons/yr]	4,015	5,980	5,980
COSTS PER TON [Rs/ton]	467.-	202.-	148.-

(1) Labour costs according to Appendix AA-2.1.

APPENDIX BB-1.3 BULK TRANSFER OPERATIONS

BB-1.3.1 Time requirements for bulk transfer of refuse

Table shows clock time
and interval in minutes between each clock time - intervals are shown in [ ]
MTS in Mahalaxmi transfer station

Departure W. Garage		Report at M.T.S.		Departure from M.T.S.		Arrival at Deonar		Departure from Deonar		Arrival W.Garage
6.30	[10]	6.40	[100]	8.20	60'	9.20	[10]	9.30	[70]	10.40
6.30	[10]	6.40	[120]	8.40	[70]	9.50	[10]	10.00	[110]	11.50
6.35	[10]	6.45	[110]	8.35	[65]	9.40	[10]	9.50	[75]	11.05
6.35	[10]	6.45	[135]	9.00	[70]	10.10	[20]	10.30	[90]	12.00
6.40	[10]	6.50	[145]	9.15	[75]	10.30	[15]	10.45	[70]	11.55
6.40	[10]	6.50	[180]	9.50	[70]	11.00	[10]	11.10	[80]	12.30
6.45	[10]	6.55	[200]	10.15	[65]	11.20	[10]	11.30	ignored	18.00
6.45	[10]	6.55	[225]	10.40	[50]	11.30	[10]	11.40	[65]	12.45
7.05	[10]	7.15	[195]	10.30	[60]	11.30	[10]	11.40	[65]	12.45

Average period 2h 37' waiting at transfer station.

Average time per round trip	1h 05'	+	12'	+	1h 18'	=	2h 35'
Distance and speed	21 km 19 km/h				24 km 18 km/h		
Own observations (08.12.93)	1h 30'		10'		1h 50'	=	3h 30'

NOTE: Data based on the log sheets of drivers, Worli Garage.

Observations at Mahalaxmi transfer station (08.12.1993)

8.10 am: 8 BRC at station, loading.
9.15 am: 4 BRC at station, one empty; two open trucks, empty; one Kirla trailer, empty.
10.35 am: 1 BRC at station, full; 3 open trucks, empty.
12.25 am: one open truck, full.

BB-1.3.2 Scenario A for bulk transport of refuse

ASSUMPTIONS: BRC vehicles perform two trips per shift.
Drivers are allowed to change vehicles at the transfer station.
"Primary" column indicates number of loaded vehicles arriving in that period

PERIOD	PRIMARY	BULK TRANSPORT TO LANDFILL (BRC number 1 to 9)
06.55-07.30	8	(1 and 2 parked, loading / 7 and 8 parked / 9 standby)
07.30-08.00	11	3 arrives 7.45, leaves with 1 at 8.00, back MTS 10.30.
		4 arrives 7.45, leaves with 2 at 8.00, back MTS 10.30.
08.00-08.30	11	(3 and 4 parked, loading / 7 and 8 parked)
08.30-09.00	11	5 arrives 8.30, leaves with 3 at 8.45, back MTS 11.15.
		6 arrives 8.30, leaves with 4 at 8.45, back MTS 11.15.
09.00-09.30	10	(5 and 6 parked, loading / 7 and 8 parked)
09.30-10.00	8	crew arrives 9.30, leaves with 5 at 9.45, back MTS 12.15.
		crew arrives 9.30, leaves with 6 at 9.45, back MTS 12.15.
		(7 and 8 parked, loading)
10.00-10.30	8	(7 and 8 parked, loading)
10.30-11.00	10	1 back 10.30, leaves with 7 at 10.45, back Garage 13.25.
		2 back 10.30, leaves with 8 at 10.45, back Garage 13.25.
11.00-11.30	10+	(1 and 2 parked, loading)
11.30-12.00	8+	3 back 11.15, leaves with 1 at 11.30, back Garage 14.10.
		4 back 11.15, leaves with 2 at 11.30, back Garage 14.10.
12.00-12.30	5	(3 and 4 parked, loading)
		5 back 12.15, leaves with 3* at 12.30, back Garage 15.10.
-----------------		6 back 12.15, leaves with 4* at 12.30, back Garage 15.10.
12.55-13.30	6	(5 and 6 parked, loading)
13.30-14.00	8	(5 and 6 parked, loading)
14.00-14.30	8	7 arrives 14.00, leaves with 5 at 14.15, back MTS 16.45.
		8 arrives 14.00, leaves with 6 at 14.15, back MTS 16.45.
14.30-15.00	8	(7 and 8 parked, loading)
15.00-15.30	8	1 arrives 15.15, leaves with 7 at 15.30, back MTS 18.00.
		2 arrives 15.15, leaves with 8 at 15.30, back MTS 18.00.
15.30-16.00	8	(1 and 2 parked, loading)
16.00-16.30	8	(1 and 2 parked, loading)
16.30-17.00	7	5 back 16.45, leaves with 1 at 17.00, back Garage 19.40.
		6 back 16.45, leaves with 2 at 17.00, back Garage 19.40.
17.00-17.30	6	(5 and 6 parked, loading)
17.30-18.00	5	(5 and 6 parked, loading)
18.00-18.30	3	7 back 18.00, leaves with 5* at 18.15, back Garage 20.55.
-----------------		8 back 18.00, leaves with 6* at 18.15, back Garage 20.55.
19.00-19.30	2	(7 and 8 parked, loading)
19.30-20.00	3	(7 and 8 parked, loading)
20.00-20.30	4	(7 and 8 parked, loading)
20.30-21.00	4	(7 and 8 parked, loading)
21.00-21.30	4	1 arrives 21.00, leaves with 7 at 21.15, back MTS 23.45.
		2 arrives 21.00, leaves with 8 at 21.15, back MTS 23.45.
21.30-22.00	3	(1 and 2 parked, loading)
22.00-22.30	3	(1 and 2 parked, loading)
22.30-23.00	2	(1 and 2 parked, loading)
23.00-23.30	2	(1 and 2 parked, loading)
23.30-24.00	1	7 back 23.45, leaves with 1* at 24.00, back MTS 02.30.
		8 back 23.45, leaves with 2* at 24.00, back MTS 02.30.
24.00-00.30	0	(7 and 8 parked)
		(1 back at MTS 2.30, parked)
		(2 back at MTS 2.30, parked)

+ Primary collection vehicles include 4 compactor trucks.
* In case one of the vehicles is not full, standby BRC 9 could be emptied.

BB-1.3.3 Scenario B for bulk transport of refuse

ASSUMPTIONS: A new semitrailer or roll-off container system will be employed for bulk transfer . Vehicles perform two trips per shift.
"Primary" column indicates number of loaded vehicles arriving in that period

PERIOD	PRIMARY	BULK TRANSPORT TO LANDFILL (vehicles number 1 to 7)
06.55-07.30	8	(two empty trailers at station, vehicle 7 standby)
07.30-08.00	11	1 arrives 7.45, leaves at 8.00, back at MTS 10.30.
		2 arrives 7.45, leaves at 8.00, back at MTS 10.30.
08.00-08.30	11	(two empty trailers at station, one standby)
08.30-09.00	11	3 arrives 8.30, leaves at 8.45, back at MTS 11.15.
		4 arrives 8.30, leaves at 8.45, back at MTS 11.15.
09.00-09.30	10	(two empty trailers at station, one standby)
09.30-10.00	8	5 arrives 9.30, leaves at 9.45, back at MTS 12.15.
		6 arrives 9.30, leaves at 9.45, back at MTS 12.15.
10.00-10.30	8	(two empty trailers at station, one standby)
10.30-11.00	10	1 back at 10.30, leaves at 10.45, back at Garage 13.25.
		2 back at 10.30, leaves at 10.45, back at Garage 13.25.
11.00-11.30	10+	(two empty trailers at station, one standby)
11.30-12.00	8+	3 back at 11.15, leaves at 11.30, back at Garage 14.10.
		4 back at 11.15, leaves at 11.30, back at Garage 14.10.
12.00-12.30	5	(two empty trailers at station, one standby)
		5 back at 12.15, leaves at 12.30*, back at Garage 15.10.
-----------------		6 back at 12.15, leaves at 12.30*, back at Garage 15.10.
12.55-13.30	6	(two empty trailers at station, one standby)
13.30-14.00	8	(two empty trailers at station, one standby)
14.00-14.30	8	1 arrives 14.00, leaves at 14.15, back at MTS 16.45.
		2 arrives 14.00, leaves at 14.15, back at MTS 16.45.
14.30-15.00	8	(two empty trailers at station, one standby)
15.00-15.30	8	3 arrives 15.15, leaves at 15.30, back at MTS 18.00.
		4 arrives 15.15, leaves at 15.30, back at MTS 18.00.
15.30-16.00	8	(two empty trailers at station, one standby)
16.00-16.30	8	(two empty trailers at station, one standby)
16.30-17.00	7	1 back at 16.45, leaves at 17.00, back at Garage 19.40.
		2 back at 16.45, leaves at 17.00, back at Garage 19.40.
17.00-17.30	6	(two empty trailers at station, one standby)
17.30-18.00	5	(two empty trailers at station, one standby)
18.00-18.30	3	3 back at 18.00, leaves at 18.15*, back at Garage 20.55.
-----------------		4 back at 18.00, leaves at 18.15*, back at Garage 20.55.
19.00-19.30	2	(two empty trailers at station, one standby)
19.30-20.00	3	(two empty trailers at station, one standby)
20.00-20.30	4	(two empty trailers at station, one standby)
20.30-21.00	4	(two empty trailers at station, one standby)
21.00-21.30	4	5 arrives 21.00, leaves at 21.15, back at MTS 23.45.
		6 arrives 21.00, leaves at 21.15, back at MTS 23.45.
21.30-22.00	3	(two empty trailers at station, one standby)
22.00-22.30	3	(two empty trailers at station, one standby)
22.30-23.00	2	(two empty trailers at station, one standby)
23.00-23.30	2	(two empty trailers at station, one standby)
23.30-24.00	1	5 back at 23.45, leaves at 24.00*, back at Garage 02.40.
		6 back at 23.45, leaves at 24.00*, back at Garage 02.40.
24.00-00.30	0	(two empty trailers at station, one standby)

+ Primary collection vehicles include 4 compactor trucks.
* In case one of the trailers is not full, the standby trailer could be emptied.

BB-1.3.4 **Working hours of crews** (Scenario A)

	CREW NUMBER		WORKING HOURS clock time	duration	TRIPS/SHIFT
Standby morning		M-1:	7.30 to 13.30	6 h 00'	up to 1
Morning	M-2 &	M-3:	7.30 to 13.25	5 h 55'	2 x 2 = 4
Morning	M-4 &	M-5:	8.15 to 14.10	5 h 55'	2 x 2 = 4
Morning	M-6 &	M-7:	9.15 to 15.10	5 h 55'	2 x 2 = 4
Standby afternoon		A-1:	13.45 to 19.45	6 h 00'	up to 1
Afternoon	A-2 &	A-3:	13.45 to 19.40	5 h 55'	2 x 2 = 4
Afternoon	A-4 &	A-5:	15.00 to 20.55	5 h 55'	2 x 2 = 4
Night	N-1 &	N-2:	20.45 to 02.30	5 h 45'	2 x 2 = 4
TOTAL	14 crews				up to 26

Notes: Arrangements for Scenario B are similar but without a standby crew in the afternoon (total 13 crews, up to 25 trips per day).
M, A and N refer to morning, afternoon and night shifts respectively

BB-1.3.5 Cost comparison for bulk transport of refuse

PRESENT SYSTEM: Calculations assume that bulk transfer is exclusively by BRC type vehicles. One crew, consisting of 1 driver and 1 attendant, performs one trip per shift as follows: Morning 13 trips / 13 crews; afternoon 8 trips / 8 crews; night 3 trips / 3 crews. The number of required vehicles in service is 13. 16 vehicles are considered (standby factor 1.23). This assumes that the present availability of vehicles will be improved.

SCENARIO A: It is assumed that three equal shifts of 6 hours will be introduced and that drivers perform two trips per shift (see Appendix BB-1.3.2) as follows: Morning 13 trips / 7 crews; afternoon 9 trips / 5 crews; night 4 trips / 2 crews. The number of required vehicles in service is 9; a total of 12 vehicles are considered (standby factor 1.33). This includes one standby vehicle directly at the station, as well as two standby crews, who perform two extra trips per day (on average).

SCENARIO B: Arrangements as for scenario A, but utilizing semi-trailer or roll-off container systems with a capacity similar to the present BRC vehicles (see Appendix BB-1.3.3): Morning 13 trips with 7 crews; afternoon 8 trips with 4 crews; night 4 trips with 2 crews. The number of required vehicles in service is 7; in addition 2 trailers or containers are required, so in total 9 vehicles are considered (standby factor 1.29). This includes one standby vehicle, which is permanently parked at the station, as well as one standby crew, who perform one extra trip per day (on average). It is assumed that capital costs for the trailer or container system are 20 % higher than the capital costs of the present BRC vehicles.

	Present	Scenario A	Scenario B
VEHICLE CAPITAL COSTS			
Unit price of vehicle [Rs]	7,70,000.-	7,70,000.-	9,24,000.-
Standby factor (vehicle number / vehicles in service)	1.23	1.33	1.29
Unit price including standby (factor 1.25) [Rs]	9,47,000.-	10,24,000.-	11,92,000.-
Depreciation (life span 10 years) [Rs/yr]	94,700.-	1,02,400.-	119,000.-
Interest on capital (12 % per annum) [Rs/yr]	1,14,000.-	1,22,900.-	1,43,000.-
TOTAL CAPITAL COSTS PER VEHICLE [Rs/yr]	2,09,000.-	2,30,000.-	2,62,000.-
OPERATION AND MAINTENANCE COSTS			
Mileage per round trip [km]	50	50	50
Total number of trips per day / number of vehicles	24 / 13	26 / 9	25 / 7
Round trips per vehicle, day	1.85	2.89	3.57
Mileage per vehicle, day [km/d]	93	145	179
Fuel per vehicle (0.45 l/km, 6.65 Rs/l, 365 d) [Rs/yr]	1,02,000.-	1,58,000.-	1,95,000.-
Maintenance per vehicle (estimated 3.75 Rs/km) [Rs/yr]	127,000.-	1,83,000.-	2,44,000.-
TOTAL O & M COSTS PER VEHICLE [Rs/yr]	2,29,000.-	3,41,000.-	4,39,000.-
LABOUR COSTS (1)			
Driver [Rs/shift]	1 x 200 = 200.-	1 x 200 = 200.-	1 x 200 = 200.-
Attendant [Rs/shift]	1 x 170 = 170.-	1 x 170 = 170.-	1 x 170 = 170.-
Total labour costs [Rs/shift]	370.-	370.-	370.-
Total crews per day / vehicles in service per day	24 / 13	14 / 9	13 / 7
Crews per vehicle per day	1.85	1.56	1.86
Labour costs per vehicle in service [Rs/yr]	2,49,000.-	2,10,000.-	2,51,000.-
Management & Admin (10 % of labour costs) [Rs/yr]	25,000.-	21,000.-	25,000.-
TOTAL LABOUR COSTS PER VEHICLE [Rs/yr]	2,75,000.-	2,31,000.-	2,76,000.-
COSTS PER VEHICLE [Rs/yr]	7,13,000.-	8,02,000.-	9,77,000.-
PERFORMANCE PER VEHICLE			
Average load (258 tons per day / trips per day) [tons/trip]	10.8	9.92	10.3
Performance (trips/d x tons/trip x 365 d) [tons/yr]	7,300	10,500	13,400
COSTS PER TON [Rs/ton]	98.-	76.-	73.-

(1) Labour costs according to Appendix AA-2.1.

Chapter B-2

Performance of Multipack compactor trucks

with P S Pahade and Dr C H Nagarabett

B-2.1 INTRODUCTION

Since secondary collection or transportation of solid waste is often the major cost amongst all the stages of storage, collection and disposal, it is important that this operation is as cost-effective as possible. It is essential to collect reliable data on costs in order to make good decisions regarding purchases and allocation of resources. It is useful to be able to consider alternative methods of operation, and estimate the costs of possible alternatives - such costings can only be done if appropriate and reliable data are available. For all these reasons the contents of this chapter are important.

The work that is described here is similar in scope and objectives to part C in a previous report "Observations of solid waste management in Bombay, 1992", published by WEDC. In this previous report two types of refuse collection vehicle in Mumbai were studied:- open trucks provided by contractors and a conventional type of rear-loading compactor truck, known as the Airtech Shörling 4R. This chapter describes the operation in late 1993 in Mumbai of the next generation of Airtech compactor trucks, known as the Multipack. Two trucks of this type are shown in photographs 5 and 6 at the beginning of this report and figure B-2.1 illustrates some aspects of the design. It can be seen that these trucks are very different in appearance from the conventional rear-loading compactor. The basic concept of the design appears to be to simplify the hydraulics by minimising the number of hydraulic rams required to perform all operations. By using chains and cables, the pair of large rams on top of the body lift the one cubic metre wheeled containers (usually called trolley bins in Mumbai), compact their contents into the body and also raise the tailgate during emptying. The body is lower than most compactors, possibly because the packer plate, being hinged at the top, does not lift the waste but provides a force that is largely horizontal. The load is ejected by means of an ejector plate that is operated by two rams operating in tandem. A considerable amount of information relating to the maintenance of these trucks are presented in chapter D. This chapter is concerned with the operation of these vehicles in Mumbai, with observations, measurements and costs. The results presented here will be compared briefly with the data measured in 1992.

B-2.2 OBSERVATIONS OF OPERATIONS

The method used was simply to follow a truck and record the information as shown in appendix BB-2.1. The distance covered was recorded using the distance meter in the car being used by the observers. The quantity of waste loaded at each point was estimated by estimating the waste that was in each trolley bin, and counting the number of times that large plastic bowls were filled with refuse gathered from the ground near each container. (The tools used to collect waste from the ground were described in the previous report, and are shown in photograph 5.) An estimate of the volume lifted in a bowl was obtained by counting the number of bowl loads needed to fill a trolley bin. The times of the beginning and end of each event were recorded. Other observations were noted because useful ideas for improvements can be developed from observations of the difficulties experienced by the loading crews and the methods they develop to solve these problems.

It is important to remember that the crew probably do not work in their normal way when they are being observed, so it is usually necessary to add an extra time allowance to the measured values. In this case the crews were expected to collect only one load per shift, so the timing is not critical for the calculation of the cost of the system. The times are useful when seeking to find ways of modifying the procedures.

Amongst the observations recorded in appendix BB-2.1 are the following:

- ◊ Waste was deposited around the containers even if they were not full. This may simply be a question of habit - what was done before the trolley bins were introduced, or it may be because much of the waste was brought in handcarts that were emptied by tipping their contents onto the ground.
- ◊ The labourers experienced several difficulties moving the containers, especially if they were located on soft or uneven ground. Two dangers in the operation of moving containers were (i) the risk that the loader pulling the cart might be struck by a passing vehicle because he was obliged to go out into the road beyond the truck, and the trolley bin moved unpredictably as the crew struggled to get it into position, and (ii) the risk that the steel wheels of the container might crush a foot of one of the labourers, since they were only wearing plastic sandals.
- ◊ When the container was being tipped to unload the contents into the truck, it sometimes slipped and needed steadying by some of the crew.
- ◊ The axles of the rear wheels of the trolley bins were fixed so that the trolleys could only be moved perpendicular to the truck. This sometimes required the truck to move backwards to meet the container (as is happening in photograph 5), and when the truck hits a full container there is a risk that the sideways force on the heavy container might break the container's wheels.
- ◊ The vehicle that was followed during the afternoon shift passed the nearest disposal site (adding more than 30 minutes to the round trip time) and unloaded at a more distant site in the dark, with no lighting available apart from its own headlights.
- ◊ The average load for the three trips that were studied was 5.8 tons. For the purpose of comparison, the results of nine weighings in the City area of Mumbai are presented in appendix BB-2.1.4, and the average weights of these loads is 4.98 tons, with one as low as 3.1 tons. The reason for the City weights being lower may be that the density of the waste was less because the waste was collected from the business areas where there is more packaging and paper in the waste, or it may be that the loads that were weighed in the City area were less because the labourers were not being observed and so they stopped before the trucks were full.

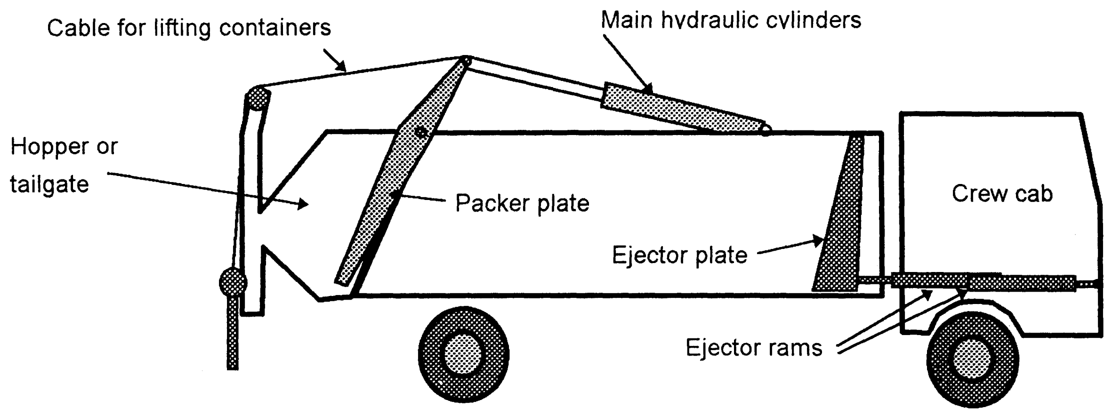


Figure B-2.1 Concept of Multipack truck design
This is not a precise representation nor to scale, but serves simply to indicate some of the design concepts of the Airtech Multipack truck.

The containers (or trolley bins) that are lifted by the trucks are an important part of the system, and if they are not maintained well the efficiency of the whole system may suffer. A common example is the wheels - if the wheels of the containers are not kept in good condition it will be difficult or impossible to move the container to the truck, resulting in delays or uncollected waste. Containers are often damaged when the waste inside them is set on fire. If they are not repainted quickly they will soon be ruined by corrosion. In Mumbai there was a contractual arrangement for repairing and repainting the containers. Each container was repainted on an annual basis, at a cost of Rs 400 per container. (The old paint was burned off and they were repainted with red oxide and yellow and black topcoats, as shown in photograph 7). The contractor also repaired wheels and other minor damage if parts and electricity were supplied. Such maintenance needs a system for collecting damaged containers and distributing repaired ones - both the information system to locate containers needing repair and the transportation system to bring them to the workshop. Damaged containers were sometimes seen overturned at collection points - to indicate that they needed repair and to prevent residents from putting more waste in them.

B-2.3 CALCULATIONS AND RESULTS

The SENS program was used to calculate the costs for each of the three trips that were studied, and also for a hypothetical case. The main inputs to the SENS spreadsheet are shown in appendix BB-2.2.

The hypothetical case considered how the work could be done with a smaller workforce. To make the work more efficient it would be necessary to increase the number of containers and persuade primary collection staff to ensure that all waste is placed into the trolley bin containers. It would also be necessary to provide concrete hard standing for each container so that it could be moved to the truck with a smaller workforce. This hypothetical case considers that the trucks would be operated with a crew of one driver, one mukadam, one cleaner and two loaders. The cleaner would be expected to help the crew on occasions. Clearly, such a change could not be instituted without considerable negotiation, and perhaps confrontation, with the labour unions. The results below could indicate whether it would be worth trying to negotiate a different working arrangement. Table B-2.1 summarises some of the data and some of the results for the three actual cases and the hypothetical case.

The results show a considerable variation in the cost per ton for the three observed trips, largely as a result of the different weights of waste collected. Most of the costs per shift are fixed, except for the fuel and maintenance which are according to distance travelled. Therefore the lowest cost per ton is achieved when the greatest weight is loaded. In both the first and third cases the vehicle was loaded to the utmost because waste was left in the last container - the truck could not take it all (appendix BB-2.1), so the deciding factor seems to be the density or the resistance to compaction of the waste.

Table B-2.1 Observed and calculated data

	Observed			Hypothetical
	7.12.93, am	8.12.93, am	10.12.93, pm	(reduced crew)
Time taken, starting at chowki (min.)	216	243	286	283
Weight of refuse collected (kg)	6280	5780	5340	
Uncompacted waste density (kg/m^3)	372	391	328	
Estimated compaction ratio	1.54 : 1	1.35 : 1	1.48 : 1	
Number of containers used	15	11	20	
Cost per ton collected (Rs)	**355**	**374**	**440**	**283**
Percentage of unit cost due to labour	73	75	69	59

It was the practice in Mumbai to estimate the maintenance cost of the vehicle as ten percent of the capital cost of the vehicle. This is 13% less than the estimate used in table B-2.1; using the Mumbai estimate of vehicle maintenance costs, the cost of the hypothetical option falls from Rs 283 per ton to Rs 280 per ton - a difference of one percent.

Using the SENS spreadsheet it is possible to investigate the effect of each of the variables, as illustrated in table B-2.2, to answer some "What if...?" questions. Representative or average values are taken from the three trips that were observed to give one value for the current system. The different "What if...?" scenarios are described in table B-2.2.

Table B-2.2 The effect of changes in variables on the unit cost of secondary waste collection

	Description of situation or modification to data	Unit cost (Rs/ton)	% change
A.	Existing situation - Multipack compactors in December 1993	390	
B	Using older compactor trucks (Airtech Shörling 4R)- operational data from 1992 report and same costs as for case A	311	-20%
C	As for case A but with a crew of three (from table B-2.1 above)	283	-27%
D	As for case A but with truck that costs twice the price	439	+13%
E	As for case A but with a 50% increase in maintenance costs, which results in an availability of 90%	394	+1.3%
F	As for case A but the container life being only three years	399	+2.3%
G	Truck with a 15 m^3 body, costing ten percent more	297	-24%

Case B (using the previous model of compactor truck) results in a lower unit cost because the capacity of the body is greater, even though the cost of this vehicle was ten percent more.

Case C is considerably cheaper because a smaller crew is used with the vehicle, and labour costs are the main component of the unit cost.

Case D shows that the contribution of the capital cost of the vehicle is not so significant - over the ten year life of the truck the unit cost is increased by only thirteen percent. This suggests that basing the selection of a vehicle on the capital cost alone may not be justified if there are other considerations that affect the unit cost throughout the life of the vehicle. In this case no benefits are assumed to result from selecting the more expensive vehicle, but possible benefits that might be expected are larger capacity, quicker loading times or higher availabilities. A further comment on vehicle prices is made at the end of this section.

Case E suggests that it may be worthwhile to spend more on maintenance if this results in shorter periods when the trucks are awaiting repair, or if the extra effort on preventive maintenance decreases the incidence of breakdowns. A 50% increase in maintenance costs is a very significant increase, and might enable the maintenance manager to hire more well-qualified craftsmen, or buy more equipment or invest more in replacement parts in a preventive maintenance programme.

Case F suggests that the data on the container life is not very critical to the cost of the collection service. (This may not be true if containers are emptied at longer intervals, since, in that case, more containers would be associated with each truck.) However, it must be remembered that defective containers make the collection operation more difficult and less efficient, and encourage careless dumping of waste by primary collectors and residents.

Case G again illustrates the importance of body volume when the number of trips per shift is fixed by negotiation with the labour unions. If each truck does only one trip per shift, then the largest possible truck will maximise the work that a crew of loaders do in one shift. (Of course there are other factors that also affect the optimum size of the vehicle, as discussed in chapter C-1.)

Table B-2.3 investigates the effect of refuse density. A denser waste results in a heavier load, reducing the unit cost. The compaction of dense waste is generally less that the compaction of light waste, though the actual values depend also on the nature of the waste and the performance of the truck. For example, a truckload of closed empty plastic bottles would have a very low bulk density, but would be compacted very little by many compacting mechanisms that operate by means of packer plates. Tree branches also may be difficult to compact because of their elasticity. In spite of these extremes, it is usual for low-density wastes to be compressed more. The compaction ratios shown in table B-2.3 are only guesses.

The density of solid wastes varies randomly to a considerable extent, but there are also more predictable variations - for example waste from a commercial district is likely to be of lower density that wastes from a slum area.

Another factor to bear in mind is that trucks should not be overloaded - as often happens with dense wastes in compactor trucks.

Table B-2.3 The effect of waste density on unit cost

Density (kg/m^3)	Compaction ratio	Unit cost (Rs/ton)	% change	Notes
363	1.45 : 1	**390**	-	Case A of table B-2.2
250	1.8 : 1	**460**	+18%	
300	1.6 : 1	**428**	+10%	
350	1.45 : 1	**403**	+3%	
400	1.35 : 1	**377**	-3%	
500	1.15 : 1	**352**	-10%	

Table B-2.3 shows that there can be a 28% range in unit costs for the magnitudes of densities that can be found in India. This also suggests that some care should be taken in comparing unit costs for refuse collection from one place to another (even different parts of the same city), because part of the variation may be due to the effect of refuse density.

For the purpose of internal accounting, a rental was charged by the Transport Department in Mumbai for the use of each vehicle. For compactor trucks, this charge was Rs 753 in 1993. Using the data obtained as described above, and assuming that the costs of the driver and the cleaner are borne by the Transport Department, the rental charges for the three trips studied were calculated to be Rs 952, Rs 890 and Rs 1067. It must be remembered that the data of this study were based on a small sample of observations, and some of the assumptions may be disputed, but these results do suggest that the internal rental charge may have been too low.

Further comment on vehicle prices When the purchase of compactor vehicles was being considered in Mumbai in 1991, the following quotations were received for the supply of Multipack trucks:

Crore Rs 3.18 3.19 3.245.

For the older model (4R) the following quotations were received

Crore Rs 3.45 3.46

The difference between prices of alternative chassis appeared to be about 1%.

Whilst government regulations may require the acceptance of the lowest tender (based on capital costs), the analysis of total costs per ton (including purchase, operation and maintenance) shows that the choice of the alternative having the lowest capital cost at the tender stage may result in a considerably higher expenditure over the service life of the equipment. The calculation of these *whole life* costs requires reliable values for operational data that are sometimes difficult to obtain, but, in view of the expenditure that can be saved, it is worthwhile to invest in the human resources needed to investigate carefully the whole life costs of alternative systems.

B-2.4 CONCLUSIONS AND RECOMMENDATIONS

◊ The costs of secondary collection of municipal solid waste are considerable, and so it is important to maximise the efficiency of this service to keep the expenditure as low as possible. Observation of collection crews in action can provide useful data which can lead to an estimation of the costs of collecting one ton of waste, and can provide useful insights into the problems experienced by the collecting crews. A knowledge of the costs of refuse collection is valuable when comparing alternatives and developing ways of improving efficiency.

◊ In Mumbai, labour costs were the major part of the expenditure on municipal refuse collection. Any way of reducing these costs would have a significant effect on the total costs of the operation. Improving the equipment and infrastructure so that a smaller crew can be used is one way of reducing total costs, but resistance to such moves from the labour unions is to be expected. There is also resistance to the crews undertaking more than one trip per shift. Faced with these restrictions, the only way to reduce costs seems to be increasing the load that is collected in one trip, by using larger vehicles.

◊ A computer program that models the collection operation is a valuable tool for the manager. The program must be prepared by someone with a good knowledge of refuse collection operations, so that it reflects actual problems and is sufficiently flexible. Such a program enables alternative strategies to be examined quickly and reliably.

◊ The selection of solid waste collection equipment should not be based solely on the purchase price. Other costs, related to operation and maintenance, can have a much larger impact than a small difference in purchase price, but some items of such cost information can often only be obtained by observation of normal operations. If a city does not already operate a particular type of vehicle, how can it collect such data? There are two possible ways - either to purchase one or two of the vehicles and operate them on a trial basis, or to observe the operation of the particular type of vehicle in another location. For this second alternative to be successful the following requirements should be met:

⇒ It is necessary to know where the particular type of vehicle is in operation. This information may be available from the supplier, but the need for such information is one reason why a network of solid waste managers throughout India should be established, so that colleagues keep each other informed about developments, including where the vehicles can be observed.

⇒ Observation of actual operations are important. Often labourers work differently - either faster or slower - when being observed, so it is important to be able to verify measured values by comparing them with times recorded in registers when the labourers are not being observed.

⇒ Local factors must be taken into consideration, such as local agreements with labour unions, the density and compressibility of the waste to be collected, and the road speeds and distances.

It may be necessary to amend regulations and procedures for evaluating tenders before this more realistic method of assessment of options can be implemented.

APPENDIX BB-2.1

WORK STUDY DATA FOR MULTIPACK TRUCKS, MUMBAI

BB-2.1.1 Compactor truck - '2504' -, 7 December 1993; first shift

Vehicle model: Airtech Multipack, approximately nine months old
Total body volume approx. $11m^3$ (Airtech)
Crew:- 1 driver, 1 cleaner, 1 mukadam, 6 loaders

Station	Distance meter (km)	Time	Notes	No. of Bowls
	067	7.22	**Dep** motor loader chowki	
1	067	7.24'00"	**Arr** Two trolleys, one half full, one full; waste lying around, two loads palm branches loaded directly, fairly dry; uneven surface. First trolley loaded 7.28'40" Second trolley 7.34 ;89 s to load	7
		7.37'05"	**Dep**	
2	068	7.39'30"	**Arr** Four trolleys- two full, one 80% full, one empty, on hard standing with some holes Coconut shells, 17 bowls filled one trolley; four men could move a trolley; those pulling container risked injuring feet; no protective clothing, no loaders wearing uniforms; when trolley is lifted it tends to slide sideways, four men needed to keep it in position; when lifting material spilled from both sides; trolley loads require three or four compacting cycles to be emptied. First trolley 7.46'35" , 85s First trolley reloaded 7.54'55", 175s Second trolley 8.00, 103s Third trolley 8.03, 85s Fourth trolley 8.05'30" 88s	43
		8.08'00"	**Dep**	
3	068	8.11'52"	**Arr** Two trolleys - one full, one 80%. Trolleys off road on rough ground; Waste light - plastic, paper, fabric, incl commercial; loaders pulling trolleys at risk from traffic First trolley 8.17'20", 130s Second trolley 8.22'40", 175s	8
		8.27'50"	**Dep**	
4	069	8.30'43"	**Arr** Two trolleys, on road, partially blocking busy road, one full, one 90% First trolley 8.33'40", 90s Second trolley 8.36'05", 95s	2
		8.39'08"	**Dep**	
5	071	8.41'50"	**Arr** Two trolleys, both about 10% overloaded, back wheels of trolleys in depression at edge of road First trolley 8.43'45", 85s Second trolley 8.47'07", 123s	3
		8.50'37"	**Dep**	

compactor truck - '2504' - continued

Station	Distance meter (km)	Time	Notes	No of Bowls
6	071	8.53'00"	Two trolleys one 70%, one 90%, narrow busy road, trolleys kept in recess cut out of footpath, good surface; much foliage, mostly dry; loaders pick up bowls by rims, not ropes First trolley 9.01'57", wood shavings tipped into trolley, second load in first trolley 9.04'20" 100s Second trolley 9.08'40", 161s	14
		9.13'47"	**Dep**	
7	073	9.19'44"	**Arr** One full trolley clean area, trolley on road, good surface; serious traffic obstruction during loading; truck full, could not take all of bin's contents (Previous collection three days before - holidays - so truck was unable to collect from three stations that were normally served on this route. Trolley loading 9.21'27", ≈6 min.	0
		9.28'25"	**Dep**	
	075	9.36'30"	**Arrive motor loader chowki** to deposit tools	
		9.43'05"	**Depart chowki**	
	079	9.56'00"	**Arrive checkpoint** on Linking Road	
		10.01'15"	**Depart checkpoint**	
	084	10.13'32"	**Arrive weighbridge**	
		10.17'00"	**Depart weighbridge**	
	089	10.26'40"	**Arrive Malad disposal site** At tipping place 10.28. Vehicle reverses and stops suddenly to clear residue. Cleaner removes any scraps.	
		10.33'45"	**Depart disposal site**	
	094	10.42'50"	**Arrive weighbridge**	
		10.46'00"	**Depart weighbridge**	
	098	10.58'05"	Passed road leading to motor loader chowki	
	106	11.25'17"	**Arrived Bandra garage**	

Weighbridge results:	Full:	15 180 kg
	Empty	8 900 kg
	Load	**6 280 kg**

BB-2.1.2 Compactor truck - '2469' -, 8 December 1993; first shift

Vehicle model: Airtech Multipack, approximately nine months old
Total body volume approx. 11m^3 (Airtech)
Crew:- 1 driver, 1 cleaner, 1 mukadam, 6 loaders

Station	Distance meter (km)	Time	Notes	No. of Bowls
	24187	7.45	**Dep** motor loader chowki	
1	188	7.50	**Arr** Two trolleys, one half full, one 0.9m^3; Little overflow; trade and domestic refuse; fairly dry; road surface uneven. First trolley loaded 8.54'15", 80s to load Second trolley 8.57'30"; 60s to load	4
		8.00	**Dep**	
2	188	8.02'30"	**Arr** One trolley, 0.4m^3; drain silt lying outside; trolley on road, good surface; 4 men push trolley. Trolley loaded 8.07'20", 40s to load	4
		8.09'30"	**Dep**	
3	189	8.11	**Arr** 3 trolleys; 0.2m^3; 0.5m^3; 0.7m^3; waste scattered, trade waste, dry, ash and wood shavings, dirty site. First trolley 8.14'30", 50s Second trolley 8.17, 120s Third trolley 8.21'15", 70s	7
		8.22'15"	**Dep**	
4	190	8.29	**Arr** One trolley, 0.55m^3; domestic waste; nearby drain full of waste; Trolley loaded 8.34'30", 55s to load	1
		8.35	**Dep**	
5	192	8.41'15"	**Arr** No trolley there, new trolley placed there. Large quantity of waste scattered; market and commercial waste, bad conditions for loading. Trolley used to load waste as follows 1st load 18 bowls 1.1m^3; 8.43'30", 180s 2nd load 18 bowls 1.1m^3; 9.05'25", 170s 3rd load 21 bowls 1.15m^3; 9.19'45", 90s 4th load 23 bowls 1.2m^3; 9.35'35", 125s About 6 bowls of garbage left at the site. 10 bowls of refuse was added by nearby residents.	80
		9.44'30"	**Dep**	

compactor truck - '2469' - continued

Station	Distance meter (km)	Time	Notes	No. of Bowls
6	193	9.51'00"	**Arr** Three trolleys, one 1.1m^3; second 0.9m^3; third 0.8m^3; market and commercial waste very scattered; surface uneven; about 1m^3 brought by nearby traders during loading; 2 bundles of sugar cane waste added. 1st trolley loaded 9.59'45", 110s to load 2nd trolley, 9.59'50", 120s 3rd trolley, 10.04'35", 90s 3rd trolley refilled, 10.16'00", 90s 3rd trolley, refilled again, 10.23'20", 130s	50
		10.25	Start of tea break	
		10.34	End of tea break	
		10.34'45"	**Dep**	
	194	10.36'30"	**Arrive checkpoint** on Linking Road	
		10.40	**Depart checkpoint**	
	199	10.55	**Arrive weighbridge**	
		10.58	**Depart weighbridge**	
	203	11.09	**Arrive Malad disposal site**	
		11.17"	**Depart disposal site**	
	208	11.30	**Arrive weighbridge**	
		11.34	**Depart weighbridge**	
	212	11.47'30"	**Arrive motor loader chowki** Andheri to return implements	
		11.49	**Depart chowki**	
	220	12.19	**Arrived Bandra garage**	

Weighbridge results:

Full:	14 820 kg	
Empty	9 040 kg	
Load	**5 780 kg**	

BB-2.1.3 Compactor truck - '2471' -, 10 December 1993, second shift

Vehicle model: Airtech Multipack, approximately nine months old
Total body volume approx. $11m^3$ (Airtech)
Crew:- 1 driver, 1 cleaner, 1 mukadam, 6 loaders

Station	Distance meter (km)	Time	Notes	No. of Bowls
	541	2.56	**Depart motor loader chowki**	
1	541	2.58	**Arr** Two trolleys, one $0.7m^3$, second $0.2m^3$, little garbage lying around; waste dry, some commercial, nearby drain filled with debris; rag pickers collecting plastic etc.; uneven surface. First trolley loaded 3.00'30"; 120s second trolley 3.04'00"; 110s	1.5
		3.06'00"	**Dep**	
2	542	3.10'30"	**Arr** Two trolleys; one $0.7m^3$, other $0.3m^3$, Good surface, domestic, dry, some fish; first trolley slipped towards the inside of the truck during loading. First trolley loaded 3.13'30", 95s second trolley 3.15'15" 70s	0
		3.17'45"	**Dep** 'U' turns necessary - could they be avoided?	
3	544	3.20'50"	**Arr** Two trolleys, one $0.9m^3$, other $0.3m^3$; much scattered waste, dry commercial and domestic, goats grazing, four can pull trolley, severe obstruction to traffic; First trolley 15.22, 90s second 15.26, 120s	3
		3.28'34"	**Dep**	
4	545	3.34'30"	**Arr** Two trolleys, one $0.2m^3$, other $0.05m^3$; large amount of scattered waste, foliage loaded directly into compactor, domestic and hotel waste, plastic bottles, serious traffic obstruction, considerable loss of hydraulic oil when compaction mechanism is working; first trolley loaded 3.43'35", 180s second trolley was not loaded - too little waste inside.	6
		3.47'	**Dep**	
5	546	3.50'30"	**Arr** Three trolleys; first $1.1m^3$, second $0.9m^3$, third $1.0m^3$, including hotel and commercial waste, mattress, rag pickers active, good surface so easy to move container; hydraulic system not working well - container dropped a short way; mukadam keeps loaders away from area under container, area left very clean, 1/3 truck load foliage left. First trolley loaded 3.53'43", 190s second trolley 3 56'35", 180s third trolley 4.04'15", 120s	12
		4.08'00"	**Dep**	

compactor truck '2471' continued

Station	Distance meter (km)	Time	Notes	No. of bowls
6	547	4.10'30"	**Arr** Three trolleys, all 1.0m^3, waste dry, domestic, commercial and hotel waste; ash, food, timber and cloth; very uneven surface, very untidy, probably because of rag pickers, who had collected 18 sacks of recyclable material, much scattered waste. First trolley loaded 4.12'20", 160s same trolley reloaded 4.21'25", 180s second trolley 4.32'35", 100s third trolley 4.36'45", 120s	18.5
		4.39'00"	**Dep**	
7	548	4.43'00"	**Arr** Three trolleys, one 0.3m^3, second 0.4m^3, third 0.7m^3; coconut, sugar cane, hotel and domestic waste, trolleys in ditch, difficult to move them; half of the road was blocked, serious risk of accidents. First trolley loaded 4.44'00", 90s second 4.46'30", 80s third 4.49'30", 75s	2
		4.52'30"	**Dep**	
8	548	4.54'20"	**Arr** two trolleys - 0.7m^3 and 0.6m^3; domestic, vegetable and garden waste, good surface First trolley loaded 4.56'40", 200s second 5.03'00", 180s	6.5
		5.10	**Dep**	
			Passed station with two trolleys which were inaccessible because a ditch had been dug in front of them for telephone cables.	
9	550	5.15'30"	**Arr** One trolley 0.6m^3, much spillage, dry domestic waste including fish and paper, horse tied to trolley; only 3/4 of trolley load could be loaded into truck; daylight could be seen above waste, though there was some foliage there; about 0.25m^3 was left in the container	16
		5.40'00"	**Dep**	
	555	5.55	**Arrive checkpoint** on Linking Road	
		6.03'22"	**Depart checkpoint**	
	559	6.15'00"	**Arrive weighbridge**	
		6.20'30"	**Depart weighbridge,** open road speed 40-45 km/h	
	564	6.29'30"	Passed turning for Chincholi (Malad) dumping ground	
	571	6.44'45"	**Arrived Gorai dumping ground**	
		6.48'00"	Unloading started, (in dark, no lighting); ejector plate operating well	
		6.52'00"	Unloading completed	
	572	6.58'10"	**Depart Gorai dumping ground** speed up to 50 km/h	
	579	7.15'20"	Passed turning to Chincholi dumping ground	

compactor truck '2471' continued

Station	Distance meter (km)	Time	Notes	No. of bowls
	583	7.22'50"	**Arrive weighbridge**	
		7.24'00"	**Depart weighbridge**	
	587	7.42'00"	**Arrive motor loader chowki** Andheri to return implements	
		7.43	Ready for departure; took approx. 10 minutes tea break	
		7.53	**Depart chowki**	
	595	8.20	**Arrived Bandra garage**	

Weighbridge results: Full: 14 280 kg
Empty 8 940 kg
Load 5 340 kg
Diesel consumption: approx. 20 litres

BB-2.1.4 Sample weights from Prabhadevi garage

In order to allow comparisons of the loads noted above with loads measured for vehicles of the same type operating in the City area of Mumbai, the following observations are provided. The weights are quoted in metric tons.

Full	16.00	14.90	12.50	14.10	13.55	15.24	14.18	13.08	13.20
Empty	9.04	9.00	9.40	9.08	9.08	9.10	9.00	9.04	9.20
Load	6.96	5.90	3.10	5.02	4.47	6.14	5.18	4.04	4.00

The average of these loads is 4.98 tons.

APPENDIX BB-2.2 CALCULATION OF UNIT COSTS FOR COMPACTOR TRUCKS USING *SENS* PROGRAM

This appendix first considers how to convert the data from appendix BB-2.1 to suit the requirements of the program, and then presents the unit costs. Costs will be calculated using a spreadsheet program known as SENS. A manual for the program is available at WEDC; some familiarity with this manual will assist the reader to follow this appendix. The *SENS* program is a tool to allow the estimation of unit costs and can be extended to systems that are not in current use. It breaks the collection operation into a number of different steps, using data for each individual step to synthesise times and costs for new operations. The program considers up to five alternatives simultaneously. In the first section, four sets of data will be considered. Data are taken from appendix BB-2.1

A This refers to data collected for compactor truck 2504 on 7 December.
B This column is based on data for compactor truck 2469 on 8 December
C This column is based on data for compactor truck 2471 on 10 December
Rec These are values recommended for alternative computations; often averages. This option estimates the cost if a smaller crew were used with each truck, and if all the waste were in containers, so that the crew were not involved in collecting up waste from the street.

Explanatory notes	A	B	C	Rec
Vehicle design capacity (volumes from manufacturer) [m^3]	11	11	11	11
Vehicle actual capacity ratio (If body is full = 1.0)	1.0	1.0	1.0	1.0
Volume loaded from trolleys (estimated, m^3) (v)	12.5	6.5	12.6	
Number of bowls (n) (Based on five observations, 17.5 bowl loads are needed to fill one trolley container, so estimated volume in one bowl is 1.0/17.5 = 0.057 m^3 .)	77	146	65	
Estimated uncompacted volume [m^3] v + 0.057n	16.9	14.8	16.3	16.0
Compaction ratio (Estimated uncompacted volume divided by estimated volume in truck.)	1.54:1	1.35:1	1.48:1	1.45:1
Refuse density (From weighbridge results and estimated uncompacted volumes) [kg/m^3]	372	391	328	363
Container capacity [m^3]	1.0	1.0	1.0	1.0
Number of containers in use	15	11	20	
Actual container capacity ratio (i.e. fraction of total container volume occupied. Uncompacted volume of waste divided by total volume of all containers used. For projected systems a value lower than 1.0 is used since it is essential that waste does not overflow, so extra spare capacity is needed)	1.13	1.35	0.82	0.75
Container capital cost [Rs] (Standing Committee Dec. 1991)	6407.5	6407.5	6407.5	6407.5
Interest rate (12% p.a. MCGB)	12	12	12	12
Container life span (A guess, data not available. Life likely to be longer for new system since more maintenance)	5	5	5	5
Days between collection (1 day assumes trolleys emptied once per day.)	1	1	1	1
Vehicle capital cost [lakh Rupees] (December 1991, tenders)	7.16	7.16	7.16	7.16
Vehicle interest rate	12	12	12	12
Vehicle life span [years]	10	10	10	10
Vehicle availability factor (This indicates how many standby vehicles are needed. Calculated from 1993 data for Multipack trucks in appendix DD-1.1 February 71% October 73%, November 72.5% average value 72% [%]	72	72	72	72
Container loading time (Total time vehicle stationary at loading stations divided by number of containers. For *Rec* system average of stations A.4, B.4, C.2 and 7 plus 30 s extra - these stations chosen because all or most of the waste was in the containers) [seconds]	417	717	366	256
Team loading one container (cleaner included)	7	7	7	3
Number of loaders with one truck (as above)	7	7	7	3
Number of containers per station	2.15	1.84	2.23	1
Vehicle unloading time (i.e. time spent on disposal site) [min]	7.1	8	12.5	10

Explanatory notes (continued)	A	B	C	Rec
Report time, Delay allowance (Time when vehicle not moving, loading or unloading can be included as report time or as delay allowance) [min]	18.3	21.8	26	30
Time between stations (For *Rec* the time has been reduced because less waste would be stored on each site, so the sites would be closer together.) [s]	202	282	231	240
Distance between two stations (Total distance between first and last storage points divided by number of intermediate stages. For *Rec* it is less since more stops are made) [m]	1000	1000	1125	430
Distance from collection area to boundary (Taken as half the sum of the distances from last collection point to weighbridge and from the weighbridge to the motor loader chowki) [km]	7.5	5	6.5	6.5
Distance to disposal site from weighbridge. [km]	5	4.5	12	5
Urban speed (Average speed between collection area weighbridge and chowki, and to/from depot.) [km/h]	19.1	17.9	17.6	18.2
Country speed (Average speed between weighbridge and disposal site.) [km/h]	32	22.5	28.2	27.5
Extra distance to the depot (both directions) [km]	16	16	16	16
Two loads per day, changeover time between shifts irrelevant				
Working hours per day (In this case the time must be chosen to allow enough time for two trips in two shifts, but not enough for three.) [h]	11	9	13	12
Container maintenance cost per year (as a fraction of its annual cost.-.values are guesses. For *Rec* system more must be spent on trolleys to ensure that the wheels are always in good condition)	0.02	0.02	0.02	0.1
Vehicle maintenance cost per km (Based on MCGM figure with other miscellaneous charges added, and inflated by 35%) [Rs/km]	2.35	2.35	2.35	2.35
Working days per year	365	365	365	365
Fuel consumption (The vehicle is operating under different conditions- running reasonably fast, moving slowly, and stationary, operating the compaction mechanism. Estimates are very approximate. [km/litre]	2.0	2.0	2.0	2.0
Cost of fuel per litre [Rs/litre]	6.81	6.81	6.81	6.81
Number of drivers (Two; one per shift)	2	2	2	2
Drivers wages per month (See appendix AA-1.2) 30 days/m [Rs]	6000	6000	6000	6000
Loader's wages per month (See appendix AA-1.2) [Rs]	5100	5100	5100	5100
Supervision; This is mainly to cover the salaries of the mukadams who supervise the collection crews, but can also include more senior supervisors. It is expressed as a percentage of the wages bill. For A, B and C one mukadam is required for a team of 8 (i.e. 12.5%), and 7.5% is added for JO's etc. For *Rec* it is taken as twice the value for A, B and C, since the wages bill is halved but the supervision costs remain the same. [%]	20	20	20	40
Insurance, taxes and import duties are all set at zero.	0	0	0	0
Wage overheads are assumed to cover wages of relief workers to cover leave, sickness etc. This is already included in values of appendix AA-1.2 so the value here is 0 [%]	0	0	0	0
Estimated collection cost per tonne [Rs/tonne] Values calculated using *SENS* program	**359**	**379**	**444**	**287**

Chapter B-3

Public sector refuse collection in Rajkot

by Manus Coffey, B. M. Desai,
Sumeet Chatterjee and V. B. Pawar

B-3.1 INTRODUCTION

This section describes a brief study of the refuse collection service operated by municipal vehicles and workforce in Rajkot, Gujarat. A parallel service was being operated by contractors, and this is described in the following section. In chapter B-4 there is a brief comparison of the two services - public and private.

B-3.2 EXISTING SYSTEM

The Rajkot Municipal Corporation (RMC) relies mainly on two types of vehicles for the municipal refuse collection service:

- ◊ Allwyn Nissan Cabstar tipper trucks fitted with 2.9m^3 tipper bodies, and
- ◊ DCM Toyota trucks fitted with Airtech dumper placer bodies which carry containers having a nominal capacity of 4.5m^3.

Further details of the vehicles used by the RMC are given in Appendix BB-3.1.

It was found during the studies that average loads of 1610 kg. were carried by the tipper trucks and 1672 kg. by the dumper placer trucks.

Recorded weights for the trucks were as follows:

Tipper trucks:

Average Gross Weight - 4,253 kg.

Maximum Gross Weight - 4,340 kg.

This compares with the manufacturer's permitted gross vehicle weight (GVW) of 5,750 kg indicating that the body size could be increased by around 90% without overloading the truck chassis. It is suggested that extension sides 0.30m high should be fitted to these trucks with drop-down top sections to enable the full load capacity to be achieved without excessive loading heights.

Dumper - placers:

Dumper placer mechanism	1 000 kg
Container	580 kg
Unloaded weight without bin	3 440 kg
Unloaded weight with bin	4 020 kg
Permitted gross vehicle weight (GVW)	5 990 kg
Payload (5 990 - 4 020)	1 970 kg

Measured loads averaged 1,672 kg. (85% of permitted load) with one load of 2,070 kg. (5% overload). This is considered acceptable and the truck is operating efficiently.

B-3.3 AVAILABILITY OF MUNICIPAL EQUIPMENT

The Conservancy Depot and Municipal Workshop were visited by the team and the information that was collected concerning the refuse collection vehicles is shown in table B-3.1.

The relatively good availability of the fleet of vehicles as shown by the records at the workshop indicate a satisfactory maintenance programme. The depot and workshop were found to be in a clean condition.

Table B-3.1 Details of municipal refuse fleet

Type of vehicle	Quantity	Capacity	Availability	History/ comments Date of study - December 1995
JCB loader	4		77%	1st machine procured 1987/8; 2nd 1989/90 and 3rd & 4th 1995
Large dumper	2	8 m^3	100%	Both trucks procured 1/5/95
Small dumper (Allwyn)	9	3 m^3	56%	All trucks procured 1988
Dumper placer (DCM)	10	4.5 m^3	81%	Two procured 1988, seven in 1989/90, one in 1995
Dumper placer containers	200	4.5 m^3		58 procured 1987; 125 procured 1995; 25 still awaited
Tractor	2		96%	One procured 1984, one 1995
Open truck (AL + TMB)	2	10 t GVW	75%	One procured 1985, one 1995
Small Truck (M + M)	3	2 t	93%	All procured 1984/5
Small dumper (M + M)	6	1.5 m^3	76%	All procured 1987/8

AL Ashok Leyland; TMB Tata Mercedes Benz

The total fleet was maintained by one deputy executive engineer assisted by two assistant engineers, 4 mechanics, 1 electrician, 1 gas welder, 1 lathe operator and 8 helpers. Each mechanic, electrician, welder and lathe operator had a locked cupboard; these cupboards were found to be kept systematically. Scrap and wastes generated were observed to be collected daily in containers earmarked for the purpose and transported daily to the locked scrap room. All equipment for maintenance (welding equipment, lathe, air compressor, water jets, fixtures for hydraulic cylinder repairs etc.) were found to be in good working condition. It was reported that, over the last ten years, no adverse report had been made of any employee and no overtime had been paid over a similar period. Monthly get-togethers for all employees were held as part of a scheme to promote goodwill.

B-3.4 PERFORMANCE OF EXISTING VEHICLES

Tipper trucks: The Municipal Corporation of Rajkot had nine tipper trucks with a carrying capacity of 2.9m^3. The team measured actual vehicle loads of refuse carried by these tipper trucks at the disposal site - (the data are given in appendix BB3.2) and calculated that the average load was 2.66 m^3 of refuse. The trucks made only 2 to 3 trips per shift and were working in 2 shifts.

Dumper Placers: The Municipal Corporation of Rajkot had ten dumper placers of which two had not been in use since the previous year, for want of suitably sized containers. The other eight dumper placers were in operation, collecting containers from different wards of the city.

The nominal volume of the containers was 4.5 m^3 according to the data received from the Municipal Corporation. However, the actual volumes of waste inside the containers and loads carried by the dumper placers were shown in appendix BB-3.2. These results show that the containers were not filled, but carried only 2.0 m^3 to 2.9 m^3 of refuse. They also were working in two shifts and making only four trips per shift.

B-3.5 DISPOSAL SITE RECORDS

The team collected reports from the register kept at the Ayodhya disposal site. This showed the number of trips, vehicle registration numbers, and arrival and departure times, but did not provide any information on waste quantities.

The study team carried out a sample survey and the data collected are shown in appendix BB-3.2. The site records indicated that there was no waste collection on Sundays.

B-3.6 LIFE EXPECTANCY OF MUNICIPAL VEHICLES & CONTAINERS

Table B-3.1 shows that all the Allwyn and DCM vehicles used for refuse collection were still within their probable economic lives (which is, in general, eight to ten years).

RMC has a large number of containers (210). Some of the containers had been damaged by fire and it was noted that if these containers were not painted immediately after being damaged by burning, then severe corrosion of the containers would take place. The life of the containers was three to four years, according to the Municipal staff.

B-3.7 MAINTENANCE FACILITIES

The Rajkot Municipal Corporation had various types of vehicles for various duties, such as sewer cleaning, refuse collection, etc. There were a total of 170 vehicles, out of which 38 were used for the transportation of refuse. A fully-fledged workshop managed by trained staff is vital for the proper maintenance of the vehicles.

During the investigations, it was observed that the central workshop of the Corporation had the following facilities:

◊ A well-planned conservancy depot, workshop and office complex surrounded by boundary walls;

◊ Separate sheds for cleaning, servicing and repairs, a tool-room, storage for essential spare parts, storage for discarded parts, storage for tyres and storage for waste;

◊ Most of the mechanical and electrical repairs were carried out by the workshop, with only major overhauls contracted out;

◊ Up-to-date records were available;

◊ The officers and staff were a devoted team and deserved high praise for maintaining the facilities in a neat and clean condition..

In a nut-shell, the staff and facilities available were operating well because they were maintaining an average availability of 80% to 85% for the vehicles, and this was a major factor contributing to the upkeep of the city.

B-3.8 WORKING CONDITIONS OF THE LABOURERS AND THEIR EFFICIENCY

The refuse collection labourers were being required to work in unhygienic conditions. In some cases they were required to handle the garbage more than once. They were being exposed to high risks for want of proper uniforms, gloves and shoes or gumboots and they had been provided with tools which were not appropriate for the requirements of the work and therefore reducing the efficiency of the labourers. Unloading of refuse from open, non-tipping trucks is time consuming and the efficiency of municipal labourers in this task appeared to be low in comparison with the performance of the contractors' labourers.

The conditions of the dumping sites at Sinduria Khan and Ayodhya were such that they were a health hazard. They could not be called sanitary landfills. Houses had been constructed on land adjoining the dumping sites and there was no proper fencing. During the field study some women residing near Sinduria Khan requested the investigators to assist them in obtaining fencing and a gate for the safety of their children. This was seen to be an urgent need. The approach roads were dusty and uneven, and there is no provision for covering the garbage with soil. Rag pickers, birds and animals were adding to the nuisance. The area was also being used for open defecation.

B-3.9 ESTIMATION OF UNIT COLLECTION COSTS

In this section the costs of collecting one tonne of solid wastes by the Municipality are estimated, using existing dumper-placer and tipper trucks, at 1995 costs for single shift working 6 days per week.

a) Unit costs for existing dumper placer system (single shift)

Line	Item		annual cost, Rs	
1	Cost of vehicle	Rs 5,37,000		
2	Economic life	10 years		
3	Depreciation	line 1 / line 2	53,700	
4	Interest of capital @ 10% *		53,700	
5	Miscellaneous annual costs (insurance etc.)		6,176	
6	Maintenance (average over life of vehicle at 10% of purchase cost)		53,700	
7	Fuel (7 km/litre; 12 km/trip; 4 trips/shift, 312 days/year, Rs 8 /litre)		17,115	
8	Labour cost (driver plus one loader)		36,500	
9	Overheads (based on single shift, 25% of labour costs)		9,125	
10	**Annual costs for dumper-placer vehicle**			**2,30,016**
11	Cost of one container	Rs 22,000		
12	Economic life of container	3.5 years		
13	Depreciation (line 11 / line 12)		6,285	
14	Interest on capital at 10% *		2,200	
15	Maintenance		1,000	
16	Annual cost for one container		9,485	
17	If each container is emptied every two days, and each truck does four trips each day, each truck services eight containers, so the annual cost of containers for one vehicle is 8 X (line 16)			**75,880**
18	Total annual cost for one truck and its containers			**3,05,896**
	Total weight of solid waste collected by one truck in one year		weight, tons	
19	Loads per shift	4		
20	Average load per container (tons)		1.673	
21	Annual capacity = 4 x 1.620 x 312 (tons/year)			**2 022**
22	**Cost per ton for single shift work = (line 18) / (line 21)**			**Rs 151**

* interest based on World Bank Loan Rate

Note: The above cost may be reduced by:

- Increasing the number of loads collected per vehicle by working longer hours or double shift work.
- Increasing the average load per container. This can be done by a careful study of all container locations and adjusting the locations and the frequency of collection to maximise on container loads.

The above costs include for both depreciation of the capital, and interest on the capital cost. A replacement fund equivalent to the combined costs of these items will allow for both the initial borrowing required and future vehicle replacement as they become obsolete. No allowance has been made for inflation and the above costs should be updated annually in line with the increased cost of replacement vehicles and with a corresponding increase in the costs/ton collected.

b) Unit costs for dumper placer system operating two shifts

Economic life reduced to 7 years due to longer working hours, and maintenance is increased to 15% of purchase cost

Line	Item		annual cost, Rs	
1	Cost of vehicle	Rs 5,37,000		
2	Economic life	7 years		
3	Depreciation	line 1 / line 2	76,714	
4	Interest of capital @ 10% *		53,700	
5	Miscellaneous annual costs (insurance etc.)		6,176	
6	Maintenance (average over life of vehicle at 15% of purchase cost)		80,550	
7	Fuel (7 km/litre; 12 km/trip; 8 trips/day, 312 days/year, Rs 8 /litre)		34,230	
8	Labour cost (driver plus one loader for each shift)		73,000	
9	Overheads (15% of labour costs)		10,950	
10	**Annual costs for dumper-placer vehicle**			**3,35,320**
11	Container cost = 16 x 9,485			**1,51,760**
12	Total annual cost for one truck and its containers - two shifts / day			**4,87,080**
	Total weight of solid waste collected by one truck in one year			weight, tons
13	Collection capacity (two shifts) = 2 x 2022 (line 21 in table above)			**4,044**
14	**Cost per tonne for double shift work = (line 12) / (line 13)**			**Rs 120**

c) Unit costs for small open tipper trucks

Item	Costs Rs Single shift	 Double shift
Depreciation: cost Rs 4,20,000,		
economic life 10 years (1 shift); 7 years (2 shifts)	42,000	60,000
Interest (10%)	42,000	42,000
Miscellaneous costs	6,176	6,176
Maintenance costs (10% for one shift, 15% for two shifts)	42,000	63,000
Fuel (2 trips per shift, 12 km per trip, 8 km/litre)	7,488	14,976
Labour (One driver and three loaders per shift)	68,400	1,36,800
Overheads (25% single shift, 15% double shift)	17,100	20,520
Total annual costs	**2,25,164**	**3,43,472**
Collection capacity (tonnes) 2 trips per shift, 1.583 tonnes/trip	988	1,976
Collection cost per tonne, Rs	**228**	**174**

B-3.10 CONCLUSION

The unit costs calculated above are summarised in table B-3.2

Table B-3.2 Summary of unit collection costs

Vehicle type	shifts	cost per tonne, Rs
Dumper placer	1	151
	2	120
Open tipper	1	228
	2	174

These results show that there are clear cost savings when vehicles are used for two shifts instead of one; in the case of the dumper placer the saving is 21% and with the open tipper the saving is 24%. The dumper placer system is 34% cheaper than the tipper truck for single shift operation and 31% cheaper when two shifts are worked each day. Other points to note are that loading the tipper is very labour-intensive and unhygienic, and that no provision is made in the cost analysis above for the provision of containers to be used with the tipper trucks.

By increasing the body size of the tipper trucks it might be possible to reduce substantially the cost per tonne, but the loading time would be increased unless more labourers were able to load the truck simultaneously - and since labour costs are already the largest item of expenditure, and transporting the loaders in a safe and hygienic way might be difficult, the decision to increase the size of the labour force should not be taken without much thought. A significantly longer loading time might reduce the number of trips that could be undertaken during a shift.

Two shift operation can be a useful way of saving costs, but operational considerations must be considered such as

- ◊ the provision of adequate supervision for both shifts - one supervisor cannot be expected to be present for both;
- ◊ the problems resulting from drivers sharing vehicles, and supervisors sharing responsibility;
- ◊ the need for lighting at the disposal site if the second shift operates after sunset;
- ◊ the time necessary for routine maintenance tasks (which can be done in the afternoon with single shift operation).

Two shift operation can provide useful flexibility to cope with larger quantities after weekends and holidays and to allow a delay in the purchase of extra vehicles to cope with the growth in demand.

APPENDIX BB-3 MUNICIPAL COLLECTION IN RAJKOT

BB-3.1 Existing Conservancy vehicles

Type of Vehicle	Number	Capacity	Working hours per day
JCB loader	4		16
Dumper		2 8 m^3	16
Dumper		9 3 m^3	16
Dumper-placer	10	4.5 m^3	16
Dumper-placer container	200	4.5 m^3	16
Tractor	2		8
Open truck	3	7000 kg	8
Small truck	3	2000 kg	8
Water tanker	4	7000 kg	8
Cesspool tanker	5	2000 to - 7000 litres	8
Dumper (small)	6	1.5 m^3	16
Dog van	1		16

BB-3.2 Results of investigation into loads carried by collection vehicles

Type of vehicle	Registration number	Loaded weight (kg)	Unloaded weight (kg)	Weight of refuse (kg)	Volume carried (m^3)	Waste density (kg/ m^3)
Dumper Placer	GJ3U 8662	5560	4010	1550	2.9	530
Dumper Placer	GJ3T 5680	6160	4090	2070	2.5	840
Dumper Placer	GJ3T 5670	5280	4040	1240	2.0	610
Tipper Truck	GRP 6180	4300	2680	1620	2.0	810
Tipper Truck	GRP 6184	4120	2660	1460	2.7	550
Tipper Truck	GRP 6181	4340	2670	1670	2.5	670
Average values						
Dumper Placer				1620	2.5	660
Tipper Trucks				1583	2.4	660

Weight of empty containers - 580 to 600 kg.

Chapter B-4

Private sector refuse collection in Rajkot

by Manus Coffey, D Mukhia,
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B-4.1 INTRODUCTION

Solid wastes from some wards of Rajkot were being collected by contractors. This arrangement was studied for two days in December 1995 in two wards - Wards 8 and 5 - and at the current dumping ground. The investigators interviewed several staff and officers of Rajkot Municipal Corporation (RMC), ward inspectors, and the contractors and their personnel.

The contractors were required to collect and transport solid waste from specified collection sites within the ward area as instructed by RMC supervisors by making a scheduled number of trips per day as specified in the contract agreement. Failure to complete the assigned work would result in a fine being imposed. In case of inability to complete the work, the Corporation would hand over the work to be done by some other agency at the contractor's cost.

This chapter reviews quantitative and qualitative aspects of the contractual arrangements, based on observations, interviews and measurements, and estimates the cost of collection of waste by this method. A cost comparison with the public sector service is presented. At the end of the chapter and in the appendix there are some more details about the contractual arrangements.

B-4.2 SUMMARY OF THE TRANSPORT CONTRACT:

Rajkot Municipal Corporation is divided into 20 wards out of which the collection of refuse from seven wards was being handled directly by the Corporation and the rest through private contracts. The private sector system was introduced in 1986. Amongst the reasons for contracting out some of the collection of refuse were

◊ the increase in the number of wards,

◊ the inability of the Corporation to employ more staff, and

◊ the desire to carry out the work in a more efficient and cost-effective manner.

At the time of the study there were eleven contractors who had been entrusted with the responsibility of removing solid waste, wet solids, rubbish etc., from the various wards. Each contract was for a period of one year beginning from 1st April to the end of the following March. At the end of each contract period, the contractor was normally required to continue with the work for another two months till he or another new contractor had been awarded the fresh contract.

At the time of bidding for the contract, the contractor was required to quote rates for loading, transporting and unloading, including labour charges etc., per day for each ward for which he was tendering, according to the number of trips cited in the tender documents. Once the contract had been signed and awarded, the contractor was solely responsible for collecting the refuse from the ward and disposing of it at the site specified in the contract.

According to the terms and conditions of the contract, the contractor was required:

- To provide the equipment, the labourers and the vehicles for transporting the garbage at his own cost from the places directed by the RMC supervisory staff of the respective wards.
- To collect the garbage and dispose of it at the dumping site by making two, three or four trips per ward as specified, within the prescribed time limit. The contractor was paid only for the number of trips specified in the contract and not for any other additional trips he might be required to make to finish his assignment. In some cases, especially during the rainy season and during festivals, he might also be required to make additional trips. Failure to complete the prescribed number of trips in a satisfactory manner would result in a penalty of Rs 100/- per trip as well as losing payment for the work not completed.
- In case of failure or breakdown of the truck, the contractor was required to arrange for another vehicle to complete the day's work.

- Each vehicle carrying the refuse was required to be covered while travelling to the disposal site.
- In case the contractor was unable to remove all of the refuse, the contractor would be liable to pay a penalty, and in addition to paying the penalty, the work might be entrusted to another agency at the risk and cost of the concerned contractor.

B-4.3 QUESTIONNAIRE RESPONSES

	Question	Answer
1	*Who are the contractors?*	Local transport contractors who are selected by RMC through tendering.
2	*How many are there?*	Eleven
3	*What are their hours of work?*	6.30 am to 2.30 pm in general, or until their daily assignment is completed.
4	*What workforce do the contractors provide?*	A driver/loader and three loaders.
5	*What are the wages*	Rs 50 per day for a driver and Rs 45-50 per day for a loader. [See note below]
6	*How old are the vehicles?*	Many are 20 - 25 years old, often with non-tipping, open bodies.
7	*What is the average time taken and what distance is covered per trip?*	90 - 140 minutes; 3 - 5 km.
8	*What is the average age of the workforce?*	23 - 40 years in general. (All workers are male)
9	*What is the average expenditure per truck for monthly maintenance?*	Approximately. Rs 2000/
10	*Do vehicles undergo regular safety checks?*	No, there are no checks until a breakdown occurs
11	*Are there any standby vehicles?*	All of the contractors have more than the one vehicle required for the contract operation. The spare vehicles are generally used for road works.
12	*Are there standby workers?*	Contractors get replacement workers from reliable sub-contractors.
13	*What health and safety measures are taken for the benefit of the workforce?*	No gloves, boots or masks are given to them. No regular medical checks are carried out but they are compensated when sick and in general treatment expenditures are borne by the contractors.
14	*What equipment is used?*	Spades, spikes, rakes, shovels and kadai (or bowls).
15	*Which days do they work?*	They work six days a week (Sunday is the rest day) and do extra work on Monday to catch up.
16	*To whom do they report at the start and end of the working day?*	To the Sanitary Inspector at the Ward Office.

Note:

[Question 5] When the driver of the truck only drives the vehicle he receives a daily wage of Rs 50/- per day. When the driver not only drives the truck, but also, at collection points, works as one of the loading crew, then besides his wage for driving (i.e. Rs 50/-) he gets a share from the payment made for loading and unloading. In general this is a total of Rs 150/- + Rs 30/- (for snacks) , so if four men are loading the share for each is Rs 180/4 = Rs 45/head. Therefore Rs. (50 + 45) = Rs 95/- is received by the driver when he helps in loading.

B-4.4 OBSERVATIONS OF THE CONTRACTORS' WORK

While observing the working of a contractor, it was observed that :

◊ According to the terms and conditions laid down, the contractor was doing the required number of trips.

◊ Loaders were clearing the spots reasonably well.

◊ In most cases, the loading process was being done at the required rate.

◊ In some cases they passed by pick-up points where the amount of refuse was very small.

◊ Loading of the truck was being done either by the labourers alone, or, in some cases, the driver was also involved in the loading and unloading activities.

◊ In conversation a contractor mentioned that he had not so far met with any labour problems or any vehicle accident.

B-4.5 SUPERVISION

As far as the supervision from both sides is concerned, observations showed that usually contractors did not engage supervisors, but were themselves supervising the work. The RMC supervisors, sub-sanitary inspectors and sanitary inspectors were also supervising. The sub-sanitary inspector directed the contractor if he missed a scheduled station or occasionally pointed out an unscheduled pick -up point where solid waste had accumulated. One peon (lowest paid worker) of the particular ward followed the contractor's vehicle and recorded whether he was satisfied with the work carried out by the contractor and also if they were keeping good records as follows:

Information provided by the register maintained at the Ward

Contractor's name	Name of driver
Date	Number of trips
Day	Arrival time at dumping site
Place of dumping	Departure time from dumping site
Truck registration number	Number of the register maintained at the site

Information provided by the register maintained at the dumpsite

Truck number	Ward number
Arrival time	Number of trips
Departure time	Number of workers

This provides good cross-checking at both places and prevents undue manipulation of individual staff. The contractor is required to submit an invoice according to the contract and should enclose a certificate provided from the daily register as a checking document.

Suggestion It is useful to evaluate the requirements of registers at intervals to ensure that all the information that is collected is necessary. If some of the information is never used, it may be advisable to remove the requirement to collect it from the register. Managers should show the clerks that the information which they collect is important (perhaps by discussing it with the clerks from time to time so that the clerks understand that the information they record is useful and valued.) If clerks think that the information that they record is of no importance, they will not take care to record it accurately.

B-4.6 PERCEPTIONS OF THE CONTRACTOR, RMC AND PUBLIC REGARDING THE CONTRACT

a) Contractor

There were some complaints from contractors about the number of trips that were sometimes required. The contract stated how many trips should be made daily, but on some occasions (festivals, fairs etc.) they were expected to carry out more trips, for which they did not get any extra payment. If payment for extra trips were to be included as a condition in the contract, then they would not have to meet this additional - and sometimes unforeseen - expenditure. A contractor was also somewhat unhappy that, at the direction of the supervisor, the crew could be required to load waste from unscheduled points in addition to the scheduled stations. Otherwise the contractor was satisfied with the terms and conditions in the contract.

b) Rajkot Municipal Corporation

Officials of the RMC were satisfied with the working of the contractors and they did not feel it necessary to make any alteration to the contract.

c) Public opinion

The operation of the contractors was discussed with some bystanders and the following comments were received. (This does not claim to be a comprehensive survey of public opinion.)

In general the opinion of the contractors' service was satisfactory but they felt that the refuse should be collected later in the morning (rather than early in the morning) in order to avoid household refuse being left in heaps after the collection crew had cleared the area.

The location of the bins should be such that they would not obstruct the movement of traffic and pedestrians.

d) Suggestions:

◊ Contractors were not paid for the extra trips which they occasionally did. The possibility of payment for such trips could be included in the conditions of the contract, provided that there was some way of ensuring that there was a real need for an extra trip.

◊ Contractors were not covering the loads with a tarpaulin during road travel, as specified in the contract. This should be enforced strictly.

◊ For better monitoring of the collection and transport of refuse, and also for future planning, the RMC should install a weighbridge at a convenient location and require that all loads be weighed. (Alternatively it may be possible to use an existing weighbridge, if this would not cause excessive delays and would not be much more expensive than to install a municipal facility.)

B-4.7 DAILY WORK SCHEDULE

At. 6.30 a.m. the contractor with his vehicle and workforce reported to the sanitary inspector at the ward office, where he was given the collection schedule for that day's work. The contractor then instructed his workforce to collect the wastes from different loading points. When the truck was fully loaded, it went to the dumping ground, was registered in RMC's register and unloaded according to the directions of the sub-inspector. The contractor received a certificate from the ward office if the trip was done properly. The Municipal Inspector checked the cleanliness of the storage points and issued certificates daily, based on which the invoices were prepared by the contractor on a monthly basis. If a vehicle and crew failed to report, Rs 100/- for each trip was deducted from their payment by RMC. Such incidents were rare.

B-4.8 SAMPLE WORK STUDY

The time spent studying the system was only two days. On the first day the investigators followed two trucks as waste was collected and transported to the disposal site. Table B-4.1 presents some of the data from one of the trips that was studied.

Table B-4.1 Work study investigation on 14th December 1995

contractor's open truck, registration number GTX 4184

Location of storage point	Distance from last point (km)	Time of arrival	Time of departure	Loading time (minutes)	Remarks
Gopal Nagar	1.0	9.50	10.15	25	Open dump
Sran Jibi	0.3	10.20	10.32	12	Cow dung, straw and normal waste
School no. 65 (west)	0.15	10.35	10.40	5	Small dump
School no. 65 (north)	0.1	10.48	11.21	33	Normal waste with building debris

Other details for the trip described in table B-4.1:

Weighbridge results (kg)		Times (minutes)		Volume and density
Truck when loaded	7 910	Stationary, loading	75	
Truck when empty	4 110	Travelling and unloading	76	Volume of waste 4.25 m^3
Weight of waste	3 800			
		Total trip time	151	Waste density = 3800/4.25 = 894 kg/ m^3

Average weight of waste for two trips that were followed 3 920 kg

The measured data and estimated densities for the loads are shown in table B-4.2.

Table B-4.2 Observations of loads in open contractor's trucks

Registration number	Date	Weights (kg)			Estimated volume (m^3)	Density (kg/m^3)
		Loaded	Empty	Load		
GTX 4184	14-12-95	7910	4110	3800	4.25	894
GTG 262	14-12-95	9030	4990	4040	4.1	985
GTA 1811	15-12-95	7120	4260	2860	3.9	733
GTK 4887	15-12-95	6700	4180	2520	4.13	610
GTX 4184	15-12-95	6880	4110	2770	3.95	701
GTZ 5866	15-12-95	7160	4970	2190	4.21	520
GTY 2818	15-12-95	6900	4280	2620	3.32	789

The fact that the trucks were being followed seemed to have a noticeable effect on the performance of the crews. The two loads that were collected under the observation of the team were considerably denser than the loads collected the next day when the team only weighed the trucks, but did not follow them as they were being loaded. The results table B-4.3 show the contrast.

The first impression is that the weights were more when the trucks were being observed because the labourers were being more diligent, but the similarities in the estimated volumes suggest that the trucks were loaded to approximately the same extent on the two days. The densities may have been less on the second day because

◊ the waste was different, being composed of less dense material on the second day;

◊ the loaders were able load the waste into the truck in a more porous way to give a lower density when they were not being watched, so that they could fill the body with less work; or

◊ the loaders leave the most dense material (nearest the ground, having been there for a longer period and compacted into the ground) except when they are being closely observed.

Alternatively, it may be that this effect is simply the result of the random variation of waste parameters, since the numbers of samples are small. It is also worth noting the magnitudes of the densities - 520 to 985 kg/m^3 - because these values are very high and totally unsuitable for collection by compactor trucks.

Table B-4.3 Comparison of loads in contractor's vehicles on the two days of the study

Date	Average weight of loads (tons)	Average volume of loads (m^3)	Average density of loads (kg/ m^3)	Comments
14-12-95	3920	4.17	874	Loading under observation
15-12-95	2592	3.90	568	Loading without observation

Note: 14-12-95 was a Thursday so there were no effects from the weekend.

B-4.9 COMMENTS ON CONTRACTORS VEHICLES:

In general the contractors vehicles were about 20 to 25 years old and were Fargo & Dodge petrol-engined, general purpose trucks with diesel engines fitted more recently. These trucks (with one exception) were fitted with flat rigid (i.e. non-tipping) bodies with low sides giving them an average capacity of around 4.0m^3.

Typically such a truck has a rated payload of 7000 kg, but observations showed that they were carrying an average of only 2,600 kg.

The contracts called for three or four loads to be collected by each truck. If these trucks were fitted with side extensions to increase their capacity by around 50% (typically 0.34m extensions) and the contract re-negotiated to allow for two loads per shift instead of three, the collection efficiency per truck might be increased and the working time reduced. Dropside top extensions could be used to maintain the present loading height for most of the loading operation but an additional labourer on the truck body would be required. Figure B-4.1 illustrates how the truck bodies could be modified. However the increase in efficiency could not be guaranteed, especially where the distances to the disposal site are short , because raising the sides of the body has the following negative effects:

◊ The waste must be lifted to a greater height, increasing the fatigue of the loaders and slowing their pace of work;

◊ Lifting the waste manually to a greater height makes the operation more hazardous to health since there is more chance for the waste - especially dust - to fall on the labourers' heads;

◊ An extra labourer may be needed to stand in the waste already in the truck, thereby increasing the wages bill (or reducing the numbers of loaders on the ground) and this labourer runs a high risk of injury and infection if he stands in the waste without satisfactory protective footwear;

◊ It is more difficult for an inspector to check that the body is full if the sides are so high that he cannot see into the body, so the trucks may not be loaded to their full potential;

◊ Old trucks may suffer more wear and tear (particularly to their transmissions) if they are required to operate on the uneven and soft ground of a disposal site at their full gross weight rather than at a lower weight.

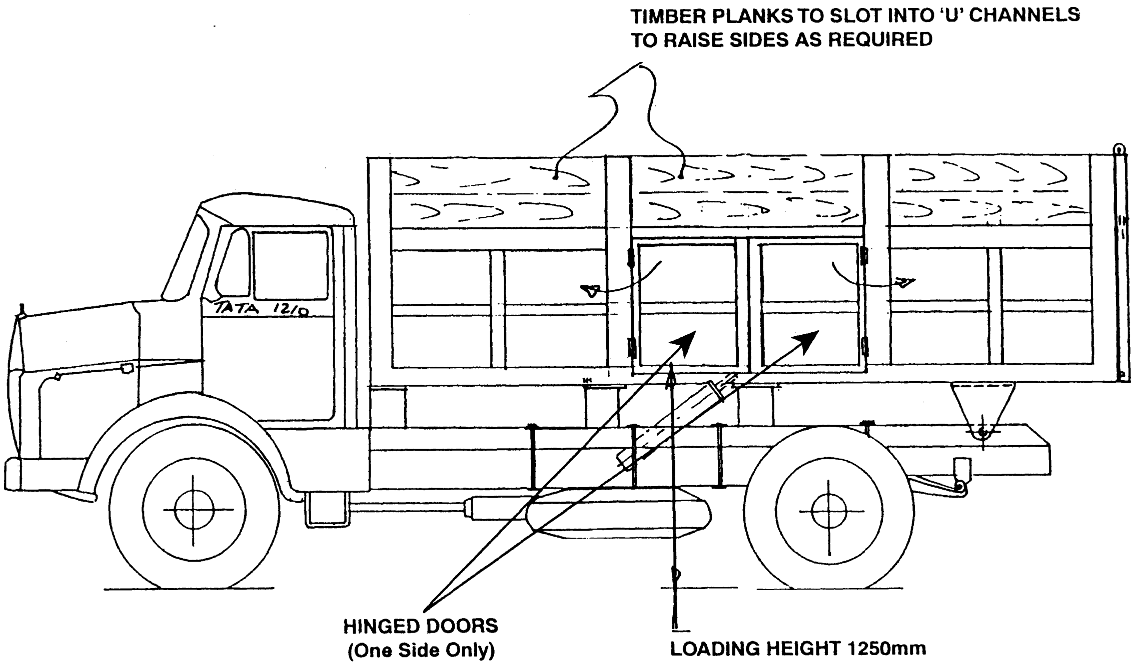

Figure B-4.1 ***Proposed modification to TATA 1210 tipper truck to increase load capacity and reduce loading height***

B-4.10 ESTIMATION OF COST OF COLLECTING ONE TON OF WASTE

Since the contractor provides manpower, vehicles and equipment , the costs of the service can be computed simply from the contract rates. This is done in table B-4.4 and the following calculations.

Table B-4.4 Rajkot Municipal Corporation Contract rates for lifting of garbage

Ward number	Number of trips each day	Rate of payment for one day's work Rs
3	3	640
4	3	600
5	3	600
8	3	625
9	4	855
11	4	875
13	4	800
14	3	700
16	2	440
17	4	736
18	3	700
19	3	650
20	4	797
Totals	43	9 018

Average cost per trip = 9018 / 43 = Rs 209.7

Average cost per tonne =209.72 / 2.592 = Rs 80.91

According to the rates given above, the cost of collection and transport of wastes comes to almost Rs. 81 per tonne.

This figure does not include the cost of supervision and administration of the contracts by the RMC, so the total cost of solid waste management is a little higher than this. The labour-related overheads in section B-3.9, part (c) [for a municipal tipper truck, single shift operation] are Rs 17100 / 988 = Rs 17.3 per ton. Much of this would be costs related directly to hiring the labourers, such as benefits and holiday replacement, but if it assumed that the costs of supervision are Rs 14/- per ton, the total cost per ton for contract operation is increased to Rs 95/-.

B-4.11 COST COMPARISON BETWEEN PRIVATE SECTOR AND MUNICIPAL OPERATIONS

The unit cost calculated above may be compared with the costs of the municipal service that were presented in the previous chapter. Table B-3.2 is reprinted below.

Table B-3.2 Summary of unit collection costs

Vehicle type	shifts	cost per ton, Rs
Dumper placer	1	151
	2	120
Open tipper	1	228
	2	174

When compared with the unit cost of Rs 95 for private sector operation that was calculated in section B-4.10, it shows that private sector collection is at least 20% cheaper than any of the municipal options.

The costs do not tell the whole story. When evaluating alternatives the following factors should also be considered:

- ◊ The most economical municipal alternative includes the purchase of containers which keep the wastes off the streets and present a neater appearance, although they may increase the distance that residents are required to carry their wastes.
- ◊ The economy of the private sector is largely due to the lower wages paid by contractors - or alternatively, to the generous pay scales and benefits paid by the Municipality. The fact that contractors do not have problems in recruiting labour suggests that rates of pay are no worse than in other activities of the private sector. It was not confirmed in the study whether contractors' practices conformed to all relevant labour laws.
- ◊ The loaders working with open trucks are more exposed to health hazards and injury as they load and unload the trucks. The municipal dumper-placer system is much more satisfactory in terms of health risks.
- ◊ Air pollution from an old truck is likely to be more than from a newer municipal vehicle, but since the contractors' trucks make fewer journeys because they carry more on each trip, the private sector system causes less traffic congestion.

B-4.12 FURTHER COMMENTS ON CONTRACTUAL ASPECTS

by Mrs Jaiwanti Sheokand, J B Kagathara and P K Raveendran

- ◊ The terms and conditions of the contract are presented in appendix BB-4.
- ◊ Since the contractor provides the vehicle, the capital expenditure of the Corporation is reduced.
- ◊ The contractors engage only hard-working labourers, and can easily end the employment of any who do not work efficiently.
- ◊ There are several ways in which the labourers may be exploited:

- ⇒ The contractor may engage a smaller number of labourers (though the municipal supervisor should object to this) and oblige the remaining workers to do more for the same wages.
- ⇒ The contractor may pay the labourers less that the statutory minimum wage.

◊ The amount of waste to be transported is not objectively defined in the contract, so, if litigation were to arise, it might be difficult for the Corporation to win its case. In fact, the first contracts were written in terms of the weight of waste that should be collected, but this encouraged contractors to mix heavy debris with the lighter domestic wastes that they were supposed to collect in order to increase their income. So after four years the basis for the contract was changed to the daily clearance of all storage sites in a particular ward. Such storage sites can quickly be filled with waste after they are emptied, so it is important for clearance to be verified by a municipal employee.

◊ Clause 27, that states that the decision of the Municipal Commissioner is binding in any dispute, might be challenged in a court of law.

APPENDIX BB-4 TENDER DOCUMENTS FOR PRIVATE SECTOR REFUSE COLLECTION, RAJKOT

RAJKOT MUNICIPAL CORPORATION

HEALTH DEPARTMENT

TENDER FOR THE YEAR 1995-6

Tender Fees Rs . . . . . . /-

Tender for daily Lifting of Solid Waste, Wet Solid, Rubbish etc. collected by way of cleaning and thrown away by the City dwellers in Ward No. 3, 4, 5, 7, 8, 9, 11, 13, 14, 16, 17, 18, 19, and 20 of the Health Department of Rajkot Municipal Corporation.

Ward	Rate for Daily Lifting of Solid Waste	
No.	Rate For Total 3 trips daily	Rate For Total 4 trips Daily

Name of the Contractor :- ....

Office & Resi. Address:- ....

....

....

Rajkot

Date:- .... Signature of the Contractor

Note:- The Contractor shall have to fill up the Wardwise Rates as per the approved trips.

On next page: Terms and Conditions

RAJKOT MUNICIPAL CORPORATION

HEALTH DEPARTMENT

Terms and Conditions for lifting of Solid Waste, Wet Solids, Rubbish, etc. collected by way of cleaning in general in the different wards under Health Department of R.M.C.

TERMS AND CONDITIONS

1) The Contractor shall have to quote the rates for Daily lifting up of Solid Waste, Garbage, Rubbish, Fillings etc.
2) The Contractor whose Tender will be accepted by the R.M.C. shall have to enter into an agreement on Stamp Paper with R.M.C. by affixing required stamp as per Stamp Duty Act.
3) The Time Limit for the said work will commence from the date of agreement up to ....1995/96. However till the new Contractor is not entrusted the said work, the First Contractor should be continued for further two months.
4) The Contractor shall have to pay the Wardwise Security deposit in favour of R.M.C. amounting to Rs. 20,000/- by Cash or F.D.R.
5) The Solid Waste, Garbage, Rubbish, Filling, and the Solid Waste from Vonkala, as well as filling shall be lifted as per the instructions and satisfaction of the Sanitary inspector or Sub-Inspector of The Ward, and shall be dumped at Sinduriakhan which is located near School No. 63 on Kothariya Road behind Indiranagar Public Toilet and the so lifted solids etc. shall be spread as per the instructions of the Supervisor-in-Charge at Sinduriyakhan.
6) The Contractor shall have to quote the rates per day including loading, unloading and Spreading Solid Waste etc. as per the instructions and labour Charges and lifting by Truck from the place as directed including Labour charges etc.
7) The Solid Waste etc. shall be lifted by making 4 Trips in Ward No. 9, 11,13,17, and 20.
8) The Solid Waste shall be lifted by making 3 Trips in Ward No. 3, 4, 5, 7, 8, 14, 18, 19, and the Solid Waste etc. shall be lifted by making 2 trips in Ward No. 16
9) After every Trip, the Contractor shall take the Signature of Supervisory staff of R.M.C., in prescribed form.
10) The Contractor will have to make his own arrangements for necessary equipment, labourers and Transporting the Solid Waste etc. at his own cost and as such the complete responsibility will be of the Contractor.
11) The Contractor shall have to complete the prescribed Trips without fail in every Ward. The Contractor shall have to keep informing in respective Ward without fail, the Trips carried out for the Work. The Contractor shall take the signature of the respective Supervisory staff for Spreading of Solid Waste, Wet Solid, Garbage, Rubbish, Filling, etc. at the place where spread.
12) The Dry Solid Waste, Solid Waste, Rubbish, Fillings, as well as The Rubbish from the Vonkala, shall be lifted as per the instructions of Supervisory Staff of respective Ward. The Driver shall get Daily Certified by the Supervisory Staff of The respective Ward, for the Solid Waste etc. lifted, as per the Instructions.
13) The prescribed Time Limit For Lifting of the Solid Waste etc. will be from morning 6.30 to 2.00 afternoon. The Vehicle should be brought at 6.30 in the morning at Ward Office. The Solid Waste etc. shall be lifted as per the prescribed trips, failing which, a Penalty of Rs. 100/- per Trip will be imposed.
14) In The respective Ward if it is observed that the Solid Waste etc. is not lifted or not lifted fully, the same will be lifted fully through other agency at the Risk & Cost of the Contractor and a penalty as per the Condition No. 10 will be imposed as well as the additional expenditure required to be incurred, if any, will be collected / deducted from the bill of the Contractor.
15) The Prescribed Trips of the Truck will have to be carried out by the Contractor and if required, the Contractor shall carry out more trips than the prescribed for lifting of Garbage, Solid Waste etc.

and cleaning of Ward, especially in Rainy Season and Festival like Janmashtami, Diwali, Makar-Sankranti, and other such occasions.

16) The Complete Details viz. from which Ward the Solid Waste etc. is to be lifted by making how many trips, etc. is given in this Tender. In the given limits of trips, the complete solid Waste etc. are required to be lifted. However if the complete Solid Waste etc. is not lifted by the Contractor within the prescribed trips, the Contractor shall lift the remaining Solid Waste etc. completely by making additional trips for which will not be paid extra amount.
17) Due To some or the other reason if the Truck doesn't come, the Contractor shall have to arrange for the another Truck immediately.
18) The truck loaded with Garbage or Solid Waste etc. shall be covered with Tadpatri. The floor of the Truck body shall be in level and without damages or holes, and shall be of sheet metal fixed at the bottom.
19) The Competent Authority or Employee of R.M.C. will carry out the Day to Day Supervision of the Work and by them, if the work carried out is not found Satisfactory, then the Rojkam will be prepared and competent officer will be at liberty to impose and deduct the penalty and will instruct for completion of necessary cleaning Work.
20) During the Day to Day Supervision by the Sanitary Inspector, Sanitary Sub-Inspector, competent officer or employee, if the work carried out by Contractor is not found as per the requirement or irregularities in the work, if any, on the basis of report from above staff of R.M.C., the Contractor will be issued a Notice through competent Officer, for declaring the Contract as terminated as well as forfeiting the deposit paid by the Contractor.
21) After entering into an agreement with R.M.C., if the Contractor fails to follow the same or if abandons the work uncompleted in that case the deposits paid by the Contractor will be forfeited and the remaining work will be carried out through other agency at the Risk and Cost of the Contractor and it will be sole responsibility of the Contractor for whatsoever expenditure. Also legal proceedings will be carried out against the Contractor.
22) During the Contract of work till completion of the same if any damage to any property, Lives of People or any accident or damages occurs due to the fault of the Contractor, his Truck Driver or his Labourers then the Contractor will have be solely responsible for the same and R.M.C. will not be responsible for the incidents, if any.
23) The Bill For The Work shall be submitted in the Health Department of the R.M.C., in the prescribed form of statement.
24) The Contractor those who are filling up this Tender should have their own vehicle and the capacity of the vehicle should be of minimum 4-5 cft, which is necessary. (See note below)
24) Alongwith the Submission of Rates for the work, The Contractor shall have to pay Earnest Money Deposit by a Demand Draft in favour of Rajkot Municipal Corporation, amounting to Rs. 2000/- wardwise. The Offer received without Demand Draft for Rs. 2000/- against E.M.D. will be rejected.
25) If the Work will not be carried out up to the mark of Satisfaction or if the work will not be carried out as per the written / oral instructions of the Competent Authority / Employee or if the Contractor is found breaching any condition/s of the Contract, in that case Security Deposit will be forfeited. Also the contract will be declared as terminated, for which no Notice will be required to be issued nor any reason thereof.
26) R.M.C. will be at its liberty entrust the work to another agency in case if it is found that the work carried out by the Contractor is not satisfactory and the same will be binding to Contractor.
27) If any dispute / legal / or litigation arises, the decision of the Municipal Commissioner will be final and binding to Contractor.
28) Upon acceptance of rate of the Contractor whose rate is found to be lowest if the Contractor fails to work, the Earnest Money Deposit will be forfeited.
29) R.M.C. will be at its liberty to terminate the Contract of any ward whenever it is felt that R.M.C. is in position to lift up the Solid Waste.

Statement showing the Details of Trips and Lifting of Solid Waste etc.

Ward No.	No. Of Trips	Ward No.	No. Of Trips
9	4	3	3
		4	3
11	4	5	3
		7	3
13	4	8	3
		10	3
17	4	14	3
		16	2
20	4	18	3
		19	3
Total =	20	Total =	29

Grand Total = 49

Medical Officer of Health
Rajkot Municipal Corporation

Notes

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Clause 24. The authors of section A-4.12 thought that a contractor who has the capacity to hire a vehicle should also be permitted to tender. As it is only those who actually own a truck may be considered.

There seems to be an error in the required volume. The volumes of the loads in table B-4.3 were approximately 4 m^3, which is equivalent to about 140 ft^3, but the payload was too low with such a capacity. Perhaps the recommended minimum should be 6m^3, or 200 ft^3. It is likely that the error in clause 24 is in the units, in that the minimum should be 4 - 5 m^3, not ft^3. In a sense it is not necessary to prescribe a minimum since it is in the Contractor's interest to carry as much solid waste as possible each trip, in order to minimise the number of trips.

The original has two clauses marked "24", and this error has been reproduced here in order to maintain the same numbering system.

Chapter B-5

Performance of JCB and tipper combination

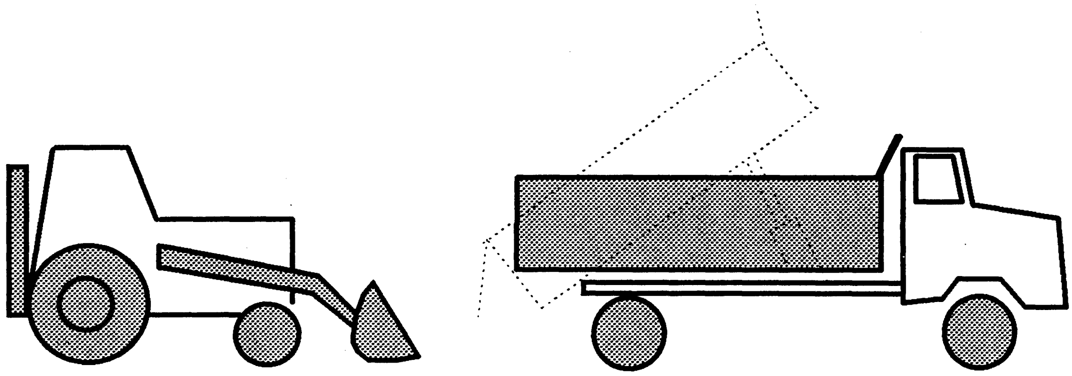
by J K Bhattacharyya
and A K Sarkar

B-5.1 INTRODUCTION

In Ahmedabad, a variety of types of vehicles are used to collect solid waste from different situations. JCB payloaders (as shown in sketch form in figure B-5.1) are used to remove wastes from open storage points. They load the wastes into open tipper trucks, which transport the wastes to the disposal site, and unload in a short time because of their tipping bodies.

A time and motion study (or work study) was carried out for this system, operating in the South Zone of Ahmedabad in 1994. The purpose of this study was to evaluate the efficiency of the system and level of utilisation of the vehicles and manpower, and to look for ways of improving the efficiency. This study is different from the studies in other chapters in that it concerns a group of vehicles of two different types working together. Costs were not calculated in this case, but the data presented here would be useful in estimating the costs of the present system and the impact on the costs of suggested improvements.

Ahmedabad Municipal Corporation owned five JCB payloaders, out of which three were in daily use, operating three shifts per day. The timings of the shifts were 7 am to 3 pm, 2 pm to 10 pm, and 9 pm to 5 am. Each payloader worked with four tipper trucks. Drivers reported to the vehicle workshop, and drove their vehicles to the zonal office where a cleaner or assistant was allocated to each vehicle.



a) JCB payloader *b) Tipper truck*

Figure B-5.1 Conceptual illustration of payloader and tipper

Payloaders are usually used for removing wastes from transfer stations and big vats (enclosures), and for clearing up backlogs of large quantities of waste, because they are most suited to removing large quantities from one place in a short time. (Such large open dumps of waste are not to be encouraged from a sanitation or aesthetic point of view, because wind, animals and rag-pickers scatter the waste, and the piles encourage rat and fly breeding.) If the system is to work efficiently, the number of trucks must be carefully matched to the quantity of waste and the time needed to take the waste to the disposal site, unload and return. Both payloaders and tippers need a higher level of maintenance than simple open trucks.

B-5.2 TIME AND MOTION STUDY OBSERVATIONS

The operation of the vehicles was followed for one shift, the times loading, travelling and unloading were noted, the distance travelled by the payloader was measured, and the loads were estimated or measured. The data collected are shown in tables B-5.1 and B-5.2.

Table B-5.1 Time and motion study of JCB Payloader

JCB Payloader No. 1792 72 HP Bucket capacity $1 m^3$ Loading height 3.33 m
1st shift - 7 am to 3 pm. Diesel issued 38.8 litres

Time	Distance meter [km]	Location / station	Tipper reg. No.	Loading time [min]	Approx. load [tons]	Notes / remarks
7.35	1118	Garage	9000 6530 6538 6546			Start from the garage
7.45	1119	South zone office	9000 6530 6538 6546			Provide cleaner to payloader and one S.S.I. No written allotment of area was given. It took only 5 minutes
7.55	1120	Chowpatti	6546 6530 6538 9000	1	0.5	
8.00	1121	Zoo garden	6546 6530 6538 9000	6 6 7 9	0.5 1.5 1.0 1.0	Attended after 3 days. Garden refuse only. All refuse vehicles left for disposal site with loads of 1 to 1.5 tons.
			6530 6546 9000	6 6 6	1 1 0.5 - 0.8	Buckets were not full. After this JCB operator had a tea break as there were no trucks.
10.10	1122	open air	6530	4	2	Refuse
10.25	1123	Macchi Pire	6546 9000	5	1.5	Tipper 9000 reported at 10.30 but there was no garbage.
10.40	1124	Bhalikia	9000	7	2	Bucket not full
11.00	1127	Uttamnagar	6530	7	3	6530 reported at 11.08, i.e. 8 minutes after payloader. 8899 reported instead of 6538, which went to carry debris. There was a good vat, but there was no waste inside it.
11.27	1128	Basant-nagar	8899	7	1.5	Dry leaves. This point had not been attended for 7 days
11.37	1128	Millatnagar 1st point	6546 9000	5	1.25	6545 arrived 8 minutes after JCB. 6545 left for garage because of brake failure
		Millatnagar 2nd point	9000	6	2.5	Rubbish and refuse
12.00	1138	Pragati-nagar	9000 6530	5 9	1.5 3.5	Refuse 6530 was taken to the municipal weighbridge at 1.45 pm. Weight of load 3035 kg.

Notes: Loads were estimated from experience.

Total estimated load	26 tons
Time taken	4 hr 25 min.
Number of trips	15
Average load per trip	1.7 tons

Table B-5.2 Time and motion study of tipper 6530

Conventional tipper Registration number 6530 110 HP Wheelbase 4470 mm
Cargo body capacity 6.4 m3 Loading height 1817 mm
Gross vehicle weight [GVW] 15244 kg Tare weight 6945 kg Payload capacity 8299 kg

Vehicle out from garage 7.35 am Issue of diesel fuel is typically 45 litres
Reporting to South Zone office 7.45 am
Departure from South Zone office 7.50 am

Trip	Location	Loading point		Disposal site		Load	Payload
no.		Arrival	Departure	Arrival	Departure	carried [kg]	utilised [%]
1	Chowpatti	7.55	7.57	There was no solid waste			
1	Zoo garden	8.00	8.12	8.37	8.47	1500	18
2	Zoo garden	9.12	9.18	9.41	9.51	1000	12
3	Open air	10.13	10.17	10.38	10.48	2000	24
4	Uttamnagar	11.08	11.20	11.38	11.48	3000	36
5	Pragatinagar	12.06	12.15	1.05	1.10	3035 *	37

Notes: * This load was measured on a weighbridge. The other loads were estimated. [The load for trip no. 5 was estimated to be 3.5 tons.]
The average payload utilisation capacity was 25.3%

At some loading points there was little or no waste, so time was wasted travelling to that site, often by several vehicles. The trucks were generally not full when they went to the disposal site, so the cost per ton was increased since the time and fuel for a trip were spent on a relatively small quantity of waste. The trucks were designed to carry a weight of over eight tons, but the average of the actual loads was less than two tons, and only 25% of the load carrying capacity of truck 6530 was used during the shift that was studied.

The average loading time of the payloader was observed to be about one minute per cycle - a cycle includes loading the bucket, moving between the waste and the tipper, and discharging the bucket.

B-5.3 ANALYSIS OF RESULTS

The working time can be divided into categories:

- ◊ Actual productive time - This is the time when the person or equipment is operating and achieving the desired purpose - in this case moving waste.
- ◊ Productive idle time is the time spent unavoidably and necessarily, but without working towards achieving the desired objective. For example, when the payloader is loading a truck, the truck is waiting, and as far as the truck is concerned this is productive idle time. Another example is the time spent reporting to the zonal office.
- ◊ Non-productive idle time is time lost to tea breaks, because of lateness etc.

Table B-5.3 is used to calculate the time utilisation of the payloader. It shows that not all of the required data were collected; as a result some values were estimated. This example illustrates the need to practice collecting work study (or time and motion) data, since it is sometimes difficult to know in advance what data will be needed and how they can be measured, so it is generally advisable to regard the first observation as a trial and aim to start using the data collected on the second observation. It is seen from the table that the actual loading time is 21% of the total shift, that waiting time is estimated to be 36% and that non-productive idle time, according to the guessed values, was 26% of the official shift time, because of a delayed start and an early return. If more trucks were available, or if the trucks were able to carry more, the productive idle time (waiting) could have been reduced.

Table B-5.3 Time utilisation of payloader

(Based on data in table B-5.1. Time intervals in minutes)

Time			Activity / location	Actual productive time	Productive idle time		Non-productive idle time
Start	Finish	Interval			Travel	Waiting	
7.00	7.35	35	Delay in starting shift				35
7.35	7.45	10	Travel to Zone Office		10		
7.45	7.50	5	Office administration			5	
7.50	7.55	5	Travel to Chowpatti		5		
7.55	8.00	5	At Chowpatti *	1	4		
8.00	10.10	130	At zoo garden	46	4	80	
10.10	10.25	15	Open air	4	4	7	
10.25	10.40	15	At Macchi Pire	5	4	6	
10.40	11.00	20	At Bhalikia	7	12	1	
11.00	11.27	27	At Uttamnagar	7	4	16	
11.27	11.37	10	At Basantnagar	7		3	
11.37	12.00	23	At Millatnagar I and II	11	12		
12.00	15.00	180	At Pragatinagar, and returning to garage	14	20 **	56	90 **
			TOTALS	**102**	**79**	**174**	**125**
			PERCENTAGES	**21**	**17**	**36**	**26**

Notes * Unless otherwise recorded, the travelling time is estimated as 4 minutes for 1 km (that is, a speed of 15 km/h)

** Insufficient data were collected, so these values are guesstimates.

Table B-5.4 Time utilisation of tipper 6530

(Data taken from table B-5.2. All times are in minutes)

Trip No.	Location / activity	Productive idle time		Actual productive time - travel and unloading			Non-productive idle time
		loading	other	to disposal	unloading	returning	
	Delay in start						35
	Garage to Chowpatti		20				
1	Chowpatti		5				
1	Zoo garden	6	6	25	10	25	
2	Zoo garden	6		23	10	22	
3	Open air	4		21	10	20	
4	Uttamnagar	7	5	18	10	18	
5	Pragatinagar	9		20 (1)	5	20 (2)	
	Weighing, returning		80 (3)				40
	TOTALS	**32**	**116**	**107**	**45**	**105**	**75**
	PERCENTAGES	**7**	**24**	**22**	**9**	**22**	**16**

Notes: (1) 50 minutes elapsed between leaving Pragatinagar and arriving at the disposal site. It is assumed that this time was taken to go to the weighbridge and weigh the full vehicle

(2) It is assumed that 50 minutes were needed to weigh the empty vehicle and return to the collecting area, and that, as before 20 minutes were for the usual journey to the disposal site and 30 minutes for weighing.

(3) This time interval comprises two periods of 30 minutes for weighing and 20 minutes for returning to the garage via the zone office

The results for the tipper truck show that 53% of the shift was actual productive time (travelling and unloading), and this could have been higher if the truck had not been weighed, or could have been weighed at a more convenient location. These results depend on assumptions to cover missing data. The non-productive idle time is less than for the payloader, probably because of the extra requirement to weigh the truck on this occasion, which prevented the driver from returning to the garage at the normal time.

B-5.4 DISCUSSION

It must be remembered that people usually work differently when they are being observed, and that taking one of the trucks for weighing may have disrupted the normal working pattern.

As is usually the case with open trucks, the load that could be carried was restricted by the volume of the body (6.4 m^3), not the load that the chassis could carry (8299 kg). The key factor is the density of the waste. Some of the waste mentioned in table B-5.1 probably had a very low density (perhaps 75 kg/m^3 - especially the dry leaves, and probably the garden waste). On the other hand, some of the domestic waste that was collected may have been wet and partially decomposed, with a density of 600 kg/m^3 - eight times as much.

The following calculations illustrate the effect of volume utilisation and body size, and point the way to a possible improvement in the system.

Present body volume		6.4 m^3
Weight of full load if density is 500 kg/m^3	= 64 x 500 =	3200 kg
Average load (table B-5.1)		1730 kg
Average current body utilisation	= 1730 / 3200 =	54%

If the utilisation rate of the existing trucks could be increased, it might be possible to operate with three tippers to every payloader, instead of the current four. Having a smaller number of tippers in the team might result in longer waiting times for the payloader - for example if three trucks are quickly filled and despatched to the disposal site, there would be a longer interval between the filling of the third and the return of the first than if there were four trucks. However, counteracting this effect, it would take slightly longer to load the same waste into fewer trucks because more care should be taken to fill all of the body, rather than just dumping a few bucket loads into the middle of the truck. Utilising the capacity of the trucks more fully would also mean that a tipper that was not quite full would need to go with the payloader to the next site in order to be completely filled - not a problem if the distance were small, but a significant delay over a longer distance because of the slow speed of the payloader.

A further increase in the utilisation of the payload capacity of the tippers could be achieved if the body size were doubled to 12.8 m^3, as the following calculation shows

Payload capacity of existing vehicle		8299 kg
Average load (table B-5.1)		1730 kg
Current payload utilisation	1730 / 8299 =	21%
If body volume 12.8 m^3 and refuse density 500 kg/ m^3, maximum payload would be	12.8 x 500 =	6400 kg
New payload utilisation would be	6400 / 8299 =	77%

The body volume could be doubled by raising the sides by 600 mm. The loading height would then be (1817 + 600 =) 2417 mm, which is still comfortably less than the height to which the payloader is able to load - 3330 mm. Raising the sides might add one ton to the weight of the body, but the weight of the refuse and the extensions to the sides would add up to only 7400 kg, which is less than the payload of 8299 kg for which the chassis and tipping mechanism are designed.

If the sides are raised, it is important to modify the tailgate so that it does not trap the waste when the body is being tipped, as shown in figure B-5.2. The hinge should be fixed at the highest point of the body, above the height of the top if the waste.

If the capacity of the tippers is increased in this way, two trucks can have the carrying capacity of four, so it may be possible to reduce the number of tippers working with a payloader from four to two, or otherwise it might be possible to greatly increase the productivity of one payloader, if the trucks it loads can carry much more at one time.

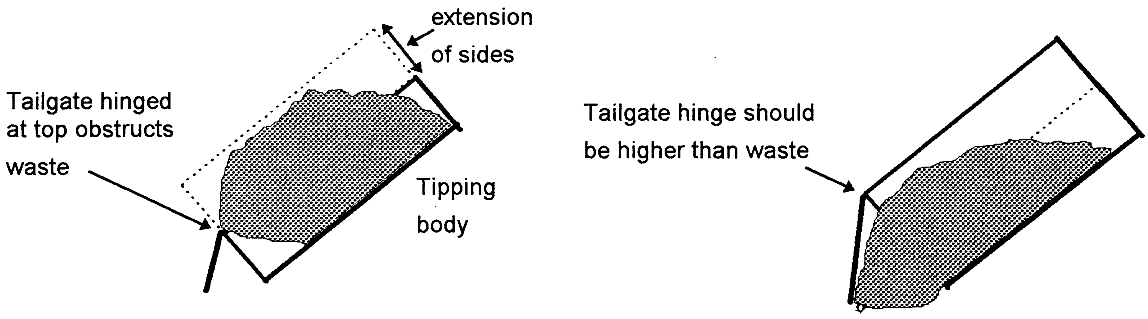


Figure B-5.2 Obstruction to unloading caused by top-hinged tailgate

At some storage points, the accumulated amount of waste was very small. (For example, the record in table B-5.1 shows that, before this study, one point had not been attended for seven days, and another for three days.) It is not economical for the payloader to go to a collection point where there is very little waste, so either money is wasted in sending the payloader to move a small quantity of waste, or the collection point is not visited for some time until a larger amount of waste has accumulated. If the waste is dry or inert, such a delay may be acceptable, though it may have unacceptable aesthetic or nuisance effects. On the other hand, if the waste contains wet or biodegradable material, there may be serious odour problems and a high degree of fly breeding if the waste is left for several days. A better solution for such places would be to use another storage and transport system, such as a hook lift container or something smaller, according to the volumes of waste generated. Payloaders should only be used where the rate of waste production is very large.

Although it may be possible to design a theoretical model for such a system to ensure high actual productive times for both payloader and tipper, in practice is it very difficult because of the daily variations in the volumes of waste at the different collection points.. Ideally the payloader should just have finished loading the last of the trucks on their first trip (for example) when the first of the tippers returns for loading for its second trip. In practice, either the payloader must wait for the tippers or some of the tippers must wait their turn while others are being loaded. However a good supervisor can achieve a satisfactory level of performance, particularly if he is able to direct the trucks to the next rendezvous with the payloader, as they travel back from the disposal site. The best way of doing this is to have two-way radio communication with the tipper drivers. In a situation where the drivers do as many trips as they can in a day, such a system could pay for itself (in terms of reduced operating costs) in a short time, but if the drivers do only a fixed number of trips in a shift (because of labour union agreements, for example) then the investment in two-way radios may not be worthwhile. A compromise arrangement might be for the supervisor to have a mobile phone with which he could relay instructions to the drivers via the gatekeeper at the disposal site. In many parts of the world, all refuse collection trucks are fitted with either radios or mobile phones in order to maximise utilisation and efficiency, and minimise the effects of breakdowns and unusual surges in waste quantities.

The unit costs for this system are likely to be comparatively low, because large quantities of wastes can be handled quickly and the labour requirement is low. To operate efficiently, this system requires large quantities of waste to be collected at a small number of sites, and this can lead to waste being left to accumulate for a few days, causing a number of sanitary and environmental problems. Such a system requires that waste be collected from a relatively large population, and this normally means bringing the waste a long distance - too far for householders to bring themselves, but reasonable if a tricycle or handcart primary collection service is provided. This method falls between the situation when a hook-lift container system is appropriate, (for which the accumulated volumes of waste are smaller), and the transfer station concept described in chapter A-3, which would be best suited to larger daily quantities.

The bucket of a payloader cannot be expected to pick up all the waste and leave the site clean. It is easy for the bucket to damage masonry walls if the operator tries to clean into the corners. A sweeper should always work in conjunction with a payloader in order to ensure that all the waste is removed each time, and that the collection point is left in a clean and orderly condition.

B-6.2 HOUSE-TO-HOUSE COLLECTION METHOD

In 1995 there were 23 routes for house-to-house collection in F North Ward, collecting on alternate days - 13 in the morning and 10 in the afternoon shift. Most of the plots had 20 to 30 apartments in them, in buildings of four or five storeys.

Observations and recommendations
The full record sheet of observations is reproduced in appendix BB-6.1, and results calculated from the data are also shown. The truck stopped at 12 places and collected waste from one community enclosure, a park, and sixteen apartment buildings.

Some of the storage facilities were located at the rear of the properties, so that the loaders were obliged to walk an extra distance carrying the waste, sometimes through narrow passages. Presumably the rear location is preferred so that residents do not see the waste every time they enter or leave their building. Such locations add to the work of the loaders, so it might be considered whether there should be a regulation to require that storage facilities be within a certain distance of the entrance to the property. A lightweight two-wheeled trolley might be helpful in transporting the waste to the truck; in this way one loader could carry the waste from the storage point to the truck, but two loaders would still be needed on the ground to lift the waste to give it to the pair in the vehicle.

The waste was generally stored in small masonry enclosures, though in some cases it was simply heaped in a pile. Loading the waste from the ground like this is inefficient and insanitary. It would be helpful if the waste were kept in bins or portable containers such that they could be lifted directly up to the pair in the truck for emptying. In this way the waste would not touch the ground. The difficulties with requiring residents to provide their own containers are:

- some of the containers may not be of a suitable type, or may be damaged so that they cannot be lifted or carried conveniently, and
- residents may fear that their containers would be stolen, even though they are kept within the property boundary.

If containers were provided by the MCGM, this would be a great expense for the Corporation, unless an effective way were found of recovering the cost from the residents, and such containers would still be at risk of damage and theft. Another alternative would be to require that waste be kept in plastic bags, but residents might object to the cost of purchasing the bags, an this would add to the quantity of plastic in the waste - and many solid waste managers are trying to find ways of reducing the amount of plastic film that is found in solid waste. Enveloping the waste in plastic bags would also have an impact on recycling.

The truck driver experienced difficulty in negotiating his way between parked cars, and on some occasions he obstructed the traffic. At least once he was prevented from getting close to the storage points, so that the loaders were obliged to carry the waste an extra distance. The areas that are suited to this type of collection, and the times when collection can be carried out, must be identified taking traffic problems into consideration. Sometimes smaller vehicles are needed.

Rat burrows were obvious near some of the storage points. Storing waste on the ground encourages rats, since the waste is an easily accessible source of food. Waste should be stored in closed containers and action should be taken to kill the rats and prevent burrowing.

Some of the storage bunkers opened onto the streets, and were in a state of disrepair so that the waste fell onto the street. Such facilities should be repaired.

Large quantities of waste were produced by restaurants and other commercial premises. Some of these wastes were especially difficult to handle - for example wet food remains and coconut shells - which were handled individually. Such businesses should be charged a fee for solid waste management that reflects the quantities of waste that they produce and the difficulties experienced in handling it.

B-6.3 BELL RINGING COLLECTION METHOD

There were three bell ringing routes in F North Ward; each route was served daily, seven days a week. One loader walked ahead of the truck, ringing a bell to invite residents to bring their waste out to the truck. The waste was lifted into the truck by two labourers, being given to two others who emptied the residents' containers in the truck. In this way the waste did not touch the ground and did not require double handling.

Only part of the waste loaded into the truck was received in this way. Street sweepers brought their containers for emptying, and there were roadside piles. Much of the waste was loaded from vats or enclosures, or from other storage facilities, that belonged to businesses, so the crew needed to have the tools mentioned earlier in this chapter in order to pick up waste from the ground.

The area from which the waste was collected was known as the Parsee Colony. The Parsees, descendants of Zoroastrians from Iran, were reputed to be very clean and orderly, and so it may be that some of the behaviour recorded here could not be expected amongst other social groups.

Observations and recommendations

Appendix BB-6.2 shows the work study record and some analysis of the data collected.

One of the most striking observations is that very little waste was collected during the first 25 stops. The reason for this is not clear. It may have been that the time was too early, but this is unlikely, unless servants come later and they are given the duty of carrying out the waste. It may have been because most of the waste had been collected the previous day, or it may have been because the residents were not yet accustomed to the system, and they or their servants were still throwing the waste onto piles beside the street. It would be worthwhile to conduct a social survey in the area to find out why the residents were not using the service, and how such a service could be modified to make it more acceptable. The graph in figure B-6.1 illustrates this slow start; each bar represents a 30 minute period, and it can be seen that the number of containers of waste received in the first half hour is much less than for any subsequent period. The number of residents bringing their waste increased by a very significant extent towards the end of the route.

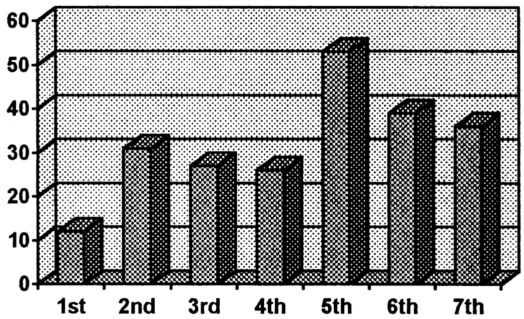


Figure B-6.1 **Number of containers emptied into the truck for successive 30 minute periods**

The number of containers of waste received in each half hour period is shown on the vertical axis.

Each bar represents one period of 30 minutes:

"1st" represents the interval 7.43 am to 8.13 am;

"2nd" represents the interval from 8.13 am to 8.43 am

and so on up till the end of the 7th period which is 11.13 am.

As has already been mentioned, waste was coming to the truck in three ways - brought by residents, brought by street sweepers, and collected by the MCGM loaders. An approximate analysis of the proportions brought in each way was made, based on the assumption that each resident brought only one container and that each sweeper brought an average of two, and that the rest was picked up by the loaders. The data were not collected with this analysis in mind, and this is why such assumptions must be made. (This illustrates the point that work study data collection should be planned according to the type of information that is needed, so that the method of collecting data can be developed and practised according to the information that is needed.) The lack of time allowed only one opportunity for following a truck on this type of duty, so the information was not complete, and, for some purposes, not in the best form. Figure B-6.2 shows an approximate breakdown of the collected waste, according to how it was brought to the truck. It can be seen that, in spite of the slow start, more than one third of the waste was brought by the residents in answer to the bell.

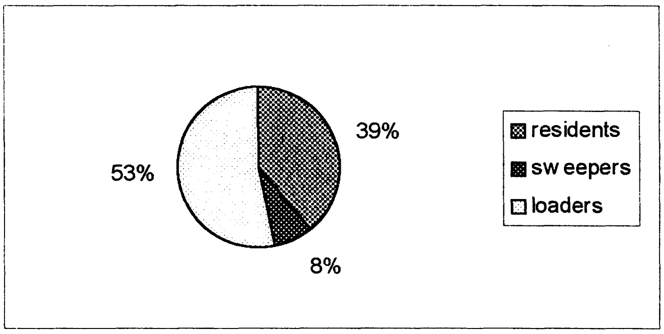


Figure B-6.2 Proportions of waste brought by residents, MCGM sweepers and loaders

Some of the residents brought their containers to the main road at the end of their lane, and left them there until the truck came. This was a very helpful action since it saved the loaders from walking up the lane and it enables the waste to be unloaded directly from the residents' containers into the truck, thereby saving picking the waste up from the ground. If more residents would do this, the task of refuse collection would be simplified. It would be worth talking to the residents who do this, asking them if they have experienced any difficulties and how they overcame them, and perhaps making a short video interview as part of a public education exercise.

It is always useful to consider a range of alternatives, and in this case it would be advisable to consider whether other types of vehicle and a smaller workforce would be appropriate for the bell ringing collection, and whether the two types of collection should be kept separate.

◊ If the same vehicle were used only for the bell ringing collection, only three labourers would be needed - one to ring the bell, one to pass the waste up to the loader in the truck, and one to place the load within the truck body. If the truck were fitted with a distinctive signal, perhaps the driver could announce his arrival, without the need for the labourer with the bell.
◊ Alternatively, the collection service could be operated by labourers with handcarts, joining the street sweeping and refuse collection functions into one. In this case a transfer point would be needed - perhaps a hook lift container.
◊ A small motorised vehicle is another alternative - perhaps a tricycle rickshaw as used in Ahmedabad, or a pickup. One loader would be sufficient, since the body would be low enough to be loaded from the ground. Ideally the driver should also do the work of the loader.

B-6.4 COMPARISONS AND GENERAL COMMENTS

There are several advantages in requiring the residents to make their own arrangements for storage. Not only is the cost of providing community storage avoided, but the residents assume responsibility for the maintenance and condition of their containers, and there is little chance of rag-pickers sorting through and scattering the waste if it is stored on private property. Complaints about the location of waste containers will be less if the residents themselves take responsibility for this issue. Sometimes residents take no care of their own storage facilities (particularly if they are shared by a large number of tenants in an apartment building), and so some of these advantages can be lost.

A wide range of containers were used, but all seemed to serve their purpose reasonably well.

The weights of waste put into the black bowls by the loaders were measured in a few isolated cases, and weights of 11, 18 and 54 kg were recorded. These figures illustrate the wide range of densities that are encountered in Mumbai's waste. It is likely that using these bowls to carry 50 kg of waste will quickly damage the bowls. It is interesting that a load of 54 kg can be handled by two loaders and lifted high enough to be loaded into the truck. The average weight of waste in such a bowl was estimated in appendix BB-6.1 to be just under 16 kg.

Table B-6.1 summarises some of the key data found during this brief study. It must be remembered that the data were based on the observation of only one trip in each case, and that the observers did not have time to develop the best recording methodology nor to practise the collection of these data, so the results must be regarded as a tentative indication, and nothing more.

Table B-6.1 Summary of some basic indicators for the house-to-house and bell ringing systems

Indicators		House-to-house	Bell ringing
Weight collected	[tons]	3.60	2.16
Time to load one ton	[minutes]	44	93
Time to load 1 m^3	[minutes]	17	23
As-loaded density	[kg/m^3]	380	243
Cost per ton	[Rs/ton]	537	895

It can be seen that the weights collected were very different, largely because of the big differences in density. Since the costs for the labour and vehicle are the same, the cost per ton depends on the weight collected, and so is very much more in the second case. The time needed to load a ton of waste is twice as much for the bell ringing case, but there is much less difference in the time required to load a unit volume. It is not possible to say from these results that the bell ringing method is more expensive as currently practised, since the basic costs are the same, and if the density difference is due to socio-economic factors (and therefore independent of the loading method) the cost difference is a geographical variable. The unit costs appear high in comparison with some other methods (for example the compactors investigated in chapter B-2), but it must be remembered the methods discussed here include primary collection to a certain extent, whereas some of the others are purely secondary collection.

Since the labour costs are 80% of the total costs, any method of reducing the requirement of labour is likely to have a significant effect on the unit collection costs.

The frequent stopping and starting required in these collection methods should be expected to shorten the lives of transmission components of the trucks, especially clutch plates. Under the present arrangement the cost of such repairs is borne by the contractor who supplies the vehicle, and so is of no concern to the Municipal Corporation.

These systems have some interesting advantages, and should be studied in more detail. If modifications to the arrangements would be accepted by the labour unions, there is scope for reducing the cost. These methods require more co-operation and participation from residents and so consideration should be given to public education campaigns.

APPENDIX BB-6 HOUSE-TO-HOUSE AND BELL RINGING COLLECTION IN MUMBAI

BB-6.1 HOUSE-TO HOUSE COLLECTION

Work study observations, F North Ward, Route No. 21, 8 December 1995

Station	Plot No.	Distance from previous site (m)	Time of arrival	Travel time to site (min' s")	Loading time (min' s")	Distance to carry waste (m)	Number of bowls / equiva- - lent	Type of waste, comments
Note 1		Note 2				Note 3	Note 4	
								Leaving muster chowki
1	-	15	7.32'00"	28"	15'40"	3	28	Bunker, street waste
2	292	730	7.51'30"	3'50"	42'30"	30	41 / 44	Heavy restaurant waste
3	305	22	8.34'48"	48"	9'21"	8	13 / 24	Apartment, leaves, paper
4	294	10	8.44'27"	18"	8'40"	5	11 / 17	
5	304	19	8.53'50"	43"	6'05"	6	7 / 10	
6	295	34	9.00'00"	40"	5'55"	34	5 / 9	Storage at back, passage 950 mm wide
7	303	15	9.07'10"	40"	9'35"	7	10 / 17	Loaded through hole in wall
8	302	17	9.17'15"	30"	4'45"	14	5 / 9	Dump without walls
9	297	53	9.23'00"	1'00"	24'05"	14	4 / 6	Parked car prevented truck
	299					42	3 / 5	stopping nearer, waste from
	300					67	5 / 9	four plots brought to truck at
	301					67	5 / 8	same place
10	park	N.R.	9.47'05"	N.R.	1'45"	N.R.	6 / 7	Street & park waste
11	318	183	9.53'15"	3'25"	10'45"	33	3 / 6	Also debris
12	317A	40	10.04'50"	50"	18'54"	56	3 / 5	Storage behind building
	317					8	4 / 7	
	298					5	4 / 6	
	315					18	9 / 12	Storage just inside gate

km reading	time	location, activity
881	10.23'44"	Loading completed, load covered, truck departs
882	10.27'00"	Arrive check post
	10.43'28"'	Depart checkpost
890	11.11'50"	Arrive weighbridge
	11.14'20"	Depart weighbridge
894	11.28'30"	Arrive Deonar disposal site gatehouse
896	11.38'20"	Unloading started
	12.22'35"	Unloading completed
898	12.30'50"	Arrive gatehouse
	12.35'00"	Depart gatehouse
902	12.48'00"	Arrive weighbridge

Notes: N.R. means not recorded

1) A "station'" here means each place where the vehicle stopped to load
2) The distance was measured by pacing, and is accurate to +/- 10%.
3) The distance that the labourers were carrying the waste in bowls was also paced.
4) Much of the waste was loaded into the truck by means of the specially designed black plastic bowls. One of these bowls can be seen in photograph 5. The bowls had a diameter of 590 mm and were 210 mm deep. Waste was also brought in other types of container - for example sweepers would bring waste in cane or bamboo baskets, and shopkeepers or domestic servants might use buckets. The number of black bowl loads was counted, but an attempt was made to estimate the volume of the waste coming in other containers, and make allowances for bowls that were only partly full or overloaded by estimating the equivalent

number of bowls - i.e. the number of bowl loads that there would have been if all the waste had been brought in well-filled bowls. An entry in this column of 13 / 24 means that loaders brought 13 bowls full of waste, but the total waste brought to the truck at this station could be reasonably carried in 24 bowls.

Data from table		
	Distance travelled within collecting area	1.1 km.
	Time travelling within collection area	13'12"
	Average speed within collection area = 1.1/[13.2/60] =	5.2 km/h
	Total loading time	158 minutes
	Time to load 1 ton of waste with 8 labourers = 158/3.6 =	43.9 minutes
	Total number of estimated equivalent bowls of waste	229
	Average weight of one bowl of waste = 3600 / 229	15.7 kg
	Average volume of waste in one bowl = 9400 / 229 =	41 litres

It is possible to estimate the distance walked by the labourers, by taking the actual number of bowl loads to indicate the number of times that the labourers walked into and out of a property. It is assumed that two labourers stayed on the vehicle so that six were walking to and fro into the properties.

Plot no.	Distance to walk [m]	Number of bowls	Distance walked to and from storage [m]
-	3	28	168
292	30	41	2460
305	8	13	208
294	5	11	110
304	6	7	84
295	34	5	340
303	7	10	140
302	14	5	140
297	14	4	112
299	42	3	252
300	67	5	670
301	67	5	670
park		6	
318	33	3	198
317A	56	3	336
317	8	4	64
298	5	4	40
315	18	9	324
	average 24.5	sum 166	sum 6316

Assuming that the walking is done by six labourers, working in pairs, the total distance covered by each person between the truck and the storage points, if the same labourers stay on the truck, is

6316 / 3 = 2105 m.

If the loaders take equal turns at working on the truck, then the average distance becomes

3/4 x 2105 = 1580 m

Half of this distance is covered carrying full bowls. To this walking distance should be added the distance between collection points, which is 1.1 km, but if it is assumed that each pair rides on the truck for one quarter of this distance , the distance walked between collecting points is

3/4 x 1100 = 830 m

The estimate of the total distance walked by each loader is therefore

1580 + 830 = 2410 m.

Further data:

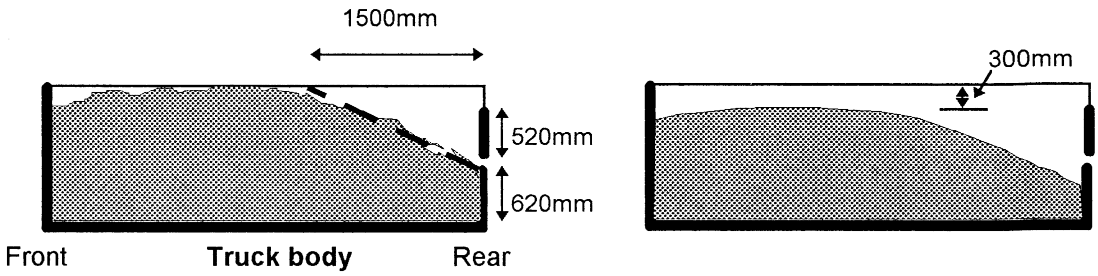
Truck provided by contractor, registration no. BMQ 8617, with 8 MCGM labourers
Truck body: length 3.78 m; width 2.17 m; height of sides 1.3 m; height of tailgate 1.14 m.

Estimate of volume of waste: [See figure BB-6.1]
If loaded to full height, volume is (3.78 x 1.3) x 2.17 = 10.7 m^3.

Since waste does not reach top at front and back, subtract triangles (in vertical section)
So estimated volume just after loading is

$$(3.78 \times 1.3 - [0.5 \times 1.5 \times \{1.3 - 0.62\}] - [0.5 \times 0.15 \times 1.0]) \times 2.17 = 9.4 \text{ m}^3$$

Estimated volume at weighbridge is $9.4 - [3.78 \times 0.3 \times 2.17] = 6.9 \text{ m}^3$



a) just loaded *b) at weighbridge*

Figure BB-6.1 Observations used to estimate volume of waste

Time to load one cubic metre = 158 /9.4 = 16.8 minutes

Weighbridge results

Weight of loaded vehicle	8060 kg	(c.f. RLW 10772 kg)
Weight of empty vehicle	4460 kg	
Weight of load	3600 kg	

Estimated density of waste:

Just after loading	3600 / 9.4	= 380 kg/m^3
At weighbridge	3600 / 6.9	= 520 kg/m^3

Unit cost of collection

		Rs	
Hire of truck and driver (including fuel and maintenance)		384	(1995)
Employment costs for 8 loaders (appendix AA-2.1.2)	8 x 170	1360	
Employment cost for one mukadam (appendix AA-2.1.2)		190	
Total cost per shift		1934	
Cost per ton	1934 / 3.60	**537**	
Percentage of cost that is labour charges	1550 / 1934	80%	

APPENDIX BB-6.2 STUDY OF BELL RINGING COLLECTION SYSTEM

Route 15, Parsee Colony, F North Ward, Mumbai, 18 December 1995

Station	Distance meter [km]	Distance from previous station [m]	Time of arrival	Time spent at station [min' s"]	No. of residents bringing waste	No. of containers brought to truck	Comments
	516		7.40'00"				Depart muster chowki
1	518		7.43'35"	3'00"	1	1	Resident came after 2 minutes
2		210	7.47'37"	5'10"	0	5	
3		140	7.54'10"	1'14"	0	0	
4		110	7.56'25"	56"	0	0	
5		70	7.57'52"	1'01"	0	0	
6		80	8.00'00"	49"	0	0	
7		40	8.01'15"	1'00"	0	0	
8		65	8.03'05"	56"	0	0	
9		25	8.04'25"	25"	0	2	sweeper's containers
10		50	8.05'35"	37"	0	0	
11		60	8.07'00"	48"	1	1	plastic bag
12		60	8.08'34"	31"	1	1	cane basket
13		55	8.09'35"	1'31"	1	1	v. large bowl, palm branches
14		55	8.11'48"	33"	1	1	cane basket
15		15	8.12'34"	33"	0	0	
16		50	8.13'51"	21"	1	1	
17		40	8.14'45"	34"	0	0	
18		45	8.15'55"	19"	0	0	
19		105	8.18'00"	35"	0	0	
20		25	8.19'00"	9"	0	0	
21		30	8.19'29"	43"	2	2	
22		25	8.20'35"	55"	0	1	twigs and branches
23		15	8.21'40"	15"	0	1	1 sweeper's basket
24		200	8.23'25"	1'04"	1	1	large plastic bin
25		100	8.25'25"	1'33"	0	0	
26		40	8.27'35"	17"	0	1	tree branches
27		45	8.28'20"	2'05"	0	4	street waste from sweepers
28		175	8.32'15"	6'47"	11	15	bags, buckets, bowls, branches
29		50	8.39'30"	3'58"	5	6	containers and garden waste
30		125	8.45'15"	1'10"	2	5	
31		60	8.47'14"	26"	0	0	
32		50	8.48'26"	16"	0	0	
33		100	8.49'28"	3'26"	1	12	street wastes from sweepers
34		75	8.53'40"	1'30"	1	1	
35		110	8.55'25"	1'10"	0	0	
36		60	8.57'12"	27"	0	0	
37		125	8.59'15"	5'10"	0	1	pile cleared by loaders
38		55	9.05'18"	17"	0	0	
39		45	9.06'08"	20"	1	1	small plastic bin
40	519	65	9.07'27"	14'03"	0	N.R.	2 sweepers' carts and roadside pile
41	521	N.R.	9.24'07'	4'48"	2	4.	oil drum emptied using bowls
42		70	9.30'43"	5'10"	2	4	largely garden waste
43		45	9.36'21"	6'08"	3	9	restaurant waste carried 75m
44		160	9.43'24"	2'31"	3	4	
45		55	9.46'47"	4'03"	4	12	

Station	Distance meter [km]	Distance from previous station [m]	Time of arrival	Time spent at station [min' s"]	No. of residents bringing waste	No. of containers brought to truck	Comments
46		105	9.51'40"	5'10"	7	10	sweeper, bins and bags
47		70	9.58'35"	22"	0	0	
48		90	9.59'48"	2'14"	3	9	traffic obstructed by truck
49		90	10.02'50"	2'16"	11	18	
				* 10'			delay - discussion with observers
50		N.R.	10.17'05"	2'05"	5	5	
51		70	10.19'35"	1'15"	3	6	
52		55	10.21'20"	2'52"	4	10	Bins waiting at end of lane.
53	521	70	10.25'30"	28"	0	0	
54			10.28'07"	24'11"	6	29	Coconuts taken from oil drum by hand, carried 15m. Restaurant waste carried 25m
55	521	N.R.	10.54'14"	9'01"	2	10	sugar cane and coconut carried 30 and 40 m.
56		50	11.04'09"	15'21"	2	25	food waste in box, bucket & bin. Also waste lifted from gutter.

			11.19'30"	30"	Tarpaulin spread over load
			11.20'00"	*22'30"	refreshment break
			11.42'30"	21'30"	depart for checkpoint
	524		12.04'	* 25'30"	depart checkpoint for weighbridge
	532		12.39'30"	* 1'55"	loaded vehicle weighed (R K Studio weighbridge)
			12.41'25"	9'55"	depart for disposal site
	536		12.51'20"		arrive Deonar disposal site gatehouse
	538		13.02'16"	25'44"	unloading at disposal site
	539		13.35'53"	4'22"	check out at gatehouse
			13.40'15"	* 9'50"	travel to weighbridge
	543		13.50'05"		arrive weighbridge

Notes: * Activities that were a result of the work study observation, and not a part of a normal trip, are marked with an asterisk.

Other data

Truck registration number MMT 3673; hire charge Rs 384 per trip
Operated with one mukadam and eight labourers from MCGM.
Dimensions of cargo body: Height of sides above ground 2.69 m;
Length 3.680 m, width 2.15 m, height of sides 1.4m, height of tailboard 0.52 m.

When the truck had just been loaded and covered with a tarpaulin, the top of the load was about 250 mm below the top of the sides, and it sloped down to the top of the tailboard over the last 600 mm, as shown in the figure BB-6.2

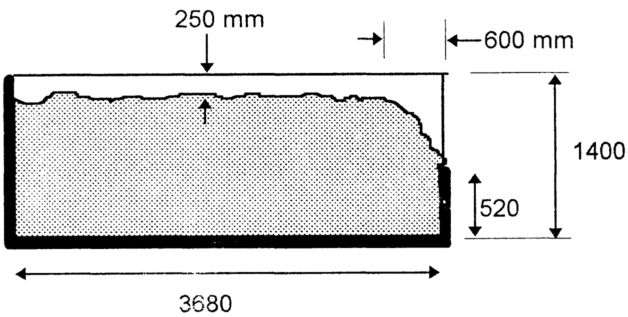


Figure BB-6.2 Extent of loading of truck 18.12.95

Volume of refuse in this case

$= 3.68 \times 2.15 \times [1.40 - 0.25] - 2.15 \times 0.5\ [\{1.15 - 0.52\} \times 0.6]$

$= 8.9\ m^3$

At Deonar disposal site gatehouse the top of the waste was 400 mm below the top of the sides, so the height of the waste had reduced from 1.15 m to 1.00 m. At this stage the volume of the waste was

$8.9 \times [1.00 / 1.15]$

$= 7.7\ m^3$

Weight of truck loaded	7100 kg
Weight of truck empty	4940 kg
⇨ weight of load	2160 kg

Density of waste = 2160 / 8.9 = 243 kg/m^3 as loaded
and 2160 / 7.7 = 280 kg/m^3 after the waste has been compacted by the vibration of the journey to the disposal site

Unit cost
Cost per shift (vehicle hire, 8 loaders and mukadam from appendix BB-6.1) Rs 1934
Weight collected 2.16 tons, therefore cost per ton = 1934 / 2.16 = Rs 895

Time data
- Time to load truck 7.44 am to 11.20 am less 10 minutes delay at 10.02 206 minutes
- Time to load 1 ton 206 / 2.16 93 minutes/ton
- Time to load one cubic metre = 206 / 8.9 23 minutes/m^3
- Total distance covered during collecting stage 3800 m walking, and approximately one kilometre in the vehicle.
- Time to unload vehicle 25'44"
- Total time on disposal site 44'30"
- Average speed between checkpoint, weighbridge and gatehouse 17 km in 55'15" 18.5 km/h, though it did travel at speeds of 50 km/h when conditions allowed.

Comparison with other days
On this particular trip the truck arrived at the check post at about 12 noon, having been delayed by a ten minute discussion and a 22 minute tea break. Excerpts from the check post records for the three bell ringing routes were used to determine whether such a finish time was typical. The records are shown below.

	Route 15			Route 18			Route 32		
Date	Reg. no.	Loading	Time	Reg. no.	Loading	Time	Reg. no.	Loading	Time
10 (Sun)	3673	PL	10.45	6612	PL	11.00	1179 *	75%	9.40
11	3673	PL	11.20	6612	PL	11.50	8862	PL	11.05
12	3673	PL	10.50	6612	PL	11.30	8862	PL	10.45
13	3673	75%	11.10	6612	PL	11.50	8862	PL	10.35
14	3673	65%	11.10	6612	PL	11.45	4324	PL	10.45
15	3673	PL	11.30	6612	PL	11.30	8862	PL	10.50
16	3673	PL	11.20	6612	PL	11.40	8862	PL	10.15
17 (Sun)	801	70%	10.50	6612	PL	11.45	4324	PL	10.35
18	**3673**	**PL**	**12.00**		PL	11.50		PL	10.25

Notes: * MCGM compactor truck
PL means properly loaded - the junior overseer was satisfied that the truck was full. Otherwise the percentage indicates to extent to which the truck was loaded, as judged by the junior overseer.

If the 32 minutes unusual delay of the observed vehicle is taken from the time of arrival at the checkpost, the checking time of 11.30 am is obtained. The records show that, for route 15, a checking time that was the same or later only happened once in the nine days of records, but for the three routes (26 other recorded times) there were nine other occasions when a bell ringing route truck checked in at the same time or later - mostly for route 18. There were no cases when a truck on route 32 was as late as this. These differences between routes suggest that either route 32 was less demanding (that is, the truck could be filled more conveniently and quickly) or that the team of loaders on route 32 worked very hard on the nine days of the record.

The records also show that the trip to the disposal site took between 45 and 70 minutes, so if the time on the disposal site is 45 minutes, as it was for the observed case, the driver and loaders on route 18 cannot usually expect to be back at the checkpost for another 2 hours and 15 minutes, which could be as late as 2 pm, which is the start of the next shift.

APPENDIX BB-6.3 CONTRACT DETAILS FOR HIRE OF TRUCKS

The following clauses and table are taken directly from a MCGM contract document, prepared by the Solid Waste Management Department for the period 1994 to 1996. It is reproduced as faithfully as possible, without making editorial modifications. Words taken directly from the contract document are written in Times New Roman font, comments are in Arial font. Excerpts from the appendices mentioned in these clauses are reproduced at the end of this section.

Specifications, terms and conditions for supply of lorries without labourers, on hire for removal of refuse from wards in the City, Suburbs & Extended Suburbs for the period from _________to ______

1) Lorries as per specifications at Page 20 & with carrying capacity exclusive of space provided for loaders and implements as indicated in Appendix 'B' at Page 30 shall be supplied to work in the wards during a shift of 8 hours.

Normally timings will be as under:

Lorry supply hours:-

6.00 A.M. to 2.00 P.M.
9.30 A.M. to 5.30 P.M.
2.00 P.M. to 10.00 P.M.
5.30 P.M. to 1.30 A.M. (Next day)
10.00 P.M. to 6.00 A.M. (Night shift as and when required)

S.W.M. Working hours:-

6.30 A.M. to 1.30 P.M.
10.00 A.M. to 5.00 P.M.
2.00 P.M. to 9.00 P.M.
6.00 P.M. to 1.00 A.M.
10.00 P.M. to 5.00 A.M.

Tenderers will note the approximate lorry shifts required in the above shifts, as indicated in Appendix 'I' at Page 31-32.

2) The Lorries shall reach the Ward Office not later than half an hour after the notified time. Lorries received thereafter are liable to be returned without use and the Municipal Corporation will not pay any charges whatsoever for the return of such lorries received late.

3) If the contractor is called upon to operate the vehicle beyond shift hours, he will be paid an extra rate of Rs. 20.00 per hour. However, less than 30 minutes additional operations will not be paid extra.

4a) The cubic capacity of the lorry excluding the space provided for loaders and implements as referred to in clause 5 shall be as indicated in appendix 'B' at Page 30 and the correct dimensions should always be made available with the driver of the lorry. In case the contractor supplies lorries of less capacity, then the rate to be paid shall be proportionately reduced to the actual capacity of vehicle supplied and the charges will be paid proportionately. Cubic capacity will be taken as the product of length, breadth and height of the body of the lorry. In case of vehicles of 10.58 cum. capacity the portion behind the driver's cabin provided for the space for the staff shall be of the same height as the said boards, if the rear board is not of full height as the side flaps, the vehicle will be treated as of less capacity.

b) In case dimension of the lorry is increased for raising the height by providing additional planks, there shall remain no gap which will cause to fall the refuse there from through the gap and litter on the road. However, the partition earmarked for accommodating the labourers and implements shall be kept at nominal height to permit free in the side and rear boards shall be rejected.

5) The vehicle of the make prior to 1980 will not be accepted for work as mentioned in tender.

5a) Every lorry supplied shall have (a) closing and opening type of tail board of permissible height at the back, (b) fixed strong partition of full height in front side of body as mentioned under condition 4(a), (c) a clear distance of not more than 0.457 mt. from driver's cabin. This shall be provided for use as standing place, for loaders and to keep implements, (d) seating arrangement for six loaders shall be provided in this compartment and this compartment shall be provided with temporary cover of canvas/hood, (e) leaving above space a clear loading space of approx. 5.66 cum. in respect of lorries of 5.66 cum. capacity and app. 10.58 cum. in respect of lorries of 10.58 cum. capacity shall be available for loading adequately with any of the items covered under condition 7. The contractor should take the advantages of length of the body and keep the height as minimum as possible to get the required volume of 10.58 cum or 5.66 cum.

6) The contractor shall supply full number of lorries indented for the day. The intimation would normally be given by previous day evening. Contractor's man should attend ward office daily to take the indent. In case of failure a fine of Rs. 25/- per day will be charged.

7) The lorries shall be used for the removal of refuse mixed with earth, debris, silt, any other waste materials including carcasses of animals.

8) Log sheets will be provided by the ward staff and countersigned by the officer in charge, on production of intimation slip from the contractors wherein it shall be mentioned the registration Nos. of lorries sent, their type whether Petrol or Diesel operated. The contractors shall ascertain that these details are incorporated in the log sheet issued.

9) Loading and unloading of refuse shall be done by the Municipal labour.

9a) The Contractor shall make arrangement for unloading the garbage when asked to do so in case of unforeseen circumstances. In that case the contractor will be paid Rs. 60/- as unloading charges per trip of 10.58 cum. capacity & Rs. 30/- for one trip of 5.66 cum capacity.

10) Average number of lorries required daily in the ward will be shown in the Appendix 'I' & as mentioned in clause 3 of the agreement.

11a) At the unloading grounds, the drivers of the contractors' lorries shall obey the instructions of the dumping ground staff for proper entry of log sheets , for treatment by disinfection operations and for systematic parking at the site as shown by the municipal staff. The failure to comply this will be viewed seriously. The contractor shall depute a responsible person at the dumping ground from time to time to see that the lorry drivers are following the instructions of dumping ground staff.

b) The contractors shall be levied a penalty of Rs. 100/- per trip per lorry if he fails to unload the vehicle at appropriate place and as per instructions.

12) In case of emergency, the contractor shall be asked to work in any of the Wards A to G in the City and H/East, H/West, K/East, K/West, L, M/E, M/W, N, S, T, P/S, P/N, R/S, R/N, Wards in the suburb as and Extended suburbs other than that allotted to him and he shall be paid at the rate quoted by him in the Ward he is operating or the rate quoted by the successful tenderer for the Ward where he is directed to work whichever is higher. However, the vehicles for unloading shall be taken to the dumping ground shown against that ward in which he is directed to operate.

13) In case of breakdown of lorries the proportionate cost would be paid to the contractor according to the actual hours of working. Proportionate cost at Rs 5.00 per man hour of the entire gang of Municipal labour together with Mukadam, to the lorry will be deducted from the relevant bills of the contractor, based on the man hours of actual works.

13a) In case the contractors vehicle fails on the road due to the mechanical break-down etc. then the contractor will make necessary arrangement to transfer the refuse immediately to other vehicle and transport the same to the site of disposal. In case the contractor fails to make necessary arrangements within 3 hours to transport the refuse, necessary arrangements will be made by the Corporation through its own staff and vehicles or through private agency and cost of the same alongwith 15% supervision charges will be recovered from the contractor in addition to penalty for non supply.

14) If the lorries are indented but not utilised for some reason or other and returned within half an hour from the commencement of conservancy working hours, no charges will be paid to the contractors, If the lorries are detained and returned within two hours thereafter 1/4 of the lorry shift charges shall be paid thereafter if the lorries are detained and not utilised for any period not exceeding 8 hours of the shift 1/2 of the lorry shift charges shall be paid.

15) In the event of non-supply of lorries, if the contractor fails to supply the number of lorries indented for the day, the cost of the labour and supervisory staff wasted due to short supply of lorries will be recorded as under:

a) In case the labour gang together with Mukadam is wasted Rs. 5.00 per man hour of gang will be recovered in proportion to number of hours wasted.

16a) In case the contractor fails to supply number of lorries indented for the day and number of lorries thus supplied less by the contractors shall be hired from any private agency of from open market of Municipal vehicle will be engaged at his risk and cost and the additional cost incurred if any plus 15% supervision charges will be recovered from the contractor in addition to usual penalties.

16b) Penalty equivalent to amount quoted per lorry will be recovered for each vehicle not supplied.

16c) If the lorry is indented for double shift and the contractor supplied only for one shift, the rate payable to him will be 50% of the accepted rate for a double shift and for non-supply for the other shift will attract penalties as mentioned above. Single shift will not be admissible.

17) The Contractor shall provide a board showing that the lorry is on Municipal duty (conservancy work) and the name of the Ward should exhibited on the front side of the lorry at a conspicuous place so long as the lorry is on Municipal Duty. Failure to display the board will render the contractor liable for penalty at Rs. 25/- per vehicle per shift.

18)a) Lorries shall be sent to work in perfect working order having proper registration and fitness certificate for road worthiness from R.T.O. and with adequate supply of fuel oil. If the lorry goes for fuelling after it is received for work at the Ward Office the time wasted thereby will be taken into consideration at the time of payment of bills, in case the output of work is affected adversely. Similarly if the driver takes away the vehicles without allowing the vehicle to be loaded adequately proportionate deduction will be effected for the under-load. Mukadam of the loading gang shall be allowed to travel in the driver's cabin.

18b) If it is found that any vehicle has made an accident or is liable to make an accident due to the vehicle not being road worthy or due to mal-operation by the contractors driver or by rash driving by contractors staff such vehicles shall be debarred for use permanently anywhere in any of the wards and it will be contractors responsibility to make up the quota immediately.

19) The Contractor shall supply the lorries with tarpaulin cover as per municipal specification which should be in good condition and of a suitable size so as to cover the lorry completely. If the contractors fails to supply cover a fine of Rs. 50/- per trip per lorry will be levied and deducted from the bill. The tarpaulin will cover both side planks and the rear tail board completely from top to the floor of the vehicle and properly fixed by the hooks.

19a) In respect of 10.58 cum. lorries tarpaulin cover should be tied by putting the rope on side and on the back side as tide in the truck. [probably ..."and tied to the truck."]

20) Lorry must go back to the Ward Office after unloading its last trip for relieving the Municipal Labour staff and depositing implements, failing compliance a penalty of Rs. 10/- per shift per lorry will be levied and deducted from the bill.

20a) For each trip lorry must report for inspection of M.L.J.O. [Motor Loader Junior Overseer] or their representatives at a fixed point for each Ward, as decided, for checking each trip before the lorry goes out of section to the dumping ground. Failure to route the lorry through check point will render the contractor liable for penalty at Rs. 25/- per trip per lorry.

21) The cost of any damage injury or death caused by the Contractor's lorry or any claim arising out of it, will be recovered from the contractor through his bill.

22) Commissioner shall terminate the contract for supply of lorries for a Ward or Wards after giving one calendar month's notice without assigning any reasons whatsoever.

23a) In case the contractors come forward with a request to allow them to withdraw from fulfilling their contractual obligations normally such a withdrawal is not allowed. However, if due to circumstances such a withdrawal is allowed, such firms may not be considered for award of work for a period of FIVE YEARS.

23b) The rates quoted should be firm for the entire contract period.

24) The contractor shall prepare separate monthly summaries of bills preferred by them against the various Municipal Departments during the month and send on or before the 5th of the next month these summaries to the respective units of the Accounts Department where the bills are admitted for payment. In case of discount bills, the contractor should submit fortnightly summaries say on 5th and 20th of the month to enable the Accounts Department to admit payment in time. The Corporation will not be responsible for delay in payment of their bills if summaries of bills as indicated herein are not submitted by them by due date as per the clause of the contract.

25) The contractor shall ensure that the payment of wheel tax for the lorries hired by the Corporation from them are cleared by their owners. If any such vehicle or vehicles supplied by the contractor are found to have run in arrears of such wheel taxes, the same shall be recovered from the contractor's bill or deposit after giving him the opportunity to clear the same.

25a) The requirement of the lorries are administrative [administered] wardwise, however for administrative convenience requirement is shown against conservancy wards in some wards. However, it shall be open for the Corporation to use any of the lorries in any of the conservancy wards in the same administrative ward without any extra cost.

26) For evaluation purposes rates as shown in Appendix 'B' at Page 30 will be taken into account.

27) In case the Refuse Vehicles are directed to dumping ground other than principal dumping ground and if the distance of other dumping ground is more than the principal dumping ground the Contractor will be paid at the rate of Rs. 5/- per k.m. for the additional distance in one direction irrespective of the capacity of the lorry. For example if the dumping ground of A/S Ward is changed from Deonar to Mulund then the contractor/s will be paid additional amount of Rs. 57.50 only.

28) In case the distance of other dumping ground where the Refuse lorries are directed, is less than the principal dumping ground then an amount of Rs. 5/- per k.m. will be deducted from the rate of Principal dumping ground for the distance less than principal dumping. The distance is as mentioned at Page 33-34 of the tender form.

29) The representation regarding dispute in distance at Page 33-34 will not be considered.

30) The contractor should display the registration No. of the vehicles and the name of the ward on the top portion of the cabin on the cleaner's side.

31) In the wards whose contractor/s vehicles, are supposed to make two trips per shift, but in case their vehicle does only one trip in a shift due to breakdown. In such cases 50% amount of the rate quoted per shift will be recovered from the contractor's bill as a penalty.

Other information from contract document

Specification of truck bodies on page 20

Specifications of loading space of lorries on 5.66 cum. capacity to be supplied by the prospective contractors.	The length shall be minimum three metre. The height should vary according to length to give required volume. Rear end tail gate shall be 0.915 mt. in height from the floor.
Specifications of loading space of lorries of 10.58 cum. capacity to be supplied by the prospective Contractors.	The length shall be 4.2 Mt. height 1.2 metres & width 2.1 metres. Rear end tail gate shall be 1.2 Mt. in two/three flaps.

Appendix B (page 30) lists the dumping grounds that should be used by each ward, the number of trips to be made per shift, and the cubic capacity of the trucks that are to be used. Two trips are required of vehicles that have a capacity of 5.66 m^3 and the larger trucks are required to make only one. Appendix C (pages 33 and 34) shows the distances from the vehicle reporting chowkies in the wards to the entrance to the assigned or alternative disposal sites. The table below combines some of this information from appendices B and C for a few wards. (F North Ward is the subject of this chapter and K West Ward is the location of the study of chapter B-2.)

Ward	Principal dumping ground	Alternative unloading point	No. of trips / shift	Cubic capacity of lorries to be provided. [m^3]	Distance from ward chowki to disposal site [km]
A South	Deonar		1	10.58	24
		Mulund			35.5
		Refuse transfer station at LBS Marg, Kurla			17
F North	Deonar		1	10.58	11.5
K West	Chincholi		1	10.58	10
		Gorai			17.5
P South	Chincholi		2	5.66	2.5
S	Mulund		2	5.66	8.75

There is also a table (on pages 31 and 32 of the contract document) showing the vehicle requirements for each ward during the "peak season" when waste quantities are highest, and during the "lean season" when there is less waste to be collected. Some examples of the entries are reproduced below

	A South	F North	K West	P South
Peak season quota daily requirement (184 days)				
6.00 am to 2.00 pm	12	11	12	3
10.00 am to 6.00 pm	1	2	1	
2.00 pm to 10.00 pm	4	8	8	2
5.00 pm to 1.00 am	0	2	1	
TOTAL	**17**	**23**	**22**	**5**
Lean season quota daily requirement (181 days)				
6.00 am to 2.00 pm	11	9	10	2
10.00 am to 6.00 pm	1	1	1	
2.00 pm to 10.00 pm	3	7	6	2
5.00 pm to 1.00 am	0	1	1	
TOTAL	**15**	**18**	**18**	**4**

Comments
Administrators like to write strict conditions and demand a high specification, but consideration should also be given to how the regulations and standards will be enforced, and whether some of them are really necessary. For example, it is likely that many of the contractors' vehicles do not meet the requirements for age and some may not meet the requirements regarding the dimensions of the loading space. Since the unit cost of waste collection depends upon the volume of waste loaded, it is important to uphold the requirements for the loading space.

The terms and conditions clearly show the benefits of using contractors to supply vehicles. All concerns about availability and maintenance are taken care of by the contractor, and enforcement of discipline in terms of timing and deviation from required operational procedures can be achieved by reducing the fee that is paid at the end of the month, provided that the staff are not intimidated by the contractor.

Perhaps a major issue is the quality of the vehicles. Loading and unloading are slow and unhygienic, and a large area of the disposal site is required for large numbers of open trucks that require 25 minutes to be unloaded. The vehicles that the contractors supply are old and suitable for a wide variety of purposes, and if a contractor does not win a contract, he might use the vehicles for other purposes. Could contractors be persuaded to supply vehicles that are specially designed for handling solid waste? Modern and efficient solid waste collection vehicles are not well suited to transporting other types of materials, so before a contractor would consider investing in a specialised refuse collection truck, he would need to know that he had a contract for a long period (at least five years) and that the contract would pay. An alternative might be for contractors to lease the vehicles, but there is always the problem of how to ensure that the operator maintains the vehicle well and takes good care of it. A maintenance contract is another possible way of reducing the workload of municipal managers, but the municipal corporation must then find the capital required to purchase the vehicles.

The contractors trucks system in Mumbai may not be elegant or modern, and it may be more expensive than some alternatives, but it has provided a reliable service, and reliability is of great importance in solid waste management.

Chapter C-1

Selection of solid waste collection vehicles

by Adrian Coad

C- 1.1 THE SELECTION PROCESS

In India, and in many other countries, the costs of collection of municipal solid waste are far higher than the expenditure on disposal. Of the collection costs, the largest component in the Indian context seems to be the labour costs, but the decision with the biggest financial implications is likely to be the selection of the vehicles, since managers generally inherit their workforces from their predecessors, and any decisions about employment are usually concerned with small modifications to the size or composition of the workforce, rather than major changes to the salaries budget.

Since the selection of the storage and transportation system is such an important decision, it should not be made hastily, but include the input of

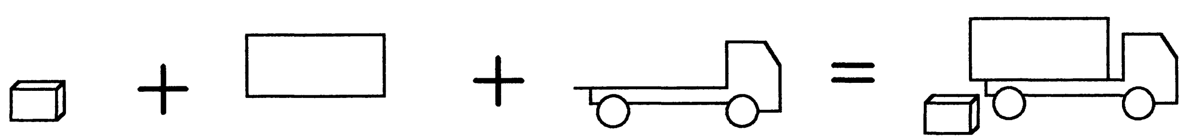
- ◊ experts with detailed knowledge of all relevant systems
- ◊ information based on operational experience of the systems under consideration. (If this is not available, and it is not possible to investigate operational experiences elsewhere, the wise plan of action is to operate the system or vehicle that is being considered on a trial or pilot basis for a period of perhaps six months, in order to gain operational experience that can be fed into the decision-making process.)
- ◊ a thorough analysis of the financial implications of the choice, concentrating on operational costs (maintenance, economic life and replacement costs, manpower requirements, and other operational costs).

It is very unfortunate that decisions about large purchases of vehicles and equipment are often not based on these factors, but are too frequently made by officials and politicians who have little technical knowledge, and are concerned only about the lowest tender price, or other non-technical factors. A study of total costs in Part B shows that capital costs of vehicles are usually less or equivalent to the costs of operation and maintenance over the lifetime of the vehicle. Furthermore the differences in capital costs between different alternatives may be relatively small. For both these reasons it is very short-sighted to base selection of equipment on capital cost alone - short-sighted, but far too common. It is hoped that a study of Part B of this report will help to acquaint future decision-makers concerning the *methods* and *considerations* of cost comparisons. The *actual* costs calculated in Part B cannot be used for other places or situations (i.e. situations different from the one in which the data in Part B were collected.) These cost figures are for particular situations and therefore should not be generalised. The system that is the most economical in Part B is not necessarily the most economical in other situations.

Another common error is to consider too few options. At the preliminary stage of the selection process all possible methods and systems that meet the required objectives should be considered, and the range of options should be reduced in a rational and scientific way.

C-1.2 FACTORS TO CONSIDER IN SELECTION

As far as equipment is concerned, a collection system can be considered in three parts: container, body and chassis.



Container + *body* + *chassis* = *system*

Whilst they are separate parts, the interrelationships between these parts must also be carefully considered.

The wide variety of systems available is well documented in the book published by UNCHS (Habitat) in Nairobi entitled *Refuse Collection Vehicles for Developing Countries,* and the reader is urged to refer to this book.

This section is not concerned with determining the numbers of vehicles or containers, but simply with selecting the type. The numbers of items required needs data on waste generation and properties, and much of the performance measurement data mentioned in Part B.

The following list suggests some of the factors that should be considered in selecting the most appropriate type of refuse collection system, considering the choice of container, body and chassis separately, and then considering the three components together. The list of factors is a long one, but it is not purely academic - many of these points have been impressed upon the author by actual problems and failures, and this section is written in the hope that it will help to prevent similar problems occurring in the future.

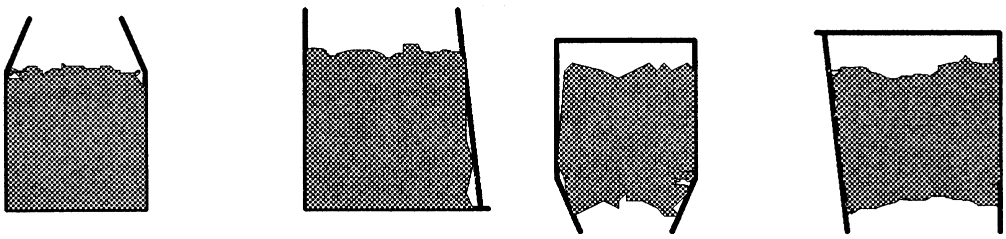
Containers (The choice of container need only to be considered if waste is not to be loaded manually from the residents' containers directly into the collection vehicle, because if refuse is loaded in that way a range of container types is possible.)

Factors to consider in selecting the best type of container are:

◊ waste density - if containers are lifted manually to load, because the maximum weight that a labourer can lift and the refuse density will determine the required size of container. Waste density is also important in assessing whether a container has sufficient structural strength (for example, a container designed for the USA would need to be able to carry five or six times the weight in India than it would in the USA).

◊ method of loading - Can the waste be transferred to the vehicle in an acceptable, efficient, reliable and hygienic way? If loading involves tipping the waste onto the ground and later lifting it into the collection vehicle, this is inefficient and unhygienic, violating the *Handle Once Only* principle of David Jackson.

◊ shape - Sharp corners accumulate waste which stays in the container when it is emptied, thereby encouraging corrosion. Containers that are tipped to empty should be wider at the top than at the base, otherwise some types of waste may wedge themselves into the container so that they can only be removed by hard banging (which damages containers and makes unacceptable noise) or by digging them out. This problem is illustrated in the sketches below.



Containers that are narrower at the opening than elsewhere

With certain types of waste, the contents are wedged inside when the containers are tipped.

◊ size of items in the waste - The container should be larger than the largest items so that it does not quickly become blocked

◊ corrosivity of the waste - If the waste is corrosive (usually because of high moisture and putrescible contents), unprotected steel containers will quickly corrode, especially if they are not cleaned regularly)

◊ presence of hot ashes in the waste - If they are present they will damage plastic containers

◊ maximum height - If waste is brought to containers by children it must be possible for them to put the waste inside the container

◊ risk of theft, damage and abuse - Do people set fire to waste, or move containers to other locations?

◊ location of the containers - How much space is available? What slope and type of ground surface will it be resting on? (Slope and surface are especially important if the container has wheels and is to be moved for emptying.)

◊ whether a cover is necessary -Covers on community bins are nearly always a failure, because people are unwilling to open them (because the lids are heavy, dirty or inconvenient) so either they are left open or waste is dumped outside the container. A great amount of money has been wasted on community bin covers that are never used.

Body - this includes lifting, compacting and unloading mechanisms. Factors to consider include:

◊ whether compaction is necessary - Compaction of the waste has economic advantages when the waste is of a low density (as in USA and northern Europe), but there is a price to pay for compaction - the mechanisms are heavy (reducing the load of refuse that the truck can carry), and compacting bodies are expensive.

◊ reliability - Some bodies are very complex or require frequent repair because of poor quality or overloaded components. Reliability is a very important criterion, and should be a major factor in selection. Information on reliability comes from operational experience. A measurement of reliability is *availability* (the fraction of time when the equipment is available for use) and this is also affected by the time taken to obtain spare parts. Part D has extensive examples of this type of information.

◊ ease of unloading - Unloading should be accomplished quickly and hygienically. Unloading should be completed in a short time so that the vehicle can quickly return to collect more waste, and to avoid occupying space at the disposal site. (In Mumbai many of the trucks are unloaded manually, by men standing in the waste and pulling it with rakes. The process usually takes between 20 and 30 minutes.) Apart from the risks of infection and injury associated with this practice, a very large space is taken up on the disposal site by up to 40 trucks unloading in this way, with the result that management and control of the placing of the wastes is much more difficult. If the trucks spent one-tenth of the time unloading, there would be one-tenth of the trucks present at the unloading point at any time.) Bodies that tip to unload should be able to tip their bodies at a sufficient angle so that the waste falls out cleanly and quickly, and there should be no obstructions to the movement of the waste down the sloping floor. Rotating drum compactors usually cannot unload at one place, but must move forwards several times to discharge a full load. Hoppers of conventional compactors should have a facility for cleaning them quickly.

◊ the corrosivity of the waste - Solid waste that has a high putrescible content, or that has been in a container for several days, is very corrosive because of the acids formed in the decomposition processes; for corrosive wastes special materials or thicker steel plate should be used.

◊ the abrasive properties of the waste - If the waste contains significant quantities of sand, it is advisable not to use certain types of bodies that cause the waste to slide against metal surfaces, because the metal will be worn away by this grinding action.

◊ method of covering the load - If the vehicle is capable of moving faster than 20 km/h (so this does not apply to handcarts or carts pulled by animals) the load should be covered in transit. Some people also require that the load be enclosed all the time, in order to keep the waste out of sight and control smells. This is a matter for personal taste, but it should be mentioned that waste in enclosed compactor trucks also emits a detectable odour, and open trucks with a reasonably high loading height keep the waste out of the view of pedestrians. As far as the prevention of the scattering of waste is concerned, the best test is experience. Compactor trucks in India can be observed to shed items of waste as they load and as they move, partly through the crack between the rear hopper and the main part of the body. The compaction of wet waste often produces an unpleasant liquid which runs onto the street unless special tanks are provided to contain it. Since the refuse in India is usually dense and low in plastic content, the amount of waste being blown out of open trucks during the loading phase has been observed to be very little. The covering of open trucks with tarpaulins may involve walking over the waste which is an unhygienic and hazardous action.

◊ design to prevent accidents - Hydraulically-operated machinery is complex and potentially dangerous. It is important that the controls are designed so as to minimise the chance of operators or bystanders being injured by moving parts (particularly descending bodies or rear hoppers) or by glass or other materials that shatter during loading. Vulnerable parts - such as hydraulic hoses - should be protected against damage - for example when the vehicle passes under a low tree branch.

Chassis - (Factors such as chassis size also affect the body.)

◊ reliability - The working conditions for a refuse collection vehicle are often arduous. These trucks must operate in congested conditions, frequently stopping and starting. They may be required to negotiate rough and soft ground at disposal sites. The chassis should be able to cope with such duty, and spare parts and maintenance expertise should be readily available. Currently in India there are two manufacturers of heavy vehicles, but a wider number of medium-sized chassis, and in the future there may be foreign-made heavy goods vehicles on India's roads. The choice of chassis should be carefully made according to experience of their operation in anticipated working conditions, the availability of spare parts and the advice of the mechanics. (The advice of mechanics is very useful in relation to maintenance considerations; they know that, for example, it is much quicker to change the clutch on one type of vehicle than on another, or that the failure of a particular component in a particular type of chassis is a frequent cause of breakdown.)

◊ local conditions - A number of factors relating to the road conditions affect the type and size of chassis that is appropriate. In big cities it may be necessary to operate several different truck models because of differences in road conditions in different parts of the city. Amongst the major local factors are:
  - ⇒ distance that the vehicle is required to travel each day - the distance to the disposal site and the number of trips required. The operating speed of the vehicle is an important consideration when comparatively long distances must be travelled.
  - ⇒ traffic speed - In congested areas a slow-moving vehicle may be adequate.
  - ⇒ road width and corner radius - Where the streets are narrow or seriously blocked by parked vehicles, a narrow chassis is appropriate. Where corner radii are small, a short, narrow chassis, or an articulated vehicle may be required.
  - ⇒ road slope - Steeply-sloping roads may need chassis with special gearing and braking systems.
  - ⇒ road surface - Where roads in the collection area or on the way to the disposal site are particularly poorly surfaced, vehicles with special wheels or extra ground clearance may be needed. On unpaved roads, four-wheel drive may be an advantage. Heavy-duty springs and reinforced structural members may also be appropriate.
  - ⇒ road construction - Heavy vehicles, especially those with double axles, can cause rapid damage to roads that have been designed for light traffic (as might be the case for roads in residential areas). The gross vehicle weight of the chassis must be limited in such cases.
  - ⇒ space for manoeuvring - In some residential areas collection vehicles are required to operate in confined spaces, do frequent 'U' turns, and drive in reverse. The chassis should be chosen with this in mind.
  - ⇒ headroom - The height of vehicle bodies or the height to which lifting equipment (such as cranes) can operate may be restricted by overhead power or telephone lines, by advertising gantries or other obstructions.

◊ crew accommodation - Refuse collection trucks often have "crew cabs" which are big enough to carry a crew of four or five with a reasonable degree of comfort. The need for transporting the loading crew should be assessed, and the ease and speed with which they can enter and leave the cab should also be considered.

◊ engine and transmission - Currently in India diesel engines and manual gearboxes are used for heavy trucks, but other alternatives may appear in the future. In some countries automatic transmissions are used to avoid clutch replacement, and there are now refuse collection vehicles designed to run on natural gas to reduce air pollution. Small, battery powered vehicles are sometimes used for street cleaning and primary collection. The decision to move away from what is well-tried and well-known should be made with caution.

The system as a whole

◊ The cost per ton is a key factor in selecting a system. Such costs have been calculated for some systems in particular conditions in Part B, and include both capital and recurrent costs.

◊ The compatibility of the body and the chassis should also be investigated. A body may be well suited to one chassis, but cause frequent problems on another. Weight distribution is a common problem with some compactor trucks, because of the considerable weight of the rear hopper overhanging behind the back axle, compounded by the weight of the refuse at the rear when the body is half full.

◊ Loading height is another issue. For some uses or applications of heavy vehicles, the height of the body is of little importance, but for solid waste collection, the height to which the solid waste must be lifted during loading is of crucial importance.

◊ The rear lights of the vehicle are important safety features, and so the body should be designed so that the lights are not obstructed or quickly obscured by dust and refuse.

C - 1.3 A FINAL PLEA TO DECISION-MAKERS

It may be that experienced vehicle engineers reading this list will say to themselves:

> "Yes, I know all this. The problem is that *they* did not ask for my advice before *they* made the decision."

(The term "*they*" refers to the senior decision-makers who selected the vehicles.)

It is to be hoped that senior municipal officials and leaders are aware that they may have in their organisations talented and dedicated engineers and technicians who have a great deal of experience and knowledge concerning the operation and maintenance of heavy vehicles, and that the information that such people have could help avoid a very expensive mistake in this issue of vehicle selection. One does not need to look far to see such mistakes, made in the past.

Chapter C-2

In search of the ideal dumper-placer container

by A. K. Sarkar

The dumper-placer, or skip-lift, vehicle comprises a standard chassis equipped with a pair of hydraulically operated lifting arms which are used to lift a separate container on or off the flat floor of the vehicle, and also tip the container to empty it. Operations of these trucks in Mumbai have been described in chapter B-1, and two current types are shown in photographs 4 and 6. Operational data for dumper-placers are given in Part D, which is concerned with maintenance. There are many different designs for the containers; these variations suggest that the ideal design has not yet been developed. This article discusses some of the problems associated with the design of the containers and the material used to construct them. It is hoped that the comments here will assist those who design dumper-placer containers to avoid some problems, and guide those who select containers to make a wise choice.

The dumper placer system has become very popular for the following reasons:

- Higher productivity, because of the short time required to load; it may replace three or four conventional tipper vehicles;
- There is no need for double handling of the waste, since the waste stays in the same container and can be unloaded mechanically;
- It is hygienic, containing the waste and keeping it off the ground;
- The containers restrict rag-picking activities;
- Most containers do not allow access to cows and goats, so that the waste is not scattered around the container by such animals;
- The breeding of rodents is minimised because the container removes all of the waste each time, if it is properly used;

The main disadvantage of this type of vehicle is that the load-carrying capacity is restricted because the container must fit between the lifting arms, and the geometry of the lifting and tipping system restricts the length. For this reason, these trucks are favoured where the haul distances are reasonably short. It should be noted that the designer should aim to maximise the capacity of the container within the restrictions imposed by the vehicle and the way in which the container is used.

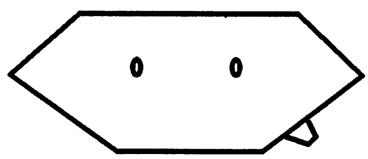
C-.1 COMMON CONTAINER DESIGNS

Skips used for municipal solid waste are usually made of mild steel and weigh between 800 and 1000 kg. The bottom plate (or floor) of the container is usually made of 5 mm plate, the sides are 3 mm thick and the lids (if fitted) are 1.5 mm thick. The structural strength is provided by channel and heavy angle sections. The volumetric capacity of the containers varies from 4 m^3 to 7 m^3. The loading height is a critical dimension if the container is loaded by the general public or from carts or small vehicles, since it has a major influence on the volume of refuse that the container will carry; this height is usually about 1000 mm.

Containers used in UK

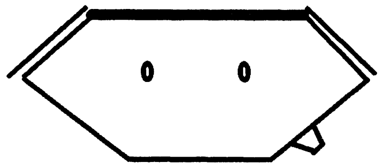
1. Open container

   capacity approx. 4 - 5 m^3
   simple and robust
   covered with net or tarpaulin
   used for rubbish, earth and soil (which are significantly more dense than municipal solid waste)



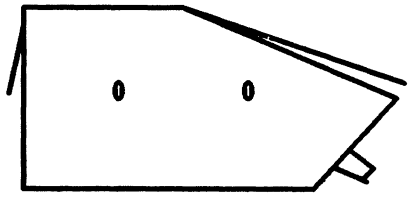
2. Covered container

   capacity approx. 5 m^3
   centre section with fixed cover, hinged flaps at either end



3. Covered container

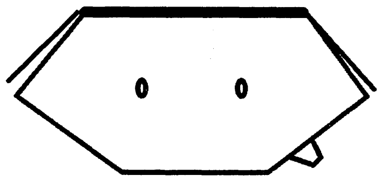
   capacity approx. 6.5 - 7 m^3
   good design, though lid is very heavy
   A second flap door at the front of the container helps to increase the volume that can be loaded.



Containers used in India - mainly in Mumbai and Calcutta

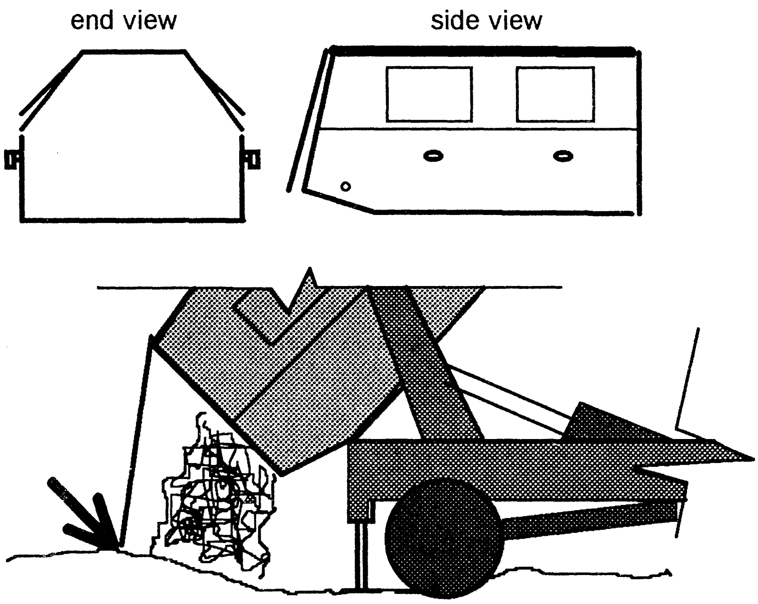
1. Covered container, Mumbai

   capacity 4 m^3
   Unloading is sometimes difficult, since the waste tends to arch across the opening so that it does not fall out when the container is tipped. In addition, the hinged lids may be damaged if they come into contact with the ground.
   The life of the container is about 3 years
   If the density of the refuse is 600 kg/ m^3, the container should theoretically carry $4 \times 600 = 2400$ kg of waste, but it is not possible to fill the whole container in practice. The maximum load is likely to be less than 2000 kg, and the weight of the container itself is 800 kg, so the total load for the vehicle will rarely reach 2800 kg.
   However, the payload capacity of the dumper-placer vehicle is about 6000 kg.
   Comparison of these weights shows that the vehicle is under-utilised, since it carries less than half its payload capacity.



2. Covered container, Calcutta

   capacity 7 m^3
   There are two hinged lids on each side and a large back lid. The volume of waste that can be conveniently loaded into this container is much less than 7 m^3 since it is not possible to fill the container up to its ceiling. All the lids are very heavy and cannot be operated easily. . The clearance between the back lid and the ground when the container is being tipped is so low that the lids frequently become damaged on uneven ground (such as is found on dump sites - see arrow in diagram). The clearance between the back lid and *level* ground is only 500 mm. Because of this problem, lids usually last between one and two months before they must be replaced if the container is to be closed properly to allow the maximum volume of waste to be stored securely in it.



C-2.2 A NEW MATERIAL FOR CONTAINERS

The Steel Authority of India is now producing a special variety of high strength, low alloy steel in its Alloy Steels Plant in Durgapur in West Bengal. The particular product of interest here is called "SAILCOR" steel, and has excellent resistance to atmospheric corrosion. It is principally intended for applications requiring durability, less weight and low maintenance. It is an excellent replacement for mild steel. A similar steel available in Britain is called "CorTen". Figure C-2.1 below shows how much more resistant "SAILCOR" steel is to corrosion than ordinary mild steel.

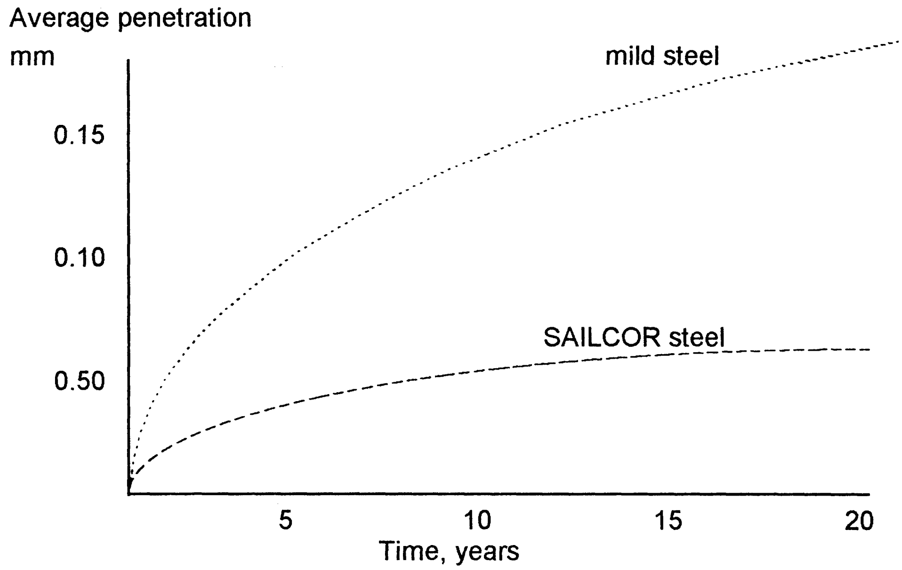


Figure C-2.1 Corrosion curve, comparing the resistance of Mild steel and SAILCOR steel in a semi-industrial environment*. Note: If the steel is in contact with garbage the rate of corrosion will be greater.*

If this material is used for dumper-placer containers, with some minor changes in design, the life of the container should be increased to nine years.

(It is perhaps appropriate to note here that design and construction details can have a significant effect on the extent and rate of corrosion. Sharp corners should be avoided since these trap garbage, which encourages corrosion. Crevices between metal sheets, where the welding is not continuous, can also favour corrosion.)

Cost comparison

As an example, consider a garage that needs 200 containers. If a mild steel container needs to be replaced after 3 years, a total of 600 containers will be needed for a period of nine years. If the containers are made of SAILCOR steel, with an anticipated life of nine years, then only 200 are needed for a nine year period. The total capital costs for the two alternatives are calculated as follows:

Material	Unit cost (Rs)	Number required	Total cost (Rs)
mild steel	45 000	600	2,70,00,000
SAILCOR steel	58 000	200	1,16,00,000

This simple comparison shows that the cost for the SAILCOR containers is only 43% of the cost when mild steel is used.

This calculation assumes that corrosion is the only reason for replacement of containers - some must be replaced because of mechanical damage - and it does not include the cost of maintenance, but the difference is so large that it cannot be ignored or explained away.

Containers fabricated from CorTen steel are being used in Gaza.

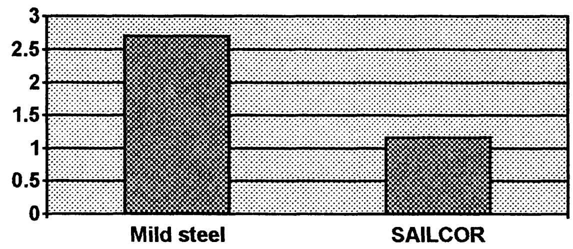


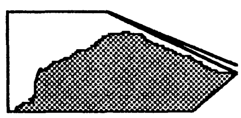
Figure C-2.2 Cost comparison of mild steel and SAILCOR containers
Costs in crores of rupees

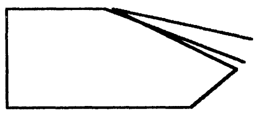
C-2.3 THE IDEAL CONTAINER?

In designing a good dumper-placer container, the following factors should be considered:

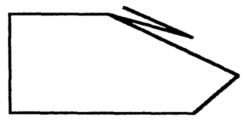
- ◊ The *effective* capacity should be as large as possible, in order to maximise the payload on each trip and so minimise the cost per ton transported. In many designs there is usually a considerable empty void above the waste because the type or location of the opening(s) are such that it is very difficult to load the waste up to the ceiling of an enclosed container. The width of the container is limited by the lifting system, and the height is usually limited by the method of loading, (especially if the container serves as community storage and is, therefore, loaded by the general public). The length of the container is constrained by the chassis dimensions and the lifting equipment. The optimum effective capacity depends on the payload of the vehicle and the density of the waste.
- ◊ The container's load should be covered when it is moving on the vehicle, so that the contents are not dispersed in transit. In some cases it may be necessary to keep the contents covered when the container is stationery, but if the container is to be used as community storage, it is not realistic to expect that lids will be closed and opened by the public using the container, so the lids should be left open in this case. A large lid can be very heavy to operate, so careful design is necessary. It is possible to cover an open container with a net or tarpaulin, but drivers will usually omit to do this unless there is strict supervision, and if the container is high, the driver may need to climb over the waste to spread the tarpaulin - a dangerous practice.
- ◊ The container should be strong. Apart from the pick up and pivoting points, the most vulnerable parts are the doors or flaps. Often the doors are damaged when the containers are being tipped to unload and the door comes into contact with the ground. The design should make allowance for tipping on uneven ground and over a concrete upstand.
- ◊ Unloading should be quick. Some designs have comparatively narrow openings through which the waste must fall, and certain types of waste form an arch that spans the opening so that the waste does not fall out.
- ◊ The container should be durable. Corrosion often limits the life of containers; the effects of corrosion can be reduced by using special steel as described above, by designing the containers with corrosion in mind, by maintaining a protective paint layer, and by washing the containers frequently. It is useful to note where rust holes develop in old containers - it is often at the lower part of the sides rather than in the base - so that the containers can be redesigned for a longer life.
- ◊ The container should be economical. Economy is often best achieved with a simple shape

One of the best designs is shown here. The shape is simple. There is a large opening to facilitate emptying, and the square end helps to maximise the effective volume. However the flap lid is likely to be very heavy and difficult to use, unless it is made of rubber - in which case the wind might catch it.

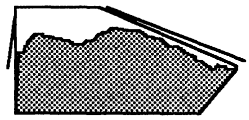




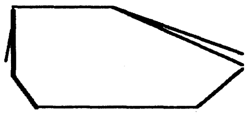
Alternatively, it may be possible to split the lid along the centreline of the container (🡐) or hinge it parallel to the main hinge (➔), but in most situations these arrangements are likely to be damaged quickly



If there is an opening only at one end it will be difficult to load it uniformly over the whole plan area, so in some cases it may be advisable to have a smaller opening, only for loading, in the vertical wall



It may be possible to maximise the useful volume by increasing the overall length and slightly modifying the shape of the front end of the container so that it does not hit the rear of the truck when it is being lifted into position.



C-2.4 CONCLUSION

Clearly this last design is not the ideal, and there is no one ideal design for all applications. The degree to which the container should be closed and the level of supervision and responsibility for the container are important factors to consider. Covering with a tarpaulin or a net has many advantages, provided that the covering operation does not involve walking on the load of waste.

This chapter has not defined the ideal container, but has illustrated many of the steps and considerations that can lead us towards the ideal container.

Chapter D
Maintenance of refuse collection vehicles

Adrian Coad and others

It is a scene that is found all over the world. The Municipal garage is almost full with all kinds of unserviceable vehicles - some modern and sophisticated, whilst others are ancient and battered; some need only minor attention whilst others are lacking their motors, rear axles or major body parts. Many of the vehicles have been there for months, some for years..
What are the different views of this situation?
*The **politicians** are unhappy because they are getting complaints that the refuse collection service is irregular and inadequate.*
*The **senior administrators** have the feeling that the engineers and mechanics do not really know their job or are not trying hard enough to keep all the vehicles going.*
*The **transport engineer** believes that the problems are not caused by him*

- *He wants to dispose of aged, unserviceable vehicles that are so old that spare parts for them are no longer available; these old trucks are taking up precious space, but the administrative procedures are so long and difficult that he does not have the time to do all this extra work to get rid of them.*
- *The modern, sophisticated vehicles are proving unsuited to the conditions they have to work in. He knew that there would be problems and would have advised against the purchase of the vehicles, but no-one asked for his opinion when the vehicles were ordered.*
- *He would like to make faster progress in the repair of vehicles, but he is hampered by the restrictions imposed by the trade unions on the working practices of his men, he spends too long filling in reports and records, and administrative arrangements leave him very little freedom to purchase the parts he needs and to send some vehicles to outside contractors for specialised repair and maintenance work.*
- *Often, when the transport engineer wants to take a vehicle into the garage for important maintenance, he is not able to get it because the operations department needs it urgently. The result is that the vehicle is not properly maintained and so it develops major faults.*
- *Some of the drivers abuse their vehicles and refuse to drive them as they should. They continue to drive their vehicles when they have developed serious mechanical faults, instead of stopping and contacting the garage. They do not report defects until serious damage has been done. The Conservancy department, which is responsible for the drivers, does nothing to rebuke or inform the drivers.*

What can be done?

D-1 INTRODUCTION

It is commonly acknowledged that a large proportion of many municipal budgets is spent on solid waste management, and a high proportion of the allocation to this field is spent on collection - usually considerably more than on disposal. The weak link in the chain, as far as collection is concerned, is often the vehicles. It is not uncommon for collection operations to be hampered by the lack of serviceable vehicles or by the inadequate performance of the vehicles. Maintenance is the key.

Refuse collection services must be reliable. If not, complaints and piles of uncollected waste accumulate at a disconcerting rate. Sometimes the failure of the service is due to labour disputes, but often it is the failure of the vehicles - a failure of maintenance.

It is easy to blame the engineer in charge of vehicles when there is a shortage of vehicles. Often it is not his fault that so many of his vehicles are unserviceable.. Unfortunately, the management environment is often constructed so that the maintenance engineer, who knows most about the problems, is not in a position to draw the attention of his seniors to the problems of vehicle maintenance because he fears that he will be accused of being unable to do his job. So no-one hears his insights, and he struggles on in silence to overcome difficulties (that could often have been avoided if others had listened to him), working long hours, receiving many complaints, and rarely being thanked for his strenuous behind-the-scenes efforts.

D-1.1 Is maintenance neglected?

Varying degrees of importance are attached to maintenance in different places, so it is not possible to generalise on the extent to which maintenance is neglected. There is no doubt that considerable thought and resources have been devoted to developing maintenance capabilities in Mumbai, and much can be learned from a study of the practices and systems in use in the Municipal workshops and garages in that city. Much of the rest of this chapter is devoted to learning from Mumbai's engineers. However, before the case of Mumbai is studied in detail, some general points will be made - some of these points could be used as a checklist.

1. *Are maintenance engineers involved* in the specification and selection of new vehicles? The experience and attention to detail of maintenance engineers can lead to vital insights when vehicles are being chosen. An experienced maintenance engineer can often predict with great accuracy what the weak points of a particular vehicle type will prove to be. Unfortunately it is common that no-one asks for his opinion when vehicles are being chosen, and when the vehicles have been purchased he is unable to draw his superiors' attention to the problems for fear of being criticised for being unable to do his job properly.
2. *Are operation and maintenance costs considered* when tenders are being evaluated? It seems common practice to consider only the purchase price of the vehicles. It would be much more reasonable to consider the operation and maintenance costs in addition to the capital costs, either as an annual cost for each year during the expected life of the vehicle, or as a present cost (i.e. the sum that must be set aside at the beginning to meet all purchase and operating costs throughout the life of the vehicle). Regrettably, in the current situation, it is difficult to obtain operating and maintenance costs from other organisations because engineers may fear the hostility of the supplying company if they release unfavourable figures. The other difficulty is that accounting procedures and records may not be organised in such a way that operating and maintenance costs for a particular vehicle can be abstracted. A later section in this chapter will discuss record keeping.
3. *Are sufficient resources allocated* to maintenance operations? Resources include manpower (especially skilled craftsmen and mechanics, and engineers), investment in buildings and machinery, and recurrent allocations for the purchase of spare parts and payment of outside contractors. The aim should be to minimise the total costs of the waste collection service, and this may sometimes require increasing the resources allocated to maintenance so that less capital expenditure (such as the purchasing of new vehicles) is required to maintain the desired level of service. (For example, a low allocation for maintenance may result in vehicle availabilities of only 50% - that is, an average of only 50% of the vehicles being available for duty on any particular day. Spending more on maintenance might lead to a higher availability figure of, say, 80%, so that more of the existing fleet are operational and therefore it is not necessary to purchase so many new vehicles.)

4. *Are administrative procedures appropriate*? It is necessary to have administrative procedures that prevent or discourage theft of tools and spare parts and that prevent unwise purchases and misuse of funds. These systems need to be evaluated from time to time to determine whether they are operating effectively without hindering the execution of maintenance work. There are stories from a variety of countries concerning bureaucratic practices that at least treble the time taken to do a certain maintenance task, and it seems to be common that bureaucratic delays result in the acquisition of spare parts from overseas taking four to six months. There was a case where the repair manuals for vehicles were kept at the head office rather than in the workshop, so that ordering a new spare part became a lengthy and disruptive operation - because there was no manual to indicate the number of a part that was required to execute a repair, it would often be necessary to take a second vehicle off the road, identical to the one under repair, and remove the corresponding part from the operational vehicle to show the parts supplier what precise component was necessary. Such practices are obviously counterproductive. Managers should be motivated to improve efficiency and to be willing to change practices.
5. *Does the management culture value maintenance*? Conventional university courses place little emphasis on maintenance, so engineers and managers may have little knowledge of maintenance issues unless they have made a special effort to learn from their colleagues or attend special courses. In solid waste management maintenance is a vital issue. Record keeping is an essential part of maintenance management, but mechanics tire of filling in forms unless they are convinced that the forms serve a useful function. Mechanics and engineers are more likely to be ready to fill in forms correctly and write thorough reports if they are aware that managers read them and act upon them. Senior managers should be aware of this need and ensure that their subordinates know that the reports they write are valued and used.

D-1.2 The two types of maintenance

(This section includes contributions from A. K. Sarkar.)

There are two ways of carrying out maintenance on vehicles and mechanical plant; they are known as *breakdown maintenance* and *preventive* (or *planned) maintenance*.

Breakdown maintenance involves taking no action till the machine fails to operate; it is only repaired after it has broken down. Preventive maintenance involves repairing the machine and replacing components before there is a failure, so that breakdowns become very rare.

There are situations in which breakdown maintenance is appropriate. Such situations are when a breakdown does not have any serious consequences, such as when there are many spare machines and only the component that has failed is affected. A simple example would be the failure of a light bulb in a room where there are many light bulbs so that the loss of illumination from one does not cause any inconvenience. There are many more situations where breakdown maintenance is being practised, but often this is by default, because of a failure of management. The practice of breakdown maintenance in the wrong situation can lead to unreliable services, extra expenditure and unnecessary emotional and physical stress for maintenance staff.

Preventive maintenance involves repair or replacement before failure occurs. As a result of such timely interventions machines are kept in good condition so that breakdowns are rare, services are seldom interrupted, maintenance work can be scheduled, and expenditure is less because less overtime is paid and repairs are made before defective components cause damage to other parts of the machine. Preventive maintenance also aims to reduce wear and tear, to cut down oil and fuel consumption, to minimise pollution, to extend the service life of the equipment and to promote reliability and safety of operation

An obvious example where preventive maintenance is essential is the engines of a passenger aeroplane. The consequences of failure are so serious that every reasonable precaution must be taken to avoid breakdown. The failure of a small component in an engine could lead to much more serious damage of other components - if the failed part breaks off other components or fractures a fuel line. Airlines strive to maintain regular schedules, and so want to schedule their maintenance work as much as possible. Airlines must be financially competitive, and so seek to reduce maintenance costs. For all these reasons it is essential that thorough preventive maintenance procedures be applied to aero engine maintenance. (In contrast with the engines, some airlines seem to operate a policy of breakdown maintenance for their in-flight entertainment systems, not making any checks or repairs until a fault is reported and the aircraft is grounded for other reasons.)

An essential element of any preventive maintenance programme is lubrication. Without an adequate supply of oil with the correct properties, sliding parts wear more rapidly, and may overheat and seize. A lubricant serves the following purposes:

- It minimises friction
- It acts as a coolant
- It carries away metallic particles resulting from wear
- It reduces corrosion
- It minimises the formation of acids and foam.

To achieve these goals a lubricant should

- ♦ be very clean
- ♦ contain no solid particles
- ♦ be free of water
- ♦ contain no acids or alkalis
- ♦ have a definite viscosity, stability and pour point.

All lubricants lose these required properties with time, the period depending on the application in which they are used, and so they need to be changed at the appropriate intervals.

Preventive maintenance work may be carried out based on either condition monitoring or replacement schedules. Sometimes the wear on a component is gradual, and regular testing can indicate when breakdown is approaching. In such cases replacement or repair can be based on a measurement of wear or deterioration, and a regular schedule of condition monitoring is required. In other cases deterioration may be unpredictable (being either difficult or uneconomic to measure or coming without warning) and in such cases components should be replaced according to a schedule based on elapsed time or the degree of utilisation of the machine (such as kilometres travelled or hours of operation).

The degree to which preventive maintenance is practised varies according to need and cost. There is a continuum between breakdown and preventive maintenance and the appropriate point between these two must be chosen according to the consequences of failure.

The consequences of failure of refuse collection vehicles are serious. If a truck breaks down the regular collection service is interrupted, causing piles of wastes to accumulate and complaints from the public. The collection crews are idle if their vehicle is inoperative. Mechanics do not like working with vehicles that are loaded with decomposing garbage. Many types of refuse collection vehicles are sophisticated and expensive. The costs of maintaining refuse collection fleets are very high. For these reasons it is clearly appropriate to operate systems of preventive maintenance for refuse collection trucks.

The two types of maintenance can be characterised as shown in table D.1 below.

Table D.1 The characteristics of breakdown and preventive maintenance

Breakdown maintenance	Preventive maintenance
Easy to carry out Needs no planning Low reliability Overall more costly	Needs corporate planning Needs trained staff Needs regular monitoring Needs backup material High reliability Overall less costly

Preventive maintenance needs corporate planning to set up the schedules and to foster the culture of preventive maintenance - of operating according to records and plans and maintaining vehicles at prescribed intervals rather than when they appear defective.

Training is essential so that staff at all levels understand the reasons behind the practice of preventive maintenance. Mechanics who have spent most of their working lives responding to breakdowns may require intensive training and monitoring before they change their methods of working.

Monitoring of the system is vital, especially in the early stages. The need to monitor staff practices has already been mentioned, but there is also the need to review schedules and recommendations to ensure that they are appropriate to the vehicles in the actual working conditions. Schedules may need to be revised in the light of experience, if, for example breakdowns are still occurring when manufacturer's schedules are being adhered to. A key feature of preventive maintenance is the usage of reports and records to determine action.

The backup material that is required includes manufacturer's manuals and service modules and systems for reporting. There are computer software packages that are used to organise preventive maintenance for large vehicle fleets, but the same work can be done manually in an effective way.

There are three tiers of maintenance work -

(i) daily maintenance, which is normally performed by the driver,
(ii) scheduled maintenance, which is normally based on the kilometres run, and
(iii) annual maintenance, which may be the preparation for an annual roadworthiness test or in response to changing seasonal conditions.

Daily checks involve a visual check of the body, checking coolant and lubricant levels, and verifying that the tyre pressures and brakes are satisfactory. Scheduled maintenance involves a large number of tasks; these are described in a later section and in appendix DD-2.3. Seasonal maintenance may involve painting exposed steel with anti-corrosive paint and checking windscreen wipers before the wet season, cleaning the radiator inside and out before the hot season, or ensuring a sufficient concentration of antifreeze before subzero temperatures are expected.

Good, reliable record-keeping is an essential feature of any good preventive maintenance scheme. A key component of the records should be the *Equipment History form*, one of which is kept for every item of machinery (in this case for every vehicle). It details the specification of the equipment and all the maintenance work that has been done on the vehicle. The costs of all maintenance work, both spare parts and labour costs, should be recorded on this form. This information enables the effectiveness of the maintenance schedule and the maintenance work to be evaluated, allows checking that the vehicle has been serviced when it should have been, and enables computation of the true cost of running the vehicle - information that is very important when decisions are being made about the purchase of more vehicles of the same type. If maintenance costs for similar vehicles are very different, the reason may be the way in which the drivers treat their vehicles, and the driver whose vehicle needs more repairs may need retraining or disciplining. The introduction of such a system of record keeping may seem like an impossible task, and it will need considerable effort and perseverance to get it started, but once the system is working it becomes a comfortable routine to keep the records up to date. Information about Equipment History forms that are used in Mumbai is shown in Appendix DD-3.3.

The concept of preventive maintenance needs the support of the highest levels of management because there is often tension between the vehicle repair department and the user departments. The users may want vehicles on a day when they have been set aside for routine maintenance work. If the maintenance department is over-ruled and the vehicles go out for duty, it may prove impossible to service them at the required intervals so that the vehicles are operated until they break down and expensive repairs are required.

One of the major challenges to the engineer who runs a preventive maintenance scheme is the motivation of his workforce. How can he motivate them to perform every task seriously, and to complete the records accurately and in full? Training is the foundation - each employee must understand how to do his work effectively and why his role is important. Supervision and spot-checks (checking that levels are correct, parts replaced and components cleaned after a service is said to have been completed) are part of the answer. Building responsibility is another vital step. Mechanics can be made to feel more responsible by requiring them to write their names and signatures clearly on the report forms that describe the work they claim to have done. Another approach is to divide a large workforce into small teams, each responsible for particular vehicles, and to emphasise the link between the work done by the maintenance crew and the condition and serviceability of the small number of vehicles that they are directly responsible for. Publishing monthly the availability figures for each team's vehicles could help to develop team spirit and a positive sense of competition between the teams.

D-2 MANAGING VEHICLE MAINTENANCE IN MUMBAI

The rest of this chapter is mostly concerned with the practice of vehicle maintenance in Mumbai. There is much to learn from the way maintenance is managed in that city. The system of record keeping is well developed, and the tables of information in the rest of this chapter and in the appendices can be regarded both as examples of data collection practice and as sources of information.

D-2.1 Maintenance infrastructure in Mumbai

Based on information collected by Mrs P Singh,
Mr P Pahade and Mr V S Rao

For the purposes of solid waste management, Greater Mumbai was divided into two zones - City and Suburbs. Within the Solid Waste Management Department there was one central vehicle workshop in each zone - the *Unit Workshop* in the City and Santa Cruz in the Suburbs. Most major repairs were carried out at these workshops, and the central stores for spare parts are kept here. In addition there were garages where serviceable vehicles were kept and both major and minor maintenance was carried out. In the suburbs these garages were at Bandra, Malad, Borivali, Kurla, Chembur and Pantnagar.

The Transport Section of the Solid Waste Management Department was responsible for the maintenance of vehicles that were used for solid waste management, and also for vehicles that were used for the following departments: Roads, Health, Hospitals, Schools. Markets, Licences and Encroachment, Pest Control, Wards, and Accounts. This wide variety of functions called for a wide range of vehicle types, including VIP cars, minibuses, ambulances, tankers, breakdown trucks and many others. The range of vehicles used for solid waste collection included at least three types of compactor truck, open tipper trucks (or dumpers), conventional trucks, tractors (some with a container at the rear), JCBs, and jeeps. It was estimated that about 27% of the vehicles were connected with solid waste collection.

An Executive Engineer (Transport) was based at each workshop and responsible for each zone. He was assisted by four Assistant Engineers (who were responsible for two or three garages each). For each garage there was normally a Sub Engineer in charge, and he was assisted by Junior Engineers.

At the central workshop there were three major functions - administration (including preparing budgets, accounting and billing), central stores and vehicle maintenance. Major repairs, including replacement and reconditioning of units (motors, gearboxes, starters, dynamos, clutch pressure plates, water pumps etc.) were carried out at the central workshops, though the following specific tasks were sent out to subcontractors:

- repairs of diesel injector pumps
- repairs of hydraulic systems of compactor trucks
- tyre retreading, and
- minor machining.

Apart from the administrative side and the engineers already mentioned, the staffing at the Santa Cruz workshop was as follows:

- two sub-engineers, one responsible for maintenance and one for stores
- three junior engineers
- two clerks
- one technical assistant
- one foreman,
- one technical time keeper,
- three shop recorders,
- four store assistants, and
- 123 craftsmen and labourers.

The ratio of maintenance staff to vehicles at Santa Cruz was 1.3 : 1 - this is a norm agreed between the MCGM and the unions and includes para-technical staff such as time-keepers, shop recorders, store assistants etc. It must be remembered that most of the vehicles were much simpler than refuse compactors, so this ratio might need to be higher if only refuse trucks were being maintained. The number of staff employed was high compared to numbers employed in some other countries, but a detailed study of staff working patterns would be needed to determine whether the workshop was actually overmanned. Similarly, the balance between skilled and unskilled staff is another factor that is to be considered.

The stores section at the central workshops was responsible for procuring almost all the spares and consumables needed for vehicle maintenance (except mild steel plate, uniforms, bleaching powder and cotton waste). Items were classified into schedules according to the type of supplier (vehicle manufacturer, component manufacturer, authorised dealers etc.) and according to class based on value. Terms and conditions were negotiated with these suppliers to be valid for two years to avoid the time-wasting procedure of tendering for every purchase. Reordering of spares was carried out when the stock levels fell to a four month supply, with the aim of holding at least two months' stock at any time. The operation of any stores department can be monitored by ascertaining the number of requests for parts that have been satisfactorily met within a given time interval. Surveys of this type conducted on a regular basis indicate whether the stores are operating in a satisfactory way, and if the operation is deemed to be unsatisfactory, the reasons should be investigated. Possible causes may be a deterioration in the performance of suppliers (which would call for a revision of the reorder levels) or insufficient powers for the engineer in charge. Delays in the supply of spare parts result in expensive vehicles being unproductive for unnecessarily long periods of time, and perhaps a failure to provide a service, a crew being idle and precious workshop space being occupied; considerations of the costs of delays should be used to justify investigations and expenditure related to spares procurement. A survey on the supply of spare parts for one month in 1993 is presented in Appendix DD-2.1

One of the suburban garages - Bandra - and one of the city garages - Prabhadevi - were studied in more detail. Much of the vehicle data used in this report comes from these two garages; the authors have been favourably impressed by the standard of record-keeping at Bandra and Prabhadevi and are very grateful for the help provided by the staff there. Table D.2 below shows the vehicles that were kept at Bandra and their status on one particular day in 1993.

Table D.2 Vehicles at Bandra garage and their status on 27 November 1993

Type of vehicle	Number	Status				
		Proposed for scrap	Annual test	Long laid up	Running repair	Available
Refuse (open)	5	5				
Refuse compactor	21	-	2	-	4	15
Mechanical sweeper	2	-	1	1	-	-
JCB	2	-	-	-	1	1
JCB dumper (open tipper)	11	1	-	1	-	9
Dog van	1	-	-	-	-	1
Ambulance	20	4	4	-	1	11
Hearse	4	-	1	-	-	3
Pest control vehicle	1	1	-	-	-	-
Dy Chief Accountant's van	5	-	-	-	-	5
Garage duty	1	-	-	-	1	-
Breakdown truck	2	1	-	-	-	1
TOTAL	75	12	8	2	7	46

Key

Proposed for scrap:	No longer regarded as serviceable; permission to scrap is awaited
Annual test	Vehicles are required to pass a condition and roadworthiness test each year, also known as "Police Passing" and RTO test
Long laid up	The vehicle is considered repairable, but it has been out of service for at least two months
Running repair	Undergoing or awaiting repairs
Available	Ready for service

At Bandra garage there were 65 employees connected with maintenance and 124 involved in operation - drivers and assistants who accompanied drivers in refuse compactor trucks. Details of the maintenance staffing are provided in appendix DD-2.2. Servicing and routine maintenance was carried out at the garages, and some of the work in preparation for the annual test (depending on workloads at garages and the central workshop). At the time of the study in 1993 most of the compactor trucks were still in their warranty period so the manufacturer was responsible for repairs for the new vehicles. The manufacturer had set up a team that was working at Bandra to undertake repairs to the bodies of the new compactor vehicles. They also helped with repairs to the hydraulics of older compactor trucks. Their presence at the garage gave the permanent employees the opportunity of observing how repairs were handled (provided that their own work was not so much that they had no time to observe the manufacturer's mechanics at work).

D-2.2 Preventive maintenance systems in Mumbai

(Most of the information in this section and in Appendix DD-2.3 has been provided by Mr V K Rao, MCGM, and the editor is very grateful for his contribution and involvement.)

Preventive maintenance in the Solid Waste Management Department of the MCGM was based on a programme regular servicing or "docking" for the refuse collection trucks. There were five levels of servicing operation for refuse collection trucks:

N	Normal servicing	every 1 000 km or monthly
A	'A' Docking	every 4 000 km
B	'B' Docking	every 8 000 km
C	'C' Docking	every 16 000 km
D	'D' Docking	every 32 000 km

The schedule for servicing was therefore decided according to the reading of the kilometre gauge (odometer) of the vehicle. For more sophisticated and larger types of machinery (such as a bulldozer) it is customary to measure usage by means of an hour meter, which records the time that the motor is actually running, rather than the distance it has travelled. However, since refuse trucks are built onto normal truck chassis, the only available method of measurement of usage is the odometer. The distances covered by a vehicle in a day vary greatly within the city - trucks bringing waste from the city centre may cover twice the distance each day that is covered by a vehicle operating close to the disposal site, so it is not feasible to base the maintenance schedules on calendar time (rather than distance covered). The intervals between servicing or maintenance for heavy municipal vehicles in Mumbai have been set as shown in table D.3

Table D.3 Frequencies of different types of service

Reading of odometer (km)	Type of service or docking
1 000	N
2 000	N
3 000	N
4 000	A
5 000 etc.	N
8 000	B
9 000 etc.	N
12 000	A
13 000 etc.	N

Reading of odometer (km)	Type of service or docking
16 000	C
17 000 etc.	N
20 000	A
21 000 etc.	N
24 000	B
25 000 etc.	N
28 000	A
29 000 etc.	N
32 000	D

[This raises the issue of whether the kilometre gauges are reliable. In some cities the workshop staff will say that it is not possible to keep these gauges operational, and so a system like this can only be operated by estimating the distances that the vehicles have covered - a task that adds a considerable degree of paperwork and introduces uncertainty. Some drivers might feel that it is in their interest to have inoperative odometers in their vehicles since that would make it more difficult to account for the usage of fuel, enabling them to sell some of their fuel without detection. Other drivers might be glad of the opportunity of travelling further than they are authorised. In other cities the management might make it a matter of priority that odometers should be kept operational at all times so that maintenance can be organised as described above, pilferage of fuel can be discouraged and the general condition of the vehicles can be monitored more precisely.]

Lists of instructions called Docking Schedules have been prepared to guide the fitters as to what should be done for each vehicle at each docking. They have been reproduced in Appendix DD-2.3. They show that components are to be replaced at certain specified intervals. These replacements were not at the discretion of the fitter, but should always be done at the time indicated. When a vehicle was expected in for a docking the necessary parts were prepared on a tray and checked by a sub-engineer. At the end of the service, all the old items that had been replaced by the new parts were to be returned on the tray to be checked and then destroyed. This degree of checking and security is essential because there is a strong temptation for mechanics to keep the new parts and sell them, leaving the old worn-out parts in the vehicles, or perhaps the used components might be cleaned and sold as new components.

Exchange units were normally replaced at predetermined intervals according to the docking schedules. For example, dynamos were replaced every 8 000 km, and clutch plates every 16 000 km. Engines were replaced every 128 000 km. (A history form was kept for each engine, recording which vehicle it was taken from, at which garage, and by whom, and showing into which vehicle it was subsequently fitted etc.) The units that were removed were reconditioned in the workshop and kept ready for fitting into another vehicle when an exchange was necessary. In this way units could be reconditioned when the fitters had time, and in clean and convenient conditions. If this unit replacement system were not used, major vehicle parts would need to be repaired in a hurry while the vehicle was kept idle in the garage. This system can only be economically applied if there is a degree of standardisation, so that components from each vehicle can be used in a number of others.

Standardisation on a few types of vehicle is important for a number of other reasons also. It reduces the number of spare parts that must be held in the stores, and it enables the mechanics to be very familiar with the small range of different types of machine so that they can perform the maintenance work efficiently. Standardisation on just one vehicle type is rarely possible in a large city because there is usually a variety of situations that must be served so that several different types of vehicle are required. A typical constraint is the width or road surface of the access route; in some situations narrow trucks are needed to reach certain parts of a city. Sometimes standardisation is prevented by the method of selection of the vehicles - if they are selected solely on the basis of the lowest tender or as a result of trade agreements, the transport engineer is not in a position to standardise his fleet as he would like to.

Determination of the intervals at which items should be changed (that is, preparation of the docking schedules) depends on the experience of the engineer. The starting point may often be the recommendations of the manufacturers; but this may need to be modified. A very good example is given by the frequency of changing engine oil. The chassis manufacturers of a particular compactor vehicle used in Mumbai recommended that the oil should be changed every 16 000 km. Engineers in charge of the vehicles monitored the condition of the oil and noticed that it reached the state when it needed to be changed sooner than it should have. They realised that this was because the engine of a compactor truck works hard when the vehicle is stationary - compacting and unloading the refuse - and so the distance covered alone is not an accurate indication of the amount of work done by the engine and transmission. (The manufacturers of the engine had set the distance that an ordinary truck could run, without thinking of the extra work done by a refuse compactor when it is stationary.) In Mumbai it has been decided to change the engine oil at intervals of 8 000 km. Intervals between oil changes depend on the specification of the oil that is used; it may be cost-effective to use a more expensive oil if the required intervals between changes are longer.

There was a similar approach in Calcutta, as described by A. K. Sarkar. Two coefficients were used; one relating to the conditions under which the vehicle was operating, and the other being concerned with the type of body. For example, a chassis manufacturer might recommend a frequency for oil change of 8 000 km, but this would be for a long-distance transport vehicle operating on paved roads and usually running in top gear. However, for a vehicle that is operating at low speeds on bad roads and dusty conditions, this interval should be reduced by the coefficient 0.6. If the standard chassis is fitted with a specialised body that includes hydraulic systems, the interval between oil changes should be reduced by a further coefficient, for example 0.8 for a tipper truck or dumper-placer truck. So, for this example, the interval between oil changes for a tipper truck collecting solid waste should be :

$$8\,000 \times 0.6 \times 0.8 = 3\,840 \sim 4\,000 \text{ km.}$$

Similarly, the manufacturer may recommend that an oil filter be serviced every 1 000 km. If, however, a vehicle is working at low speeds and in dusty conditions, the interval between servicing should be reduced by the coefficient 0.6 to 600 km. If the vehicle also has hydraulic equipment that causes the engine to operate when the vehicle is not moving, the interval should be reduced by a further 0.8 to 480 (or 500) km.

Maintenance records should also be used to determine the frequency at which parts should be replaced or overhauled. If breakdowns still occur as a result of failures of parts that are exchanged or repaired in the preventive maintenance schedules, it is likely that it would be appropriate to increase the frequency at which these parts should be replaced. It is recommended to use a report form that is to be filled in whenever a vehicle breaks down; the breakdown is classified into one of three groups:

a) due to a fault in the last servicing or docking
b) non-avoidable, or
c) accidental.

If the breakdown is thought to be as a result of poor servicing (category [a]), the name of the fitter who carried out the last servicing should be written on the breakdown form. A regular inspection of these breakdown forms would enable the engineer to form an opinion as to whether the frequency of servicing of a particular part of the vehicle has been sufficient. The form is reproduced in Appendix DD-2.4. These forms might also indicate if the routine maintenance is being done correctly, if the results were collated in such a way that any trends or high frequencies of particular faults could be discerned.

Another key element of preventive maintenance is the scheduling of the maintenance work so that the work for the mechanics is evenly spread throughout the year. This requires good judgement from the transport engineer to know how long different tasks will take, to know when vehicles can be spared, and to continue to make allowances for unforeseen breakdowns and complications. Appendix DD-2.5 shows a table used to forecast when each vehicle will need to be called in for its next docking.

Tyres can be an expensive item in the maintenance of refuse trucks because of the high risk of punctures when driving over refuse, and the risk of rubbing the tyres against kerb stones. The maintenance of tyres has been discussed in some detail in Appendix DD-3.2.

New vehicles were allowed to run for two years before the first annual RTO roadworthiness test must be taken. If a number of new vehicles arrive at the same time it will be necessary to test most of them at staggered intervals early (i.e. before the two years has passed) so that it is not necessary to take all the new vehicles out of service at the same time

D-3 MAINTENANCE RECORDS

D-3.1 Recording systems

As has already been mentioned, record keeping is an essential prerequisite of preventive maintenance. The records should be in a form so that the required information is easily abstracted. Record-keeping is not an end in itself; all records should be evaluated from time to time in an effort to reduce unnecessary form-filling and report writing. The amount of time that craftsmen spend on record keeping should be kept to the necessary minimum.

At Bandra garage in 1993 it was noted that there were 36 registers used to record a variety of operational and maintenance data. Their titles were as follows: (Items marked * are discussed later in this chapter or in the appendices.) The titles of the registers are listed in table D.4 below

Table D.4 List of titles of maintenance registers

1.	Staff muster	19.	Tyre register* - see Appendix DD-3.1, 2
2.	Driving licences	20.	Tyre repair register* - see Appendix DD-3.1, 2
3.	Addresses	21.	Tool register
4.	Spot muster	22.	Inward and outward register
5.	Overtime statement	23.	Dead stock register
6.	Overtime register	24.	Plant and machinery register
7.	Daily diaries	25.	Despatch slip register
8.	Additional work allotment	26.	Cannibalising register
9.	Job allocation	27.	Store receipt register
10.	Vehicle allocation / vehicle manufacturer	28.	Store issue register
11.	Breakdown register	29.	Store ledger
12.	Sickness register (vehicle defects) * see D-3.2	30.	Gate pass register
13.	Log sheet	31.	Spare parts register
14.	Fuel and trip register** - see Appendix DD-3.1	32.	Stores indent
15.	Daily utilisation report	33.	Material requisition notes
16.	Oil register	34.	Servicing schedule
17.	Oil consumption register* - see Appendix DD-3.1	35.	Police passing dates schedule
18.	Battery register	36.	Maintain module

D-3.2 Data on vehicle defects

Before discussing data on vehicle defects it is appropriate to discuss the main types of vehicle that are referred to in this section. Two basic types are considered - compactor trucks and *dumper placers* - known outside India as skip lift or container hoist trucks.

At the time of the study there were two types of refuse compactor vehicle in common use. The older vehicles were the Airtech Schörling 4R type which have been described in a previous report (*Observations of solid waste management in Bombay 1992* by Scheu and Coad) and which are conventional ram-operated rear-loading compactors.

The more modern compactors are the Airtech "Multipack" model which is an Indian design which aims to reduce maintenance by minimising the number of hydraulic rams required to perform all operations. By using chains and cables, the pair of large rams on top of the body lift the one cubic metre wheeled containers, compact their contents into the body and also raise the tailgate during emptying. The load is ejected by means of an ejector plate that is operated by two rams operating in tandem. (See figure B-2.1.) There have been some teething problems with this new design which have hopefully now been sorted out. The lifting mechanism at the rear reduced the ground clearance of the body considerably so that on soft ground at disposal sites it sometimes became held by the ground, so that when the vehicle tried to move the *resting rods* that held this equipment in position became bent or broken. The cables that lifted the wheeled containers sometimes became elongated or displaced, affecting the operation. The ejector rams, being offset from the line of action, sometimes became bent. Minor problems, such as the lack of bushes in a lever mounted on a shaft, and the lack of grease nipples in the cable pulleys have hopefully been rectified by now. The seals in the hydraulic rams were also prone to leaking and this suggested that a higher specification for the rams would be appropriate. There were also some chassis problems in the early models received by the MCGM. Multipack trucks are shown in photographs 5 and 6.

Two types of dumper placer were in widespread use in Mumbai, though there were other, smaller models also being used. One was based on an Ashok Leyland chassis and the other on a Tata chassis. One problem with the former type was the hydraulic rams used to stabilise the vehicle when lifting heavy containers - they were simple vertical rams which could be damaged if the driver started his vehicle moving while the ram was down.

The basic source of information on vehicle defects has been the "sickness register" which is kept in a foolscap-size bound notebook. It was completed every day except Sundays, and the entries were summarised daily for compactors and weekly for all vehicles. The basic format that was being used at Mumbai garages is illustrated in table D.5

Table D.5 Sample of vehicle sickness register from Prabhadevi Garage, October 1 1994

Serial number	Vehicle number	Vehicle type	Service	Laid-up since	Remarks
1	1185	AL	Ref	9/8	Hopper beam (Bandra)
2	1081	"	"	5/9	Accident (Waiting for other parts)
3	1069	"	"	"	Automotive (Kurla)
4	1198	"	"	27/9	Packer plate not operating (Bandra)
5	1183	"	"	29/9	B servicing and PTO mod^n work
6	1088	"	"	1/10	Air lock
7	1095	"	"	30/9	F/L leaf spring work, other work
8	1199	"	"	30/9	Ejector cylinder bent (B)
9	7996	"	Asp	18/9	RTO passing
10	7994	"	"	25/9	"
11	1131	"	"	21/9	Accident, door lock
12	1110	"	"	1/10	Brakes weak, horn, driver's seat faulty

The last part of the registration number of the vehicle is written in column 2.
The third column may have a description of the vehicle such as "MPRC A/Leyland" (**M**ulti**p**ack **R**efuse **C**ompactor **A**shok Leyland), or, simply as here "AL" for Ashok Leyland.
Column 4 shows the service that the vehicle is put to; "Ref" refers to refuse collection and "Asp" may refer to road repairs.
The next column shows the date when the vehicle was taken off the road. This could be taken from the previous day's entry.
The last column gives the reason for the vehicle being off the road, and in this case also shows where the vehicle has been taken for repair (Bandra or Kurla). Alternatively, some registers have a column headed "Attended by" in which would be written the initials of a mechanic or (for example) "Airtech" - the manufacturer of the compacting bodies who had a base at Bandra.

This register provides a vast amount of data concerning the maintenance of the vehicle fleet, but the register took unnecessary time to complete, and abstracting certain items of information for a long period of time is a lengthy process.

Preparing the table each day and writing in the data took more time than was necessary. If a proforma were prepared in advance some time could be saved, and the repetition of data from one day to the next could be avoided. For example, if a vehicle is off the road for twenty days for the same reason, the same entry is made for the vehicle each day, that is, twenty times.

If information is sought about the performance of maintenance tasks, the occurrence of certain failures, or the duration of specific problems, many pages of the register must be referred to. The method of recording the data shown in table D.6 would reduce some of these problems and provide the data in a much more accessible way. A blank table of the form shown would be started each month. It should have enough columns to accommodate all the refuse collection trucks at a particular garage, and enough rows to allow the entry of data from each day of the month. If a vehicle is used on a particular day the appropriate space should be ticked. If the vehicle is serviceable but not used, the entry should be "Sp" as an abbreviation for "spare". If the vehicle is off the road for other reasons, the reason should be indicated according to the key at the bottom of table D.6. The key separates the defects into basic categories of mechanical problems, concerned with the chassis (supplied by Ashok Leyland usually) and the body (manufactured by Airtech). The other major categories are "S" for preventive maintenance servicing and "P" for preparation for the annual roadworthiness test. Lower case letters are then used to specific mechanical and body problems in more detail according to a code that can be developed to suit common failures and convenient categories. The second and third columns are for daily summaries of the total number of vehicles allocated to the particular garage and the number on-line or spare i.e. the number available. This method of record keeping simplifies the data entry process and enables a supervising engineer to see at a glance how many vehicles have been available, how long any particular vehicle has been laid up, and what types of problem are occurring frequently. Records for several months have been compiled and are presented in slightly different forms in Appendix DD-1.

One obvious way of using the data extracted from the sickness records is to calculate the availabilities of the vehicles - that is, the percentage of the time that the vehicles are available for service. Availability data show the effectiveness of the maintenance operation and also suggest the number of vehicles that should be purchased - if, for example, the availability is 50 % it means that two vehicles should be purchased for every vehicle needed on the road each day. Availabilities would be expected to vary with the type and age of the vehicles. Figure D.1 below shows availability data for compactor trucks for almost two years. It can be seen that the availabilities vary between 53% and 74%. The lower values suggest that there is a need to investigate the most common causes for vehicles being off the road. Bus companies are able to achieve availabilities approaching 90%, but before comparisons are made with refuse truck fleets it must be remembered that buses are much simpler vehicles than rear-loading compactor trucks, and refuse collection trucks are often obliged to run on difficult ground at disposal sites. The graph also shows that for the period February to August the figures for 1993 are lower than for those for 1992. The most obvious explanation for this is that the new compactor trucks which were supplied from February 1993 onwards were not as reliable when they first arrived as the older vehicles they were replacing. (A detailed study of maintenance records would show if this was indeed the case and what the common problems were.)

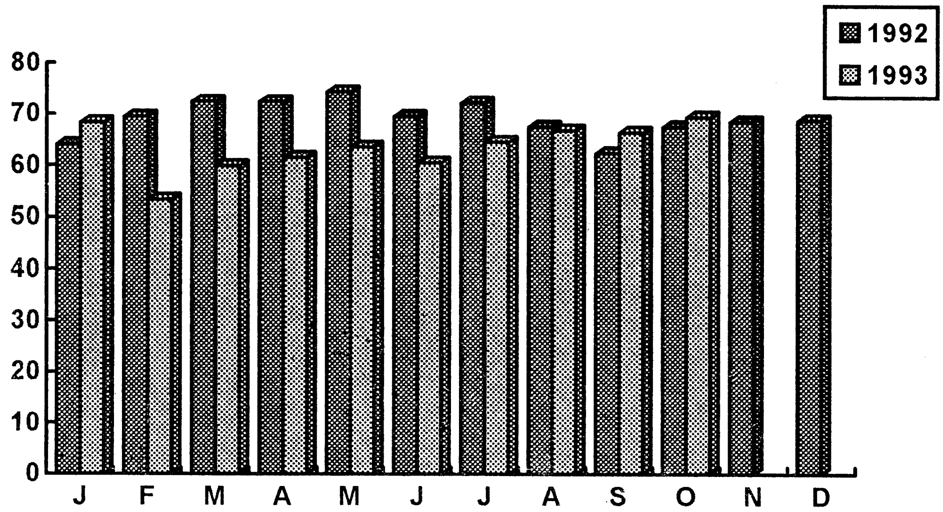


Figure D.1 Monthly availability of refuse compactor trucks for the period January 1992 to October 1993

An inspection of the charts in Appendix DD-1 shows that considerable time is sometimes taken to prepare the trucks for the annual roadworthiness test, and for the test itself. Figure D.2 shows how the time for this work has varied over the period December 1991 to April 1993.

Similarly, it is possible to use information such as that presented in table D.6 to determine the time taken for any repair. If a vehicle is off the road for a long time for the same reason it is likely to be either because of a shortage of skilled fitters to carry out the repair or the lack of the necessary spare parts. The lack of parts may be due to the failure of manufacturers or dealers to have them available, or because of lengthy bureaucratic purchasing procedures. It was reported that, in 1993, sub-engineers and junior engineers had no right to purchase spares from the open market, and assistant engineer had the right to spend only up to Rs 50. - a limit that had been in place for about 30 years. Delays in repairs can be very expensive because an expensive vehicle is lying idle and workshop space is being occupied unproductively. In many cases it might be worthwhile to examine the degree to which repairs are taking more time than they should, and if this appears to be a problem, to identify ways of reducing the periods for which vehicles are off the road. One further reason for delays in

Table D.6 Data from Bandra Garage October 1993

October 1993			Vehicle registration numbers								
Day	Total	O/L+Sp	2469	2470	2471	2472	2473	2474	2475	2476	2477
1	22	12	B u	✓	M h,l	✓	✓	✓	M b,i	✓	✓
2											
3											
4	22	14	B	✓	✓	✓	✓	✓	M	✓	✓
5	22	16	✓	✓	✓	✓	✓	✓	M	✓	✓
6	22	16	✓	✓	✓	M m	✓	✓	M	✓	✓
7	22	15	✓	B o	B u	✓	✓	✓	M	✓	✓
8	22	16	✓	B	✓	Sp	✓	✓	M	✓	B o
9	22	15	✓	B	✓	✓	✓	✓	M	✓	✓
10											
11	22	15	✓	B o	Sp	✓	✓	✓	M	✓	✓
12	22	14	✓	B	✓	✓	✓	✓	M	✓	B p
13	22	14	B o	B o,pc	B o,l	✓	✓	✓	M	✓	B m,p
14	22	15	✓	✓	✓	✓	✓	✓	M	✓	B
15	22	17	✓	✓	B p	S	✓	✓	M	✓	✓
16	22	15	✓	✓	B	S	✓	✓	M	✓	B u,i
17											
18	22	17	✓	✓	B	S	✓	✓	B t	✓	✓
19	22	17	B l,p	✓	B	S	✓	✓	B	✓	✓
20	22	15	M c	✓	B	S	✓	✓	B	✓	✓
21	22	17	✓	✓	B p	S	✓	M c	B	✓	✓
22	22	16	✓	✓	B	✓	✓	M	B	✓	✓
23	22	14	✓	✓	B	M d	✓	M	B	✓	✓
24											
25	22	16	✓	✓	✓	M	B t	M	B	✓	✓
26	22	16	M c	✓	✓	M	✓	✓	B	✓	✓
27	22	16	?	✓	✓	M	✓	✓	B	✓	✓
28	22	16	✓	✓	B p	M	✓	✓	B	✓	✓
29	22	14	✓	✓	B	M	✓	✓	✓	✓	✓
30	22	15	✓	✓	✓	M	✓	✓	✓	✓	B
31											

Note: Servicing for new vehicles is done by supplier (BML)
Observations: Older vehicles kept as spares when sufficient vehicles are available

B Body repairs **M** Mechanical, i.e. chassis **P** Annual Police test **S** Service **Sp** Spares **L** Long laid up (More than 2 months)

The list of lower case characters may be difficult to remember; the author has taken some liberties with spelling and added reminders for his personal use; the reader should consider developing his own system.

a	chassis	j	washing (j cloth)	s	steering sp springs
b	brakes	k	lubrikation system	t	pto
c	clutch cb cab	l	container lift	u	rams - uther (not leaks)
d	differential	m	motor	v	rust (vanishing steel)
e	electrical	n	starting	w	wire rope
f	fuel	o	ram leaks (o rings)	x	ejector plate (exit)
g	gearbox	p	packer plate pc chain	z	tailgate lock (at the end)
h	wheels	q	qontrols		
i	air pipe, system	r	resting rods		

repairs may be the facilities that are available to the mechanics - shortages of tools for certain tasks or inadequate protection from the weather (especially monsoon rains) may be the reason for some repairs taking a long time.

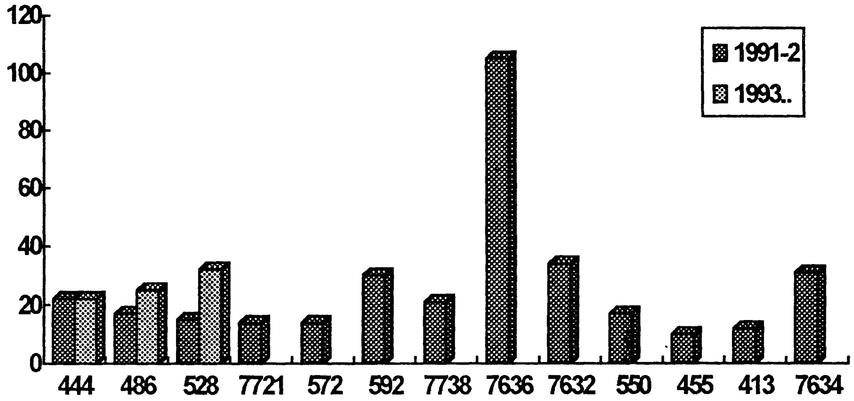


Figure D.2 Time taken for annual roadworthiness test

Compactor trucks for refuse collection have complex hydraulic machinery for lifting, loading, compacting and unloading solid waste. It is to be expected that such machinery will fail from time to time. A review of failures of hydraulic systems in compactor trucks based at Prabhadevi Garage is shown in figure D.3.

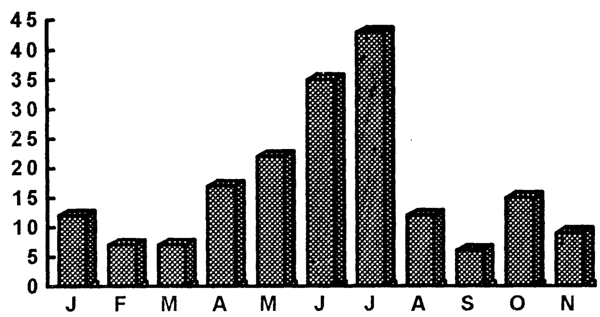


Figure D.3 Hydraulic failures in refuse compactor trucks based at Prabhadevi Garage in 1994
(The value for November is for the month up to the 20th day)

The results show particularly high failures during the monsoon months. This is probably because the density of the waste is much higher when it is wet and so the lifting equipment is overloaded. At Prabhadevi garage a wheeled refuse container has been partly filled with concrete so that the lifting gear can be tested after repairs have been made and before the vehicle is sent out for duty

Another common problem with refuse collection vehicles is the wearing out of clutch plates. This is because these vehicles spend much of their time in slow moving traffic in which there are frequent gear changes, and because driving with a full load on soft ground on refuse disposal sites adds to clutch wear. Figure D.4 shows, for different vehicles, the replacement rates for clutch plates during the period April 1991 to March 1992, and the replacement rates for pressure plates for the period June 1991 to March 1992. The chart shows which vehicles have suffered most clutch wear, and suggests that there might be benefit in providing some training for the drivers of the vehicles with the most clutch wear. The reasons for low wear, particularly for 4143 should be examined - it may have been because the vehicle was little used during that period because it was kept as a spare or was awaiting repairs for much of the time, or it may have been the result of skilful and careful driving.

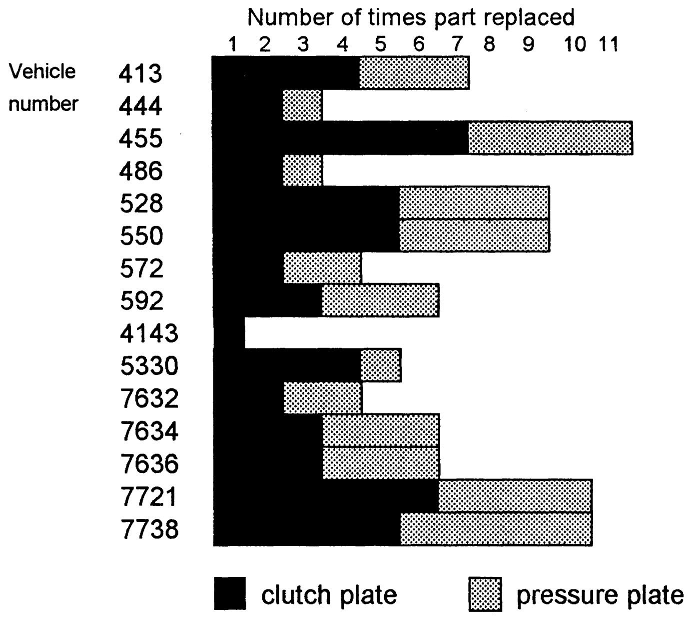


Figure D.4 Replacement rates for clutch parts for various compactor trucks.

A detailed way of calculating the achievement of a garage in the area of maintenance is shown in table D.7, which is taken from the records of Prabhadevi Garage. It analyses the situation in terms of vehicle days - for example the total number of vehicle days in a month is the number of vehicles based at the garage multiplied by the number of days in that month.

Table D.7 Record of operations May-November 1993, Prabhadevi Garage

Row #	Description	May	June	July	Aug	Sept	Oct	Nov
1	Total number of vehicles	22*	28*	28	28	28	28	28
2	Total vehicle days for whole fleet (number of vehicles multiplied by number of days they were at the garage)	586	766	868	868	840	868	840
	Number of vehicle days lost to							
3	body failures	112	181	190	158	185	134	136
4	mechanical (chassis) failures, including servicing and docking	72	163	146	136	143	112	151
5	vehicle not being required (spare)	31	10	45	44	17	10	16
6	vehicle days lost because of accidents	6	26	36	31	30	33	30
7	Total of vehicle days lost [rows (3+4+5+6)]	221	380	417	369	375	329	333
8	Balance of vehicle days [rows (2 - 7)]	365	386	451	499	465	539	507
9	Required vehicle days - i.e. demand	380	390	454	503	493	546	518
10	**Service efficiency [rows (8/9)] percent**	**96**	**99**	**99**	**99**	**94**	**99**	**98**
11	Number of vehicles supplied	13	13	15	17	17	18	18
12	**Fleet efficiency [rows (11/1)] percent**	**59**	**46**	**54**	**61**	**61**	**64**	**64**

Notes Row 1 * varying through the month
Row 7 It appears that the author made an error in transcribing the values for October since the values in rows 3 to 6 do not add to the figure in this row.

This method of analysis gives a useful summary of the service provided by the garage. By including the spare vehicles with the vehicles not available the service efficiency provides a useful indicator of how well the garage has met its obligations over the month. Considerable effort is required to collect all this data from the daily register.

D-4 CONCLUSIONS

- The management of maintenance is a subject that is challenging and important.
- Good preventive maintenance can save money and improve reliability.
- A successful maintenance programme requires teamwork and commitment; from the fitters and drivers who carry out regular inspections and maintenance work and fill in information slips, to the manager who designs and modifies the information management system, monitors the reports regularly and acts upon the information he receives.
- Information costs money. It takes time to fill in forms and update records, so ways should be found of simplifying reporting procedures without losing useful information.
- Information is valuable if it is used to save money and improve efficiency.
- Information is worthless if it neither reviewed nor used. The use of maintenance information can be encouraged by presenting it in a form that is convenient to use.
- The kilometre gauge or odometer is an important tool in maintenance management. Kilometre readings are used in many maintenance records and so a high priority should be placed on keeping the kilometre gauges in trucks in good condition.

D-5 EXERCISES

Review the charts in Appendix DD-1 and answer the following questions:

1. Note the slight differences between the styles of presentation of the different charts and make recommendations as to which features are most useful, and which style is easiest to use and interpret.

2. List the items of information that can be deduced from the charts. Write your answers in the form of questions that can be answered from the charts.
   (For example the charts could be used to answer the question -
   Which is the most common fault occurring in the trucks?)

3. Compare these charts with the daily sickness register method of recording vehicle faults, as illustrated in table D.5.
   a) Discuss the advantages and disadvantages of each system in terms of the time taken to enter the information and the ease with which a manager could extract information.
   b) If charts were used in this way for recording the condition of the fleet, would a daily register still be necessary? If it would, for what purposes would it be used?

4 Compare the availabilities of different types of vehicles. (There are three types of vehicles mentioned in the charts: older compactors, Multipack compactors, and dumper-placers or skip trucks.)
   a) Consider whether there is enough information to draw reliable conclusions about the average availability of each type.
   b) Examine the relationship between vehicle age or make and reliability for dumper-placer trucks.
   c) Consider whether workshop practices and priorities might have an influence on availability figures, giving evidence for your opinions.
   d) Imagine that you were appointed as a manager of one of the garages studied. Develop a strategy for improving availabilities, based on the records that are presented here.
   e) How could information about availabilities be used in the process of selection of the most economical type of vehicle for use in a particular situation?

Review the registers in Appendix DD-1

1. Consider whether it would be helpful to add any further columns to the tables to assist managers in identifying any important information. Do this for two cases:
   (i) where the records are prepared manually
   (ii) where computers are used and the software is being developed especially for this application.

2. Estimate the fuel consumption of the compactor vehicles. Consider whether it is better to use an average of the values that can be calculated rather than to select only two or three of the figures that you can calculate.

Using on the records in Appendix DD-1.3:

1. Estimate the utilisation ratio (number of vehicles in service divided by total number owned) for the different types of vehicles and different months. Comment on the results.
2. Discuss reasons why this ratio may not be the same as availability. (Some of the reasons may apply to only some types of vehicle.)

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Appendix DD-1.1 Charts of vehicle defects, Bandra Garage, Mumbai Suburbs

DD-1.1.1 February 1993

10 vehicles are required for duty each day

continued on next sheet

Numbers 24xx and 25xx are for new type of compactor (Multipack); others are for previous type (4R)

Feb	Total	2469	2470	2471	2472	2473	2474	2475	2476	2477	2482	2483	2503	2504	2505
1	17	M b													
2	17									M z,n	M n				
3	14									M					
4	23						M			M					
5	19		M ms				B p			M					
6			M				B		M s						
7															
8	21						B			M n	B	M s			
9	24				S		B		S	M	B	M			
10	24				B xu		B	B p		M	M e				
11	23				B			M n	B l	M	M				
12	24	Sp	Sp		B	Sp		M		M	M			Sp	Sp
13	24							M	M g	M	M		M f		Sp
14															
15	24	Sp	Sp					M	M	M	M			Sp	
16	24	S						M	M	M	M				B z
17	24	B z	B l	S			M g	M	M	M	M				
18	23	B					M	M	M	M	M				M m
19	-	-					-	-	-	-	-				-
20	23		M g				B	M			M				
21															
22	23		M					M			M				
23	23		M					M			M				
24	22		M			M n		M			M				
25	22		M			M	M g	B	B z,t		M				
26	22		M			M	M	B p	B		M				
27	22		M				M	B			M		B z		
28	-		-												

Records show 2513 fuelled at Bandra 16th Feb., 2512 17th Feb

Key to lower case letters is on next sheet

B Body repairs **M** Mechanical, i.e. chassis **P** Annual Police test **S** Service **Sp** Spares **L** Long laid up (More than 2 months) **E** Elsewhere (but included in numbers)

page DD-1

Data from Bandra garage   February 1993   continued

Feb	413	444	455	486	528	550	572	592	7632	7634	7636	7721	7738	Overall availy
1		P	M c		B p					M n	L		M	76
2		P	M		B						L		M	76
3		P			B			M d			L			77
4		B									L			72
5		B	M f		B p	M t					L			72
6		B	M		B	M					L			69
7														
8		B	M	P	B		B q	B o			L			76
9		B	M	P	B						L			68
10	B p	B	M	P	B			S			L	B z		68
11	B	B		P	B						L	B	B v	67
12	B			P							L	B	B	69
13	B	M h		P					M c		L	B	B	72
14														
15	B	M		P					M		L	B	B	63
16	B	Sp		P			Sp			Sp	L	B	B	63
17				P					Sp	M t	L	B	B	66
18	B p			P					M		L	B	B	66
19	-			-					-		-	-	-	-
20	B	M e		P			M m		M		L	B	B	62
21														
22		M		P					M	Sp	L	B	B	61
23	B p	M		P					M		L	M c	B	66
24	B	M		P					M		L	M		67
25				P							L	M spr		68
26				P						Sp	L	M		68
27	B u			P					B l		L			68
28														

a chassis
b brakes
c clutch
cb cab
d differential
e electrical
f fuel
g gearbox
h wheels
hy hydraulic system
i air pipe, system
j washing (j cloth)
k lubrikation system
l container lift
m motor
n starting
o ram leaks (o rings)
p packer plate
pc packer plate chain
q qontrols
r resting rods
s steering
spr springs
t pto
u rams - uther (not leaks)
v rust (vanishing steel)
w wire rope
x ejector plate (exit)
xu ejector ram
z tailgate (at the end)

B Body repairs   **M** Mechanical, i.e. chassis   **P** Annual Police test   **S** Service   **Sp** Spares   **L** Long laid up (More than 2 months)   **E** Elsewhere (but included in numbers)

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DD-1.1.2 Data from Bandra Garage October 1993

			Vehicle registration numbers																					
Oct	Total	O/L+Sp	2469	2470	2471	2472	2473	2474	2475	2476	2477	2482	2483	2503	2504	2505	2584	2585	2586	2721	444	7632	7634	7636
1	22	12	B u	✓	M h,l	✓	✓	✓	M b,i	✓	✓	M s,f	✓	✓	B t	M cb	M c	✓	✓	✓	M b	✓	M spr	L
2																								
3																								
4	22	14	B	✓	✓	✓	✓	✓	M	✓	✓	M	✓	✓	✓	M	✓	✓	✓	✓	M	B p	M	L
5	22	16	✓	✓	✓	✓	✓	✓	M	✓	✓	M	B p	✓	✓	M	✓	✓	Sp	✓	M	✓	Sp	L
6	22	16	✓	✓	✓	M m	✓	✓	M	✓	✓	✓	✓	✓	✓	B o	S	✓	✓	✓	M	✓	Sp	L
7	22	15	✓	B o	B u	✓	✓	✓	M	✓	✓	✓	✓	✓	✓	✓	S	✓	✓	B z	M	✓	✓	L
8	22	16	✓	B	✓	Sp	✓	✓	M	✓	B o	✓	✓	✓	✓	✓	S	✓	✓	✓	M	✓	✓	M
9	22	15	✓	B	✓	✓	✓	✓	M	✓	✓	✓	✓	M	✓	✓	S	✓	✓	✓	M	M d	✓	P
10																								
11	22	15	✓	B o	Sp	✓	✓	✓	M	✓	✓	B	✓	✓	M		S	✓	✓	✓	M	✓	✓	P
12	22	14	✓	B	✓	✓	✓	✓	M	✓	B p	✓	M	✓	✓	B l	S	✓	✓	✓	M	✓	✓	P
13	22	14	B o	B o,pc	B o,l	✓	✓	✓	M	✓	B m,p	✓	✓	✓	B o		✓	✓	✓	✓	M	✓	✓	P
14	22	15	✓	✓	✓	✓	✓	✓	M	✓	B	✓	✓	B i	✓	B u	✓	✓	✓	✓	M	✓	B t	P
15	22	17	✓	✓	B p	S	✓	✓	M	✓	✓	✓	✓	✓	✓	B	✓	✓	✓	✓	Sp	Sp	✓	P
16	22	15	✓	✓	B	S	✓	✓	M	✓	B u,i	B o	✓	✓	✓	✓	✓	✓	✓	✓	✓	B p	✓	P
17																								
18	22	17	✓	✓	B	S	✓	✓	B t	✓	✓	✓	✓	✓	✓	✓	✓	✓	B r	✓	✓	Sp	Sp	P
19	22	17	B l,p	✓	B	S	✓	✓	B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Sp	Sp	P
20	22	15	M c	✓	B	S	✓	✓	B	✓	✓	✓	✓	✓	M b	✓	✓	✓	✓	✓	B p	Sp	✓	P
21	22	17	✓	✓	B p	S	✓	M c	B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Sp	Sp	P
22	22	16	✓	✓	B	✓	✓	M	B	✓	✓	✓	B	✓	M	✓	✓	✓	✓	✓	✓	Sp	✓	P
23	22	14	✓	✓	B	M d	✓	M	B	✓	✓	✓	M m	✓	M	✓	✓	✓	✓	✓	✓	M c	✓	P
24																								
25	22	16	✓	✓	✓	M	B t	M	B	✓	✓	✓	✓	✓	✓	✓	B r	✓	✓	✓	✓	✓	✓	P
26	22	16	M c	✓	✓	M	✓	✓	B	✓	✓	✓	✓	✓	✓	✓	B	✓	B	✓	✓	✓	Sp	P
27	22	16	?	✓	✓	M	✓	✓	B	✓	✓	M i	✓	✓	M c,b	✓	✓	✓	✓	✓	✓	✓	✓	P
28	22	16	✓	✓	B p	M	✓	✓	B	✓	✓	M	✓	✓	M	✓	✓	✓	✓	✓	✓	✓	✓	P
29	22	14	✓	✓	B	M	✓	✓	✓	✓	✓	M	M	✓	✓	B z	✓	✓	✓	✓	✓	B o	B	P
30	22	15	✓	✓	✓	M	✓	✓	✓	✓	B	M	M	✓	✓	✓	✓	✓	✓	✓	✓	B	B	P
31																								

Note: Servicing for new vehicles is done by supplier (BML)   Observations: Older vehicles kept as spares when sufficient vehicles are available

KEY

B Body repairs   **M** Mechanical, i.e. chassis   **P** Annual Police test   **S** Service   **Sp** Spares   **L** Long laid up (More than 2 months)

a	chassis	e	electrical	i	air pipe, system	m	motor	q	qontrols	u	rams - uther (not leaks)	z	tailgate lock (at the end)
b	brakes	f	fuel	j	washing (j cloth)	n	starting	r	resting rods	v	rust (vanishing steel)		
c	clutch cb cab	g	gearbox	k	lubrikation system	o	ram leaks (o rings)	s	steering spr springs	w	wire rope		
d	differential	h	wheels	l	container lift	p	packer plate pc chain	t	pto	x	ejector plate (exit)		

DD-1.1.3 Data from Bandra Garage November 1993,

including summary table according to maintenance categories. The key to the symbols is the same as on the chart for October 1993.

			Vehicle registration numbers																				
Nov	Total	O/L+Sp	2469	2470	2471	2472	2473	2474	2475	2476	2477	2482	2483	2503	2504	2505	2584	2585	2586	2721	7632	7634	7636
1				B p		M					B o	M	M								B o		P
2				B		M		B w				M									B	Sp	P
3				B		M	M g	B				M									B	S	P
4				B		M	S	B				M								B i	B		P
5						M	S	B				M									B		P
6				M a		M	S	B				M	M g							B p	B		P
7																							
8					M t	M		B p				M	M							B	B		P
9					B	M		B				M	M								B	M b	P
10					B	M		B				M									B		P
11				B x	B	M	B l													Sp	S		P
12					B	M	S	Sp						Sp				B w,r		Sp	P	M t	P
13																							
14																							
15																							
16				B x,q	B	M						M c						B			P	M	P
17				B	B	M										Sp					P		P
18				B	B	M		S									M c				P		P
19				B	B	M		S								B t					P		P
20					B	M	M m,s			M g,h											P		P
21																							
22					B	M	M	S						M c		B o	B o				P		P
23					B	M	M	S		M											P	B t	P
24					B		M	S		M						B o					P		P
25					Sp		M	S		M						B					P		P
26							M	S		M	M e					B		B t			P		P
27					M		M	S	Sp						B o,p	Sp		Sp	Sp		P	Sp	P
28																							
29							M	S	B												P	Sp	P
30							M	S		M g	M c		M a								P		P

Summary - number of days lost for each cause 24 days of records

	2469	2470	2471	2472	2473	2474	2475	2476	2477	2482	2483	2503	2504	2505	2584	2585	2586	2721	7632	7634	7636
Mechanical	0	1	2	18	10	0	0	6	2	9	5	1	0	0	1	0	0	0		3	0
Bodywork	0	9	12	0	1	8	1	0	1	0	0	0	1	5	1	3	0	3	9	1	0
Servicing	0	0	0	0	4	11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
P Test, preparation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	24
TOTAL	0	10	14	18	15	19	1	6	3	9	5	1	1	5	2	3	0	3	24	5	24

Appendix DD-1.2 Charts of vehicle defects, Prabhadevi Garage, Mumbai City

DD-1.2.1 September 1994

MAINTENANCE RECORD TATA AND ASHOK LEYLAND DUMPER -PLACERS IN PRABHADEVI GARAGE

Sr. No.	Make	Reg^n No.	Year of purchase	Start of problem	Day in September 1994: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	A.L.	7958	1991		✓	✓	✓	✓	Ms	Ms	Ms	Ms	Ms	Ms	Ms	Ms	✓	✓	✓	✓	✓
2	A.L.	7960	1991		✓	S_N	✓	✓	✓	✓	✓	✓	✓	✓	✓	S_B	S_BP	S_BP	P	P	P
3	A.L.	7961	1991		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Hr
4	A.L.	7964	1991		✓	✓	✓	✓	✓	✓	✓	Mt	Mt	✓	✓	✓	✓	✓	✓	✓	✓
5	A.L.	8043	1991		✓	✓	S_N	✓	✓	✓	✓	✓	✓	✓	Mm	✓	Mc	Mc	Mc	Mc	Mc
6	A.L.	8044	1991	25/8/94	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Hg	Mf	Hh
7	TATA	5733	1986		✓	✓	✓	✓	✓	Mf	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8	TATA	5734	1986		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Mt	Mt	Mt	Mt
9	TATA	8848	1988		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10	TATA	8890	1988		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
11	TATA	8891	1988		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	S_C	S_C	S_C	S_C	S_C	S_C
12	TATA	8893	1988	30/8/94	Mc	Mc	Mc	✓	✓	Mf	✓	✓	✓	Ms	✓	✓	✓	✓	✓	Mf	✓
13	TATA	1377	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	Hc	Hc	Hc	Hc	Hc	Hc	Hc	Hc
14	TATA	1378	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15	TATA	1379	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
16	TATA	1380	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
17	TATA	1383	1994		✓	✓	S_NHp	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
18	TATA	1384	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19	TATA	1392	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
20	TATA	1399	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
21	TATA	1402	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
22	TATA	1395	1994		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Hg	✓	✓	✓	✓
23	A.L.	8045	1991		S_N	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Number of trucks unserviceable					3	3	4	1	2	4	2	3	3	4	4	5	6	6	6	7	7

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MAINTENANCE RECORD TATA AND ASHOK LEYLAND DUMPER PLACERS IN PRABHADEVI GARAGE

DD-1.2.1 September 1994 continued

Sr. No.	Make	Reg^n No.	Day in September 1994: 18	19	20	21	22	23	24	25	26	27	28	29	30	Repair finished	Avail^y %
1	A.L.	7958	✓	✓	✓	Mf	✓	Mf	✓	✓	✓	✓	✓	✓	✓		67
2	A.L.	7960	P	P	P	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		67
3	A.L.	7961	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Hg	1/10/94	93
4	A.L.	7964	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Mf	Mf	✓		87
5	A.L.	8043	Mc	Mc	Mc	Hg	Hg	Hg	Hg	Hg	Mc	Me	Me	✓	✓		40
6	A.L.	8044	Hg	Hg	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		37
7	TATA	5733	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	S_B	S_B	1/10/94	90
8	TATA	5734	✓	✓	Mt	✓	Md	Md	✓	✓	✓	✓	✓	✓	✓		77
9	TATA	8848	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		100
10	TATA	8890	✓	✓	✓	✓	✓	✓	Hr	✓	✓	✓	✓	Hl	Hl	6/10/94	90
11	TATA	8891	S_C	S_C	S_C	S_C	S_C	S_C	S_C	✓	✓	✓	Me	✓	✓		53
12	TATA	8893	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		80
13	TATA	1377	Hc	Hc	✓	✓	✓	Hc	Hc	Hc	Hc	Hc	Hc	✓	✓		47
14	TATA	1378	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		100
15	TATA	1379	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		100
16	TATA	1380	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		100
17	TATA	1383	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		97
18	TATA	1384	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		100
19	TATA	1392	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		100
20	TATA	1399	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		100
21	TATA	1402	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		100
22	TATA	1395	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		97
23	A.L.	8045	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Mc	Mc	Mc	6/10/94	87
Trucks unserviceable			5	5	4	3	3	5	4	2	2	2	5	4	4		

KEY

S Service
N/A/B/C
P Preparation for test
M
- **b** brakes
- **c** cab
- **d** steering
- **e** electrical
- **f** fuel system
- **g** gearbox
- **h** chassis frame
- **m** motor
- **r** radiator
- **s** starter
- **t** clutch
- **u** universal joint
- **x** exhaust

H hydralics
- **c** controls
- **g** PTO
- **h** chains
- **l** leak
- **p** pipes
- **r** ram
- **t** tipping rear hook
- **u** pump

DD-1.2.2 October 1994 MAINTENANCE RECORD FOR 28 MULTIPACK COMPACTORS IN PRABHADEVI GARAGE

The date of registration (column 2) would not normally be included in a maintenance record The Key to the symbols is on the continuation of this table

Day Vehicle	Date of reg^n	Start of problem	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	availability percent
1069	19/10/92	5/9/94	M	M	M	A	P	M	P	Mz									50
1076	21/11/92										P	P	P	P	P	P	P	P	50
1078	30/11/92						Msp			Mh			SNH		Sp	Mh			75
1080	15/12/92							MsBo											94
1081	15/12/92	5/9/94	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	0
1085	18/12/92												Bu	Bt					88
1086	18/12/92											Bz						SNBz	88
1087	19/12/92							Msb	Msp		Sp	Mm			Sp			BoMs	75
1088	19/12/92		Mz	Sp							Sp	BvMv							88
1091	28/12/92							SNH	SN	Sp				Msp	Msp		Msp	Sp	69
1092	28/12/92								Mm			Mm		SNH	SN	SNMsp	Msp		63
1093	28/12/92									SN					Sp				94
1094	28/12/92						Sc	Sc	Sc	Sc	Mu								69
1095	28/12/92	30/9/94	Msp	Bz	Bz	M	Bz				SN								63
1096	2/1/93				Bz							SN		Bu			Msp	Mc	69
1098	2/1/93	27/9/94	Bp							Mf			Mm						81
1162	7/4/93															SB	SB	Sp	88
1173	23/4/93						SNH	SNMh	M	SBMsp		Mcb		Mbg	Sp				63
1178	27/4/93								MmSB		Bu				Bu	Bu	Bu		31
1179	27/4/93			Bz	Bz								SNH						81
1180	28/4/93											McbSB	SB	Sp				Md	81
1183	29/4/93	29/9/94	BtSB	BtSB	Bt	Bt		Bt			Bt								63
1185	28/4/93	9/8/94	Bz	Bz	Bz	Bt		Sp		Bu			Sp	Bo	Bo	Bto			50
1198	25/5/93												Sp		Sp				100
1199	26/5/93	30/9/94	Br	Bt,cb	Sc	Sc	Sc										Bw		63
1203	27/5/93																		100
1209	31/5/93						Mb												94
1210	31/5/93				SNH	SN			Mm		Sp			Sp	Sp		Bu	Bu	69

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DD 1.2.2 October 1994 continued MAINTENANCE RECORD COMPACTOR TRUCKS AT PRABHADEVI GARAGE

Day / Vehicl	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Problem continued until	Avail^y per cent	KEY
1069	ByMs									Mf		Mf		Mf			73	**Capitals**
1076	P													Sp	Bz		87	**A** accident
1078	P	P	P	P	P	P	P	P	P								40	**B** body
1080				Md	P	P	P	P	P	P	P	P	S_{NH}		Mbcs		27	**M** mechanical
1081	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	after 21/11	0	**P** Annual police test
1085					Mn	S_B	By				Bq	Bq	Bq	P	P,Bt		47	**S** Servicing - **N/A/B/C/H**
1086				S_N													93	**Sp** spare
1087	S_NBoMs	S_H						Md									80	**Lower case**
1088			Mf												Sp		93	**a** chassis
1091							Mb								S_N		87	**b** brakes
1092			Mf				Mfm	Mm	Mm	MmBt	MmBt	MmBt	MmBt	Mm	Mm	4/11/94	33	**c** clutch **cb** cab
1093	Boy																93	**d** differential, rear axle
1094										S_N							93	**f** fuel
1095																	100	**g** gearbox
1096						Mb											93	**h** wheels
1098	Mg	Mfg	Mg	Mg	Bt	BtS_A	Mg										40	**m** motor
1162																	100	**n** starter
1173			Sp							Mc		S_A		Sp			87	**o** hydraulic leak [o-rings]
1178		Sp															100	**p** packer plate
1179													Bo				93	**q** hydraulic controls
1180	Md		Md			S_N											80	**r** general repairs
1183			S_N				Bo	Bo	Bo	Bo	Bo						60	**s** steering
1185		Bo	Bo	Sp	Sp			Sp	Bq								80	**t** PTO
1198		S_N		By					Bw								80	**v** electrical
1199		Bo		Mg	Sp	S_N	S_N	Bp					Bw		MgBw	1/11/94	53	**w** wire rope
1203								McS_C	S_C	McS_C	MspS_C	S_C	S_C				60	**x** ejector plate
1209					S_C	S_C	S_C							Bz			73	**y** hydraulics
1210	By			By					S_N			Bqr	Bz	Sp			67	**z** tailgate

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Appendix DD-1.3 Vehicles in service, May to October 1994 Ahmedabad Central Workshop

These records show the number of vehicles in service on each day for three months in 1994. May is one of the hottest months, July is during the monsoon, and October has a less extreme climate. Where the data is available, the total number of the particular type of vehicle based at the workshop is shown. The vehicles are operated on a seven days a week basis, with Sunday being the same as any other day. These records do not exactly indicate availabilities, because on some days there may be more vehicles ready for duty than are actually needed and used.

1. JCB - Front loader and backhoe.

	Day in month															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Month																
May	2	2	2	2	2	2	3	2	3	3	3	3	2	3	2	3
July	2	3	2	3	2	3	4	2	3	1	3	2	3	2	3	2
Oct	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2

	Day in month															
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ave
Month																
May	3	3	3	3	2	2	2	2	2	3	3	3	1	3	3	**2.48**
July	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	**2.71**
Oct	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	**2.39**

2. JCB tipper - Open tipper truck loaded by JCB

	Day in month															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Month																
May	8	8	8	8	7	7	10	8	11	12	12	12	8	12	8	12
July	8	8	8	8	8	2	2	2	2	4	4	4	4	4	4	4
Oct	14	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8

	Day in month															
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ave
Month																
May	4	4	4	4	8	8	6	6	6	4	4	4	4	3	3	**7.19**
July	12	4	4	12	4	4	4	8	4	4	4	4	4	3	4	**5**
Oct	8	12	12	8	12	12	12	12	12	4	8	12	12	12	12	**11.3**

3. Large roll-on roll-off [hook lift] trucks Total number - 18

	Day in month															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Month																
May	11	11	11	10	12	6	6	11	10	6	6	10	8	11	11	11
July	10	11	8	6	10	10	6	10	10	7	6	6	10	10	10	10
Oct	8	8	8	10	10	10	8	10	8	10	8	6	6	10	8	6

	Day in month															
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ave
Month																
May	10	11	12	11	11	10	9	8	11	11	6	10	6	8	10	**9.52**
July	6	10	10	11	11	6	11	10	8	7	11	11	11	10	6	**9.0**
Oct	6	10	8	8	7	6	5	8	7	8	8	8	6	9	10	**7.90**

4. Small roll-on roll-off [hook lift] trucks   Total number - 3

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
May	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
July	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2
Oct	2	2	2	2	2	1	1	1	1	1	1	1	2	1	1	1

Month	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	**Ave**
May	1	1	3	2	2	3	2	1	1	2	2	2	2	2	2	**1.52**
July	1	1	1	1	1	2	2	1	2	2	2	-	2	2	1	**1.35**
Oct	1	1	1	1	1	2	0	0	1	2	2	2	2	1	2	**1.32**

(Column headers: Day in month)

5. Compactor trucks   Total number 6

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
May	3	3	4	4	3	3	3	3	3	4	4	4	4	4	2	4
July	3	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4
Oct	4	3	4	3	4	3	4	4	4	3	3	4	4	4	4	3

Month	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	**Ave**
May	4	3	3	3	3	2	3	3	1	3	3	3	3	4	4	**3.23**
July	4	4	4	4	4	4	4	3	4	4	4	4	4	4	3	**3.87**
Oct	4	4	4	4	4	4	4	4	3	4	4	4	3	3	3	**3.68**

6. Large dumper-placer [skip lift] trucks   Total number - 3

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
May	2	2	2	2	1	1	2	2	2	1	1	2	1	2	2	2
July	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Oct	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Month	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	**Ave**
May	2	1	2	2	2	1	1	2	2	2	2	2	2	2	2	**1.74**
July	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	**1.97**
Oct	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	**1.97**

7. Small dumper placer [skip lift] trucks Total number - 4

Month	Day in month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0
Oct	2	1	2	2	2	2	2	2	1	1	1	2	2	1	1	1

Month	Day in month 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ave
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**0.03**
July	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	**0.26**
Oct	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	**1.78**

8. Refuse rickshaw - three wheeler with tipping box Total number - 24

Month	Day in month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
May	11	13	11	12	11	13	13	12	13	12	12	10	11	12	12	12
July	8	7	8	4	10	6	11	11	11	11	10	10	6	6	7	6
Oct	12	12	12	12	6	6	6	8	8	8	9	7	10	12	11	11

Month	Day in month 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ave
May	11	11	12	11	6	0	0	5	11	12	12	13	11	13	11	**10.5**
July	7	6	5	5	13	13	13	14	13	13	13	12	12	12	6	**9.32**
Oct	14	12	13	13	10	11	10	10	14	12	11	12	11	11	11	**10.5**

Calendar for 1994 - to indicate whether there is a pattern according to day of the week

Month	Day in month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
May	Su	M	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa	Su	M
July	F	Sa	Su	M	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa
Oct	Sa	Su	M	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa	Su

Month	Day in month 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
May	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa	Su	M	Tu
July	Su	M	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa	Su
Oct	M	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa	Su	M

The average numbers shown on the right end of the tables do not necessarily lead to availability data, since a vehicle may be unused on a particular day because of a decision by a supervisor, not just because it is awaiting repair. The results shown here do indicate the degree of utilisation of each type of vehicle, and could be used in estimations of the costs of the different methods.

Appendix DD-2.1 Stores supply survey

This survey was based on data from one garage regarding the ability of central stores to provide the parts requested, for October 1993.

Day in October	Number of items indented at central stores	Number of items that were **not** available at central stores	Percentage of items requested that were supplied
1	7	6	14
4	17	12	29
5	8	5	38
6	8	3	63
7	10	3	70
8	9	6	33
9	10	5	50
11	9	5	44
12	8	5	38
13	7	3	57
14	7	4	43
15	9	9	0
16	10	7	30
18	9	7	22
19	9	6	33
20	7	5	29
21	8	4	50
22	6	4	33
24	10	7	30
25	7	5	29
27	10	5	50
28	10	5	50
29	20	4	80
30	5	3	40
TOTAL	229	131	43

It shows that, over the whole month, the central stores were able to supply the parts requested on only 43% of the occasions that they were requested. The method of recording the data is important here because it may be that when a request is made some, but not all of the requested parts of one particular type can be supplied. The table above is according to type of item (i.e. if five filters were requested but only two supplied, the entry in the table above would show that the order had been supplied). A better method of analysis might be to regard each object as an individual item, whether it is a washer or a large component, so that the "total" row at the bottom of the table shows the number of objects supplied.

Appendix DD-2.2 Maintenance staff at Bandra garage

Name of gang	Number of gangs	Makeup of gang	Total manpower
Service	1	1 fitter 1 labourer 1 oiler and greaser 2 washermen	5
Welding	2	2 welders 1 labourer	6
Carpentry	1	1 carpenter 1 labourer	2
Tyres	1	1 tyreman 1 tyre pressure man 2 labourers	4
Painting	1	1 painter 1 labourer	2
Electrician	2	1 electrician 2 labourers	6
Breakdown	2	2 fitters 6 labourers	16
Repair gangs	7	mechanics fitters labourers	24

Appendix DD-2.3 Servicing and docking schedules

MUNICIPAL CORPORATION OF GREATER BOMBAY
TRANSPORT BRANCH

MONTHLY MAINTENANCE SCHEDULE

GARAGE: . . . .   Date . . . .

Veh. Reg. No.: . . . .

Note:
1) Figures in brackets indicate number of greasing points.
2) The vehicle should be thoroughly washed and cleaned before servicing work is taken in hand.
3) A road test should be performed after the servicing is over and report duly filled in here.
4) Strike off whichever is not applicable and put a tick mark on the work done.

Sr No.	Description	Report
1.	Change oil in sump. Drain off while still hot. Use SAE 30 oil.	Changed/Not changed ....litres
2.	Check oil level in injection pump and governor housing, top up if necessary	Checked/Not checked Topped up with ....litres
3.	Check oil level in gearbox. Top up if necessary. Use SAE 90.	Checked/Not checked Topped up with ....litres
4.	Lubricate with oil can	
	i) controls to injection pump	Lubricated/Not lubricated
	ii) linkages of foot and hand brakes	Lubricated/Not lubricated
	iii) felt pads of clutch release bearing sleeve (some drops only)	Lubricated/Not lubricated
	iv) clutch linkages	Lubricated/Not lubricated
	v) door hinges, outer door handles, door latches, dovetails/strike plates	Lubricated/Not lubricated
5.	Grease with grease gun	Whether greased or not
	i) accelerator pedal bushing (1)	Yes/No/Obstruction
	ii) clutch pedal bushing (1)	Yes/No/Obstruction
	iii) brake pedal bushing (1)	Yes/No/Obstruction
	iv) propeller shaft U joints (3)	Yes/No/Obstruction
	v) propeller shaft centre bearing (1)	Yes/No/Obstruction
	vi) propeller shaft sliding yoke (1)	Yes/No/Obstruction
	vii) king pins (4)	Yes/No/Obstruction
	viii) tie rod ends (2)	Yes/No/Obstruction
	ix) drag link ends (2)	Yes/No/Obstruction
	x) front spring pins (6)	Yes/No/Obstruction
	xi) rear spring pins (6)	Yes/No/Obstruction
	xii) apply grease on helper spring brackets (4)	Yes/No/Obstruction
	xiii) hand brake level mounting bracket (1)	Yes/No/Obstruction
	xiv) intermediate level shaft (2)	Yes/No/Obstruction
	xv) upper ball socket (for	Yes/No/Obstruction
	xvi) swivel pin of tipping for rear (2) tipper)	Yes/No/Obstruction
6.	Check oil level in rear axle, top up, if necessary, with GP90 oil.	Checked/Not checked . Topped up with ....litres
7.	Lubricating water pump with bearing grease	Lubricated/Not lubricated
8.	Clean engine oil filter. Fill up filter with app. 0.5 litre oil	Cleaned/Not attended filled .... litre oil
9.	Clean the prefilter at fuel pump	Cleaned/Not attended
10.	Check brake fluid level in master cylinder. Top up if necessary	Checked/Not checked Topped up with .... litres

Sr No.	Description	Report
11.	Check and tighten if necessary	
	i) U bolts of front and rear springs	OK/Tightened/Not attended
	ii) Bolts of spring pin-lock plates	Checked and tightened/Not attended
	iii) Wheel nuts	Checked and tightened/Not attended
	iv) Mounting bolts of steering gear assembly	Checked and tightened/Not attended
12.	Drain off condensed water from air tank	Drained/Not attended
13.	Clean oil bath air filter and fill up to correct level with SAE-30 oil	Cleaned/Not attended Filled ......litres
14.	Check chassis frame for cracks	OK/Attended/Not attended
15.	Check and attend	
	i) battery mountings	OK/Attended/Not attended
	ii) head lights	OK/Attended/Not attended
	iii) parking lights	OK/Attended/Not attended
	iv) stop lights	OK/Attended/Not attended
	v) blinkers	OK/Attended/Not attended
	vi) brake lights	OK/Attended/Not attended
	vii) wiper machine	OK/Attended/Not attended
	viii) electric horn/bell	OK/Attended/Not attended
	ix) dipper	OK/Attended/Not attended
16.	Clean battery terminal. Tighten and smear Vaseline/petroleum jelly	OK/Attended/Not attended

Examine

Battery No. ....

Cell	1	2	3	4	5	6
Sp. Gr.						
Voltage						

	Check electrolyte level and top up with distilled water	OK/Checked/Not checked Topped up .... litres
17.	Check level of hydraulic fluid in tipper tank and top up.	Checked/Not checked Topped up .... litres
18.	Check fan belt tension and adjust	OK/Attended/Not attended

Names
Fitter I ....
Auto Wireman ....
Greaser ....
Labourer ....
The above work was carried out under my supervision

signed ....
Foreman

MUNICIPAL CORPORATION OF GREATER BOMBAY

DOCKING SCHEDULE "A" (4000 km) FOR HEAVY VEHICLES

Veh. No. .... Date ....
KM Reading .... Fitter's name ....

Sr. No.	Details of Work	Report
1.	Check gear oil level; top up if necessary	Attended ....litres / Not attended
2.	Check differential oil level; top up if necessary	Attended ....litres / Not attended
3.	Check steering oil level, top up if necessary	Attended ....litres / Not attended
4.	Check brake oil level in master cylinder; top up if necessary	Attended ....litres / Not attended
5.	Lubricate spring of clutch release bearing	Attended / Not attended
6.	Check and lubricate accelerator spring	Attended / Not attended
7.	Remove fuel tank strainer, clean and refit	Attended / Not attended
8.	Remove dirt/dust from primary and secondary filters	Attended / Not attended
9.	Remove water separator. clean it, replace gasket and refit	Attended / Not attended
10.	Check central bolts of all suspension springs (except Leyland vehicles)	Attended / Not attended / OK
11.	Check bolt and lock pin of shackle bracket and tighten if necessary	Attended / Not attended / OK
12.	Check steering free play and adjust	Attended / Not attended / OK
13.	Clean slack adjuster and grease it	Attended / Not attended
14.	Check sound of compressor	Attended / OK / Not OK
15.	Check for leakage in compressor lubrication connections and correct if necessary	Attended / OK / Not OK
16.	Check compressor inlet hose; replace if necessary	Attended / Not attended OK/ Replaced
17.	Check and tighten compressor mounting nuts and bolts	Attended / Not attended
18.	Paint/touch up the body wherever necessary	Attended / Not attended / OK
19.	Remove water from air filter of brake system	Attended / Not attended
20.	Check the condition of seats and repair if necessary	Attended / Not attended / OK

signed ....
fitter

The above works have been carried out satisfactorily directly under my supervision.
Remarks on the vehicle:

signed ....
Asstt. foreman / foreman

I have checked the following points from the above works:

1) Free play of steering
2) Condition of seats
3)
4)

signed ....
Sub-engineer

MUNICIPAL CORPORATION OF GREATER BOMBAY
EX. ENG TRANSPORT - CITY

Docking Schedule "B" (8000 km) for heavy vehicles

Veh. No. .... Date ....
KM reading .... Fitter's Name ....

Sr. No.	Details of work	Report
1.	Remove oil pan and clean it	Attended / Not attended
2.	Clean oil sump strainer	Attended / Not attended
3.	Replace starter with O.H. (overhauled) unit	Attended / Not attended
4.	Refit the oil pan with new	Attended / Not attended
5.	Replace dynamo with O.H. unit	Attended / Not attended
6.	Check the coupling of fuel injection pump for play	OK/Not OK/Replaced
7.	Remove and clean fuel line from fuel tank to feed pump and refit with new banjo washers	Attended / Not attended
8.	Remove and clean fuel line from feed pump to filter and refit with new banjo washers	Attended / Not attended
9.	Remove and clean fuel line from filter to injection pump and refit with new banjo washers	Attended / Not attended
10.	Check and tighten delivery valve holders at fuel injection pump	Attended / Not attended
11.	Check and tighten overflow lines joints	Attended / Not attended
12.	Check and tighten brake fluid line joints (Not for A/L [Ashok Leyland])	Attended / Not attended
13.	Check the metal brake fluid lines for wear and repair if necessary	Attended/Not attended OK/repaired
14.	Check and tighten bleeding nipples	Attended / Not attended
15.	Check and tighten wheel cylinder mounting bolts	Attended / Not attended
16.	Check and adjust brakes	OK/Adjusted/Not attended
17.	Check and adjust hand brake	Attended / Not attended
18.	Check and replace if necessary the engine foundation	OK/Adjusted/Not attended
19.	Check tie rod ends	OK/Not OK/Not attended
20.	Check, record and adjust tappet clearance if necessary	

cylinder	I		II		III	
valve	In	Out	In	Out	In	Out
Original						
Adjusted						
cylinder	IV		V		VI	
valve	In	Out	In	Out	In	Out
Original						
Adjusted						

21.	Check and tighten the heat exchanger bolts (TATA/TMB)	Attended / Not attended
22.	Replace tappet cover packing	Attended / Not attended
23.	Clean radiator fins with compressed air (Blow from engine side)	Attended / Not attended
24.	Check the tightness of driving head nuts and axle shaft nuts	Attended / Not attended
25.	Check the tightness of front and rear spring brackets	Attended / Not attended
26.	Check and tighten spring claiming bolts	Attended / Not attended
27.	Check and tighten shock absorber mounting bracket bolts	Attended / Not attended
28.	Clean compressor fins from oil sludge and dust	Attended / Not attended
29.	Check the vent hole in the top cover for unloader valve is not blocked	Attended / Not attended

Sr. No.	Details of work	Report
30.	Check the travel of push rod and ensure that it is at its minimum	Attended / Not attended
31.	Lubricate the four grease points of slack adjuster	Attended / Not attended
32.	Check the electrical connection and correct operation of brake light switch	Attended / Not attended
33.	Check all brake hoses for any leakage	Attended / Not attended
34.	Check for any damage to steel air pipe, replace if any	Attended / Not attended
35.	Check the rubber gaiter is in good condition for hand control valve, graduated HCV. Operate the lever and check proper functioning	Attended / Not attended
36.	Check the pneumatic wind off connector is in good condition (only for fail safe system).	Attended / Not attended
37.	Check the rubber gaiter for quadruple system protection valve (Dualline system).	Attended / Not attended
38.	For dual brake valve, lift the boot from mounting plate and apply few drops of engine oil between mounting plate and plunger	Attended / Not attended

Fitter Signature

The above work was carried out satisfactorily directly under my supervision.
I have checked the following points:

1) Bolts of oil pump strainer
2) Adjusted tappet clearances
3) Adjusted push rod travel of brake chamber

Asst. Foreman/Foreman

Sub-Engineer (

REMARKS:

MUNICIPAL CORPORATION OF GREATER BOMBAY
(TRANSPORT BRANCH, CITY)

DOCKING SCHEDULE "C" (16000 KM FOR HEAVY VEHICLES)

VEHICLE NO. .... DATE ....

FITTER'S NAME ....

KM READING ....

Sr. No.	Details of work	Report
1.	Change engine oil, Drain off while it is hot (only for milky grade superior quality heavy duty engine oil) (All vehicles except for compactors and dumper placers.)	Attended / Not attended
2.	Change oil in gear box. Drain off while it is hot; clean the drain plug.	Attended / Not attended
3.	Change the oil in the differential. Drain off while it is hot.	Attended / Not attended
4.	remove and clean injectors, check injector pressure, record, and refit injectors	

Cylinder No.	I	II	III	IV	V	VI
Pressure						

Sr. No.	Details of work	Report
5.	Replace the primary fuel filter element	Replaced / Not replaced
6.	Remove injector pipes, clean all pipes by blowing compressed air through them.	Attended / Not attended
7.	Remove and clean overflow lines and refit with new banjo washers	
8.	Replace clutch plate with serviced one.	Replaced / Not replaced
9.	Replace clutch release bearing	Replaced / Not replaced
10.	Replace the locking wire of the clutch fork	Replaced / Not replaced
11.	Replace oiled felt strips in the clutch bearing sleeve	Replaced / Not replaced
12.	Replace pressure plate assembly with serviced one	
13.	Check and tighten back plate nuts and bolts (brake system)	Attended / Not attended
14.	Check brake linings, change if necessary	Attended / Not attended
15.	Lubricate brake shoe return spring with few drops of oil	Attended / Not attended
16.	Replace shock absorber rubber bushes	Replaced / Not replaced
17.	Replace radiator foundation	Replaced / Not replaced
18.	Repack wheel bearings front and rear with heavy duty bearing grease	Attended / Not attended
19.	Replace oil seals of front and rear hub	Replaced / Not replaced
20.	Replace bearing (wheel bearing) lock of bearing adjusting nut	Replaced / Not replaced
21. i)	Add washing soda to radiator water, run the engine for 10 minutes, drain the water from block and radiator.	Attended / Not attended
ii)	Refill fresh water into radiator, run the engine for 10 minutes , drain the water from block and radiator	Attended / Not attended
iii)	Refill the radiator with fresh water	Attended / Not attended
22.	Replace all radiator hoses and their clips	Attended / Not attended
23.	Replace the fan belt	Replaced / Not replaced
24.	Lubricate speedometer cable and refit	Attended / Not attended
25.	Adjust head light focusing	Attended / Not attended

Sr. No.	Details of work	Report
26.	Replace vehicle number plate	Replaced / Not replaced
27.	Attend the body building work if necessary	Attended / Not attended
	<u>HYDRAULIC BRAKES SYSTEM</u>	
1.	Remove master cylinder, dismantle it with care, clean the parts, assemble with a new kit, refit on vehicle	Attended / Not attended
2.	Replace w.c. (wheel cylinder) kit front	Replaced / Not replaced
3.	Replace w.c. (wheel cylinder) kit rear	Replaced / Not replaced
4.	Remove and clean brake oil container and refit	Attended / Not attended
	<u>PNEUMATIC SYSTEM</u>	
1.	Check the compressor head securing bolt, cover bolt and mounting bolts for correct tightness.	Attended / Not attended
2.	Check for leak through oil seal of compressor and change it if necessary.	Attended / Not attended
3.	Check whether worm shaft locks for all slack adjusters are functioning properly.	Attended / Not attended

ASSTT. FOREMAN

I have personally checked the following points and with observations as mentioned below:

(i) Removed (old) clutch plate ....

....

(ii) The wearing of brake liners ....

....

(iii) All the parts mentioned in this form have been replaced and the following (old) parts can be reused in case of an emergency:

(a)

(b)

(c)

SUB-ENGINEER............................

(GARAGE)

[Extra servicing for compactor trucks]

MUNICIPAL CORPORATION OF GREATER BOMBAY
TRANSPORT (CITY) BRANCH

1000 KM / 50 Hours / 150 Hours
HYDRAULIC SERVICING AND MAINTENANCE SCHEDULE

			REMARKS
1.	Remove, clean and refit the filter	Attended / Not attended	
2.	Check PTO mounting bolts, tighten if loose	Attended / Not attended	
3.	Lubrication of tailgate hinges	Attended / Not attended	
4.	Greasing of all pivot pins		
	i) Packer cylinder mounting pins	Attended / Not attended	
	ii) Push out (ejector) cylinder mounting pins	Attended / Not attended	
5.	Check the cylinder mounting pin lock bolts	Attended / Not attended	
6.	Check the slider pin locks	Attended / Not attended	
7.	Check cylinder eye bolts	Attended / Not attended	
8.	Check the tilting rope holding pins	Attended / Not attended	
9.	Check rope holding pins and knuckle joints	Attended / Not attended	
10.	Greasing of container arm hinge pin and tailgate hinge pin	Attended / Not attended	
11.	Check free movement of manual hopper	Attended / Not attended	
12.	Check the looseness of all hydraulic connections/hoses etc.	Attended / Not attended	
13.	Checking and resetting hydraulic pressure if necessary	Attended / Not attended	
14.	Check and replace suction hose pipe if necessary	Attended / Not attended	
15.	Lubrication of all hydraulic operating levers	Attended / Not attended	
16.	Lubrication of sliding channels	Attended / Not attended	
17.	Check hydraulic tank filler and its seal	Attended / Not attended	
18.	Filter hydraulic oil in every "B" servicing	Attended / Not attended	

MUNICIPAL CORPORATION OF GREATER BOMBAY
TRANSPORT (CITY) BRANCH

16000 KM / 500 HOURS HYDRAULIC SERVICING AND MAINTENANCE SCHEDULE

			REMARKS
1.	Replace all filters	Attended / Not attended	
2.	Drain and refill hydraulic oil	Attended / Not attended	
3.	Open all the cylinders and replace seals	Attended / Not attended	
4.	Dismantle control valves DV?RV and replace "O" rings if necessary	Attended / Not attended	
5.	In addition attend 1000km/50hr/150hr schedule		

Appendix DD-2.4 Breakdown Report form

MUNICIPAL CORPORATION OF GREATER BOMBAY
TRANSPORT BRANCH

BREAK DOWN REPORT

J.E. Garage ....

Name of garage ....

REPORT FROM TRAFFIC SECTION

Vehicle No. ....

Date ....

KM reading ....

Type ....

Last S & D type N A B C D Date .... KM reading ....

Time of breakdown ....

Breakdown register serial number ....

Place of breakdown ....

Nature of defects (as reported by driver) ....

....

....

signed ....

Junior Engineer

To Executive Engineer (Transport)

REPORT FROM MAINTENANCE SECTION

Name of fitter attending ....

Time: From .... To ....

Report of fitter ....

....

Sub-engineer's findings:

....

....

Classification (A), (B) or (C)

A) Due to fault in last S & D

B) Non avoidable

C) Accidental

Details of artisans who attended last S & D if the classification is (A)

Name: ....

Designation: ....

Junior Engineer's signature .... Assistant Engineer's signature ....

Final report by Sub-Engineer (Maintenance)

....

....

Appendix DD-2.5 Table for scheduling preventive maintenance

Servicing and Docking Programme for the next month September to be framed on the 25th of the current month and submitted on 26th in three copies.

Yes/No/Obstruction

Sr No.	Vehicle No.	Opening reading of the current month	Closing reading of the 24th of current month	Expected running of the current month [(4-3)x5/4]	Opening reading of the next month [3+5]	Closing reading of the next month	Projected servicing or docking schedule	Programme of next month			
								1st week 1-7	2nd week 8-15	3rd week 15-23	4th week 24-30
1	2	3	4	5	6	7	8	9	10	11	12
1	ABC 123	17953	18608	819	18772	19591	N, week 2		N		
2	DEF 456	21707	22650	1179	22886	24065	B, week 4				B

The programme for the next month may need some adjustment after it has been determined in a preliminary way by the method shown here so that the workload is evenly distributed through the month. This calls for the judgement of the maintenance engineer who knows how long each service or docking is likely to take.
If the distance covered by particular vehicle in a month has been unusually low because it has been in the workshop for repairs or for preparation for the annual test, it will be necessary to increase the figure shown in column 5.

Appendix DD-3.1 Examples of registers

July 1994 Prabhadevi Garage 1. Kilometre readings

Ser. No.	Vehicle No.	July 1994: 1	2	3			21	22	23	24	25	26	27	28	29	30	31	TOTAL
1	1069	27282	27452	27533			28685	28899	A 899	28821	28943	29064	29113	29198	29290	29407	25450	2208
7	1086	34035	34035	34035			34035	34035	34035	34035	34035	34035	34035	34035	34035	34035	34035	0
18	1173	21564	21784	21822			21992	23109	23203	23247	23330	23384	23521	23593	23737	23828	23871	2307

Note: Servicing is shown, for example 1069 had an "A" service on 23 July when the odometer reading was recorded as 28899. (Probably misread, it is more likely to have been 28799, judging from the other readings and the fact that the third row 8 advances at or before 99.)

July 1994 Prabhadevi Garage 2. Fuel consumption

Ser. No.	Vehicle No.	July 1994: 1	2	3	4		22	23	24	25	26	27	28	29	30	31	TOTAL
1	1069		120		100				110		130		85			130	1105
7	1086																0
18	1173	125			105		115				120				120		960

July 1994 Prabhadevi Garage 3. Engine oil consumption

Ser. No.	Vehicle No.	July 1994: 1	2	3	4	5	6	7	8	9	10	11		21	22	23	24	25	26	27	28	29	30	31	TOTAL
1	1069															3									6
7	1086																					3			3
18	1173		3			2		3														2			10

July 1994 Prabhadevi Garage 4. Gear oil consumption

Ser. No.	Vehicle No.	July 1994: 1	2	3	4	5	6	7	8	9	10	11	12	13		23	24	25	26	27	28	29	30	31	TOTAL
1	1069																								
7	1086																								
16	1098													-/10					3						13
17	1162						3						2/5												10
18	1173																								

Note: Gear oil use is recorded as x/y, where x is the oil used for the gear box and y is the oil used for the differential; the same grade is used for both. For example, on 13 July no oil was put into the gearbox of 1098, but 10 litres were put into the differential.

July 1994 Prabhadevi Garage 5. Ram [hydraulic] oil consumption

Ser.	Vehicle	July 1994																							
No.	No.	1	2	3	4	5	6	7	8	9	10	11		21	22	23	24	25	26	27	28	29	30	31	TOTAL
1	1069								40											45					85
7	1086															15									15
18	1173							15						10		30									55

October 1994 Prabhadevi Garage 6. Kilometre readings

Ser.	Vehicle	October 1994																		
No.	No.	1	2	3		10		21	22	23	24	25	26	27	28	29	30	31	TOTAL
1	1069	32104	32104	32119		32270		32270	32270	32270	32349	32427	32427	32460	32470	32544	32544	32615	511
7	1086	34035	34161	34212		34761		35576	35661	35747	35790	35867	35950	36030	36114	36197	36281	36367	2332
18	1173	27601	27773	27870		28174		28948	29040	29097	29097	29097	29099	29142	$\boxed{\text{A-148}}$	29275	29311	29545	1944

October 1994 Prabhadevi Garage 7. Fuel consumption

Ser.	Vehicle	October 1994														
No.	No.	1	2	3	4		22	23	24	25	26	27	28	29	30	31	TOTAL
1	1069						125			125				100			860
7	1086	110			100					110			80			95	830
18	1173		125		115		123			25			130				838

TYRE HISTORY REGISTER

TYRE N°. I2579PR89 . MAKE DUNLOP DATE OF PURCHASE 20.3.90 RECEIVED FROM A.E. (Tr) .

GATE PASS N° .________._ Above tyre received along with vehicle No MH01 H 7716 on 20.3.90

Vehicle No.	Fitted on	Km reading	Removed on	Km reading	Total run	Details of repairs				Total cost	B.R.T. No. and date	Signature shop recorder
						Gate pass & indent No.	Name of the firm	Delivery note No.	Repair details			
MH01 H 7716	Original	0	3.6.90	02107	2107	77945 20.6.90	M/s Tyreline	3228 20.6.90	cut	10		
MH01 H 7768	28.6.90	5363	17.6.91	25039	19676	38632 18.6.91	"	1509 18.6.91	"	10		
MH01 H 7698	18.6.91	06919	23.6.91	07284	365	38636 24.6.91	"	1523 24.6.91	"	10		
MH01 H 7768	30.6.91	08843	5.4.92	21615	12772	38685 7.4.92	M/s Unisol Tyres	405 21.4.92	resole	850		
MH01 H 7779	22.4.92	28601	5.6.92	31870	3269	38688 22.4.92	M/s Tyreline	1004 22.4.92	cut	10		
MH01 H 7814	7.6.92	24986	25.7.92	27987	2992	38699 6.6.92	"	1097 6.6.92	"	10		
MMK 7762	27.7.92	71089	16.8.92	72473	1409	33815 17.8.92	M/s Unisole	539 28.8.92	resole	1375		
MH01 H 7698	29.9.92	33124	19.12.92	40848	7729	76234 15.6.94	"	1296 11.7.94	resole	1220		
MH01 H 7688	22.12.92	61697	9.4.93	67274	5577	62458 15.8.94	M/s Tyreline	40 15.8.94	cut	10		
MH01 H 1092	14.4.93	6712	4.6.94	32923	26211							
1185	12.7.94	15671	14.8.94	15671	2560							
MH01 H 1093	16.8.94	36463	14.10.94	42203	5740							
TOTALS					90407					Rs3505		

Km run to first resole 34920; then to second 7670; to third 7729; run on last resole 40088km

Tyre rejected due to tread damage under order form No. 9503 of 15.11.94 M/s Kumar Ent. S.E.Tr A.E.Tr III Ex Eng. Tr (City)

page DD-26

Appendix DD-3.2 Tyre records and ways to increase tyre life

Introduction

by A K Sarkar

Every year a large amount of money is spent on the procurement of tyres and tubes for solid waste vehicles. The tyre section is often the most neglected part of any garage or workshop. Records may not be maintained properly, sometimes no records are kept and the section is controlled by unqualified staff.

The prices of tyres are increasing day by day, and as the solid waste vehicles are to dump the refuse at disposal grounds which are full of scrap metal, nails, broken glass etc., there are chances of punctures and damage to the tyres. So, attention should be given to getting the optimum life from each tyre and thereby satisfactory service from each refuse vehicle.

Tyres for Solid Waste Vehicles

There are many tyres available in the market. These tyres are specified in the following ways:

1. Size - 900 x 20; 1000 x 12, 825 x 20 etc
2. Material used - Nylon, Rayon
3. Ply ratings - 12, 14, 16 ply
4. Pattern - General, Mining etc

As most of the solid waste vehicles have gross weights of 12 to 19 tonnes, 900 x 20 and 1000 x 20 sizes will be suitable with 16 ply ratings.

In Prabhadevi Garage, Mumbai, for its Multipack compactors, 1000 x 20; 16 PL tyres are used. Tyre manufacturers' recommendations in respect of the tyre pressure and load on each tyre are below:

Tyre Size	Ply Rating	Tyre Pressure psi	Load on Each Tyre, Kg
900 x 20	12	85	2540
900 x 20	14	95	2730
1000 x 20	14	90	2955
1000 x 20	16	100	3170

Rayon tyres are suitable for small distances and for resoling, but the price difference between rayon and nylon is negligible and as there is only one manufacturer now making rayon tyres in India, it is better to go for nylon tyres. Mining type tyres may be used at the rear because of their gripping capacity, especially during the monsoon season.

Problem of Tyres in Solid Waste

The main enemies of tyres of refuse vehicles are nails, glass, metal scraps, pieces of cups and plates, sharp edges of stones etc. Sometimes tyres are scrapped after only 5000 to 10000 kilometres because of heavy damage caused by these materials. The average life of the 1000 x 20 tyres of Prabhadevi Garage is 60 000 km, which is excellent for refuse vehicles.

In the monsoon the number of punctures increases significantly compared to other seasons because of the slushy condition of disposal grounds. Statistics available from Prabhadevi garage, Mumbai are shown in figure DD-3.1.

Tyre Records

All records regarding tyres are being kept in three registers in Prabhadevi Garage. These records help in planning, for future purchasing, stocking etc. These records also indicate the reasons for tyre failures and any bad decisions, and thus indirectly increase tyre life. They also help to stop pilferage of good tyres.

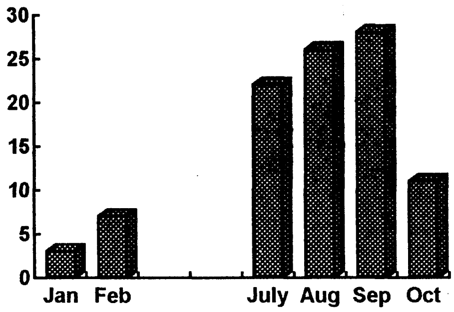

Figure DD-3.1 Variation of punctures with season
(The monsoon in Mumbai is between June and September.)

The following three registers are maintained in Prabhadevi Garage:

1) Tyre pressure register
2) Tyre movement register
3) Tyre history register

Tyre Pressure Register
Tyre pressure must be checked before releasing the vehicle for duty. The tyre pressure register is a very simple register and is maintained by the staff of the tyre section. Pressure is measured before the vehicle leaves the garage, and if necessary the tyre is inflated to the pressure recommended by the tyre manufacturer.
Low tyre pressure damages the side walls and the two ends of the tyre rolling surface. High pressure causes wear at the middle of the tyre surface. Both low and high pressure damage the tyre and reduce tyre life significantly. (Tyre life can be reduced by 30% if the tyres are underinflated by 15%.) Overinflation can also increase the incidence of wheel spin on soft wastes, leading to more punctures because the spinning wheels cut down through the waste until they reach something hard, which may also be sharp. The Prabhadevi Garage experienced tyre bursts due to uneven tyre pressure of the rear wheels. It has been reported in Britain that there is sometimes a tendency for tyres of the same size to be always inflated to the same pressure; the optimum pressure depends on the loading on a wheel (different between front and rear wheels) and should always be to the manufacturer's recommendation.
The recording of tyre pressures in this way adds significantly to the work of checking the tyres, but, if diligently monitored, shows the condition of the tyres (including the existence of slow punctures) and may prevent vehicles requiring a change of tyre in the middle of a shift. The example of a register shown below is for the rear tyres only; whilst serious underinflation is less obvious in a tyre that is paired with another on the rear axle, it is also useful to monitor the pressure in the front tyres on a regular basis.

Example of Tyre Pressure Register (20.8.94)

	Tyre pressure found/after inflation; psi			
Vehicle No	Rear right outer tyre	Rear right inner tyre	Rear left outer tyre	Rear left inner tyre
1198	80/80	40/80	80/80	80/80
1098	50/80	80/80	80/80	80/80
9067	80/80	65/80	65/80	80/80

Tyre Movement Register
This is an important register. It may form a part of the tyre history register. If regularly monitored it may help to stop pilferage of tyres by drivers.

Example of Tyre Movement Register

Date	Veh No	Tyre No	Tyre Size	Where Fitted	Removed from Where
02/03/94	5890	JK4926	1000 x 20	RRO	-
10/03/94	6712	DUN 426	1000 x 20	-	RRO

Note: "RRO" stands for *rear right outer*

Tyre History Register
This is the main register, showing tyre life, repairs to tyres by outside agencies, expenditure for each tyre, defects of the tyre and its movement from one vehicle to another.

It helps in the planning of the yearly procurement of tyres. For example, the Prabhadevi Garage has only 203 tyres (1000 x 20) including 20% spare tyres for its 28 Multipack compactors. The Garage can buy tyres only against scrapped tyres as noted in the register and duly signed by officials. This also restricts the over purchase of tyres.

An example of a Tyre History Register is shown on page DD-3.3

There is no schedule of servicing of tyres because greasing or tightening of nuts and bolts etc. are not required. However, some visual inspection and proper inflation of tyres are essential to obtain optimum life from each tyre. Sharp materials should be removed from tread pattern and between the rear tyres before they can cause damage to the rolling surface and side walls of the tyres.

The following checks are essential
1) Cuts on side wall
2) Cuts on surface
3) Nails inside tyre
4) Distance plate to check the gap between wheel rims.

If there is any cut, tyre should be repaired immediately and not continue to be used for work because this will reduce the tyre life further.

The tyre surface should be checked visually and if it is also found from the tyre history register that it has covered its normal life it should be sent for resoling (retreading) to extend its life. However, it should not be resoled on more than one occasion.

Conclusion
The tyre movement register and the tyre history register are very important and should be maintained strictly and precisely. This will reduce expenditure and improve the serviceability of the tyres and the refuse vehicle.

Appendix DD-3.3 Equipment history record

Two examples of vehicle history records were studied. One was used for compactor trucks at Prabhadevi and the other for road rollers.

Vehicle history books used at Prabhadevi garage were notebooks 14cm by 17cm, and included the following information and table for writing in details about maintenance work:

Vehicle No.	MH01 H 1069
Vehicle type	CS 1611
Engine No.	
Chassis No.	DJG 025
Wheelbase	CS 166"
Service	Refuse

Job date	Km reading	System attended and job carried out	Fitter	Issue slip no.	Parts replaced	Signature

The form that was being used for road rollers can be taken as an example of what a comprehensive equipment history record should comprise. The record is 31 pages long, so, instead of reproducing the record in full, its contents will be described in general terms. Each type of vehicle has its own specific requirements for such a history document, so the type of information asked for and the space allocated to each type of information should vary according to the type of equipment and duty.

Considerable thought should be given to the preparation of the history document. Requests for information that can easily be found elsewhere should be avoided, as should information that is not likely to be put to an important use. The space allowed for each entry should be sufficient, suggesting that a proposed format should first be used on an experimental basis so that the space needed for each entry is reasonable. If the document is to be used regularly and last as long as the vehicle, it should be strong enough to survive regular use, with good quality paper and binding. Clerks and mechanics are more likely to look after a document that has an expensive appearance. The paper should be ruled so that entries can be made neatly and without using too much space.

The first page describes the type of vehicle, gives its number and the garage at which it is based. A list of contents then follows since the document is so large.

Page two is concerned with recording details of occasions when the record has been checked or when references have been taken from it. It has two columns, each with space to write the date, the person checking, the part of the record checked or referred to, and any remarks or instructions.

The third page is known as the *equipment record*, and gives many details about the machinery:

A Purchase details:

- Sanction number and date
- Authority
- Amount sanctioned
- Name and description of equipment
- Manufacturer's name and address
- Year of manufacture
- From where it was purchased

- Estimated life
- Date of receipt
- Garage where kept initially
- Expiry date of warranty
- Operation manual number and location
- Service catalogue number
- Identification number

B Technical and operational specifications

- Manufacturer's classification
- Service needed
- Special operation and maintenance instructions
- Details of major units, accessories and assemblies

C Maintenance standard specifications - manufacturer's recommendations

- Preventive maintenance tasks and frequencies - checks, adjustments, lubrication, replacements, overhauling of units; specification of parts and lubricants.

The fourth page is known as the *transfer record*, and it allows recording of the date when the machine is transferred to a new location, the name of the new location, and the reason for transfer.

Page five is concerned with the *Engine overhauling schedule and attendance report*. Since it is likely that engines will be exchanged at least once during the lifetime of the vehicle, the record notes the engine number, type, date of installation, date of overhaul, compression pressures and main dimensions of each engine.

Pages six to ten require information about units, assembly and system overhauling or replacement. For each of the following units or items there are ten spaces for writing down when the components were overhauled:
Cylinder head assembly, fuel injectors, fuel injection pump, fuel filter, oil filter, clutch plates, clutch assembly, radiator, water pump, gear box, differential, steering assembly, and brake assembly,
A compactor truck would have a number of other components that would need regular servicing. It would be useful to indicate the type of problem that cause these components to be replaced, or whether they are replaced according to the preventive maintenance schedule, but there is the danger of requiring too much clerical work, so if the information is available somewhere, it might be better to cross reference that information rather than writing the same information twice (in two different types of record). Equipment history records are useful for determining the total costs associated with each item of plant, so it would be a useful compromise to write here the total cost of repairs and maintenance (parts and labour).

The eleventh page is entitled *battery record*. This provides space for writing the specification of battery required and details of replacements - the dates on which replacements were made, the make of each battery used, the reasons for the replacements and the condition of the replacement batteries (specific gravity, voltage and levels).

The next two pages are called the *operational record*, and there is a large amount of information that could be recorded here. One must consider the purposes that the information would be put to, and whether the information is readily available in another document. If the information system were computerised, it would be useful to have the following information in an operational record:

- hours utilised
- number of trips made,
- weight of refuse collected,
- cost of service (based on internal charging system rates),
- value of work done,
- fuel consumed
- engine oil consumed
- hydraulic oil consumed
- other fluids consumed
- total cost of fuel and oils consumed.

Such information could be kept on a monthly basis throughout the life of the vehicle, and would furnish useful management information about the condition, relative costs and economic life of each vehicle.

The next two pages are devoted to the Preventive maintenance schedule and attendance record. Again a great deal of information could be entered into such a record, but in the absence of a computerised system the best approach might be to record the date, odometer (km gauge) reading, type of service (if appropriate) and location where each maintenance task is carried out. This information would allow more detailed information to be found easily from other records.

A more detailed record of the maintenance work is to be written on the following five pages. This information should be kept somewhere, but it may be that the equipment history record is not the most convenient place. The information requested is

- the type of work - breakdown repair, preventive maintenance (type of service or docking), overhaul, unit replacement etc.,
- the date on which the work is completed,
- the job number,
- the tasks performed,
- the down time (in days)
- the agency undertaking the work - if a municipal workshop or garage, the man-hours spent on the work, if outside, the charge for the work,
- the spares and materials used, and their costs, if used internally.

A further ten pages are left blank for the addition of miscellaneous notes. Experience might show that it is a better use of paper and the document as a whole if more space is given to the specific types of entry mentioned above, and less to random or unstructured comments

Finally, there is a page concerned with the *scrapping* of the equipment. This begins by asking for the reasons for wanting to scrap the equipment or vehicle. It then solicits details of the proposal to scrap the vehicle - date and authority. The date of inspection by the scrap committee, the members of the committee and comments by the committee are requested next. Next come the date the tender is invited, the sanction number and date, the authority responsible, the buyer and the selling price. There is also space for an inventory of any spares or materials sold with the scrapped vehicle. Finally, there are the signatures of the people responsible for this transaction.

From acquisition, through operations and maintenance, and finally to scrapping, this is the complete history of one vehicle or machine.

Appendix DD-3.4 List of vehicle defects

This list was compiled from records as a management monitoring exercise to investigate the problems that affected the refuse compactor trucks. The right hand column has been added to the original record to give an understanding of the time lost because of these defects.

MUNICIPAL CORPORATION OF GREATER MUMBAI
(TRANSPORT BRANCH)

LIST OF THE VEHICLES WITH THE DEFECTS IN DETAIL

Sr. No.	Vehicle No.	Failure From	Period To	Nature of Failures	Days off road
1.	MH01-H-1069	5.4.1993		Tailgate not operating	
	- " -	14.5.93	15.5.93	Ram pipe broken	1
2.	MH01-H-1706	13.4.93	15.4.93	Ram oil leakage	2
	- " -	4.5.93	4.5.93	Tailgate hook broken	1
	- " -	5.5.93	11.5.93	Tailgate lifting mechanism hydraulic servicing	6
	- " -	20.5.93	20.5.93	Container lock	1
	- " -	31.5.93	31.5.93	Tailgate not operating	1
	- " -	2.6.93	3.6.93	Hydraulic work	1
	- " -	4.6.93	5.6.93	Intermediate lock	1
	- " -	15.6.93	16.6.93	Hydraulic servicing	1
	- " -	23.6.93	26.6.93	Intermediate lock. Tailgate lock opens while loading	3
	- " -	10.7.93	10.7.93	Hopper rod bent	1
3.	MH01-H-1078	12.4.93	13.4.93	Hydraulic Servicing	1
	- " -	23.4.93	23.4.93	Tailgate lock	1
	- " -	8.5.93	11.5.93	Tailgate lock	3
	- " -	15.5.93	15.5.93	Tailgate chain broken	1
	- " -	17.5.93	17.5.93	Pipe broken	1
	- " -	21.5.93	22.5.93	Tailgate opens while operating	1
	- " -	25.6.93	25.6.93	Tailgate chain broken	1
	- " -	2.7.93	3.7.93	Tailgate opens while operating	1
4.	MH01-H-1080	5.4.93	6.4.93	Carrier plate not working	1
	- " -	21.5.93	22.5.93	Tailgate lock. Tailgate opens	1
	- " -	24.5.93	26.5.93	Hydraulics not working	2
	- " -	14.6.93	15.6.93	- " -	1
	- " -	18.6.93	19.6.93	- " -	1
	- " -	10.7.93	10.7.93	Tailgate lock opens	1
	- " -	21.7.93		Ejector cylinder bent	
5.	MH01-H-1081	7.4.93	8.4.93	Hydraulic servicing	1
	- " -	23.5.93	25.6.93	- " -	2
	- " -	7.7.93	7.7.93	PTO lever. Cylinder leakage	1
6.	MH01-H-1085	15.5.93	19.5.93	Container rope broken	4
	- " -	18.6.93	19.6.93	Both container lifting arms broken	1
	- " -	28.6.93	29.6.93	Container arm LHS broken	1
7.	MH01-H-1086	17.5.93	19.5.93	Hopper plate broken	2
	- " -	20.5.93	20.5.93	PTO pump work	1
	- " -	21.5.93	25.5.93	- " -	4
	- " -	3.6.93	5.6.93	- " -	2
	- " -	17.6.93	18.6.93	Container lock	1
	- " -	25.6.93	26.6.93	Hydraulic servicing	1
	- " -	13.7.93		- " -	

Sr. No.	Vehicle No.	Failure From	Period To	Nature of Failures	Days off road
8.	MH01-H-1087	21.6.93	21.6.93	Tailgate pin	1
9.	MH01-H-1088	17.5.93	24.5.93	Hopper lifting platform bent	7
	- " -	22.6.93	24.6.93	Ejector cylinder bent	2
	- " -	13.7.93	15.7.93	Hydraulic servicing	2
10.	MH01-H-1091	31.5.93	2.6.93	- " -	2
11.	MH01-H-1092	17.5.93	17.5.93	Hydraulic work	1
	- " -	14.6.93	14.6.93	Hydraulic servicing	1
	- " -	16.6.93	21.6.93	Ram oil leakage. Hopper arm rod bent	5
12.	MH01-H-1093	21.6.93	24.6.93	Tailgate lock.	3
	- " -	26.6.93	28.6.93	PTO not working	2
	- " -	7.7.93	7.7.93	Hopper not coming down	1
13.	MH01-H-1094	19.5.93	20.5.93	Tailgate chain broken	1
14.	MH01-H-1095	15.4.93	17.4.93	Hydraulic servicing	2
	- " -	12.5.93	14.5.93	- " -	2
	- " -	19.5.93	24.5.93	Hydraulic work	5
	- " -	19.6.93	19.6.93	Both packer cylinders not working	1
	- " -	3.7.93	3.7.93	Ram oil leakage	1
	- " -	7.7.93	9.7.93	Hopper not working	2
15.	MH01-H-1096	15.4.93	17.4.93	Hydraulic servicing	2
	- " -	2.6.93	3.6.93	Ram oil leakage. Hydraulic servicing	1
	- " -	11.6.93	14.6.93	Ram oil leakage	3
	- " -	26.6.93	28.6.93	Hopper rod bent	2
	- " -	29.6.93	2.7.93	Hopper rod bent. Tailgate lock. Ram oil leakage.	3
	- " -	7.7.93	8.7.93	Intermediate lock bent	1
	- " -	17.7.93	21.7.93	Hydraulic servicing	4
16.	MH01-H-1098	29.5.93	31.5.93	Intermediate lock	2
	- " -	16.6.93	17.6.93	Hydraulic servicing	1
	- " -	16.7.93	17.7.93	Tailgate chain broken	1
17.	MH01-H-1098	19.4.93	22.4.93	Hydraulic servicing	3
	- " -	4.5.93	5.5.93	Hopper pin broken	1
	- " -	24.4.93		Packer cylinder not working	
	- " -	21.6.93	21.6.93	Hydraulic servicing. Container plate bent	1
	- " -	24.6.93	24.6.93	Tailgate lock opens	1
	- " -	29.6.93	29.6.93	Hopper bent	1
	- " -	12.7.93	12.7.93	Hydraulic servicing	1
18.	MH01-H-1178	11.5.93	12.5.93	Hydraulic servicing	1
	- " -	17.5.93	17.5.93	Tailgate chain	1
	- " -	29.5.93	2.6.93	Container arm not proper	4
	- " -	4.6.93	5.6.93	Rear hopper rod bent. Hydraulic servicing	1
	- " -	14.6.93	14.6.93	Tailgate lock opens. Hopper not coming down	1
	- " -	17.6.93	17.6.93	Tailgate opens	1
	- " -	28.6.93	28.6.93	Hopper rod bent (vehicle sent twice during the same period)	1
	- " -	21.7.93	21.7.93	Hopper rod bent (vehicle sent twice during the same period). Ejector cylinder piston not closing	1
		22.7.93	22.7.93	Hopper not coming down	1
19.	MH01-H-1173	25.5.93	27.5.93	PTO not working	2
	- " -	11.6.93	12.6.93	Tailgate opens	1
	- " -	14.6.93	21.6.93	Hopper bent	7
	- " -	30.6.93	3.7.93	Ejector cylinder not closing	3
	- " -	8.7.93	11.7.93	Ejector cylinder bent	3
	- " -	21.7.93	21.7.93	Hopper rod bent	1

Sr. No.	Vehicle No.	Failure From	Period To	Nature of Failures	Days off road
20.	MH01-H-1183	20.5.93	20.5.93	Tilting rope pin broken	1
	- " -	29.5.93	31.5.93	Hopper rope broken	2
	- " -	2.6.93	4.6.93	Ejector cylinder bent	2
	- " -	6.7.93	6.7.93	Tailgate opens while loading	1
	- " -	8.7.93	9.7.93	Hopper lock bent. Hydraulic servicing	1
	- " -	12.7.93	17.7.93	Hydraulics not working	5
	- " -	21.7.93	21.7.93	Loaded container not lifting	1
21.	MH01-H-1179	28.5.93	28.5.93	Tailgate chain broken	1
	- " -	14.6.93	16.6.93	Hopper rod broken	2
	- " -	6.7.93	12.7.93	Tailgate opens. Hydraulic servicing	6
	- " -	15.7.93	15.7.93	Hopper rod both side bent	1
	- " -	16.7.93	17.7.93	- " -	1
22.	MH01-H-1180	17.6.93	18.6.93	Tailgate opens	1
	- " -	8.7.93	8.7.93	Container arm and hopper rod bent	1
	- " -	13.7.93	14.7.93	Hopper rod bent	1
23.	MH01-H-1198	9.6.93	10.6.93	Hydraulics not operating	1
	- " -	12.6.93	12.6.93	- " -	1
	- " -	15.6.93	16.6.93	Tailgate chain broken	1
	- " -	16.6.93	16.6.93	Tailgate lock broken	1
	- " -	22.6.93	23.6.93	Ejector cylinder piston bent	1
	- " -	2.7.93	8.7.93	Ejector not closing and hydraulic servicing	6
24.	MH01-H-1203	11.6.93	11.6.93	Hydraulic work	1
	- " -	14.6.93	16.6.93	PTO gear not working	2
	- " -	29.6.93	29.6.93	Hopper rod bent	2
	- " -	8.7.93	8.7.93	Hydraulic servicing	1
25.	MH01-H-1209	24.6.93	25.6.93	Hydraulic servicing	1
	- " -	21.7.93		Hopper mounting beam work. Major work on both sides Hopper rod bent	
26.	MH01-H-1199	28.6.93	30.6.93	Hopper rod bent	2
	- " -	14.7.93	15.7.93	Container arm bent	1
27.	MH01-H-1162	19.6.93	24.6.93	Ejector cylinder piston bent	5
	- " -	30.6.93	3.7.93	- " -	3
	- " -	15.7.93	17.7.93	Packer plate not working	2
	- " -	28.6.93	28.6.93	Hopper rod bent	1
	- " -	21.7.93		Ejector cylinder not closing	
28.	MH01-H-1210	24.6.93	30.6.93	Ejector cylinder piston bent	6
	- " -	12.7.93	12.7.93	Hydraulic servicing	1

Chapter E-1

Land disposal in Mumbai

By Manfred Scheu and Adrian Coad, with assistance from G P Vora, Dr L S Reddy and Mrs Preeti Singh for sections E-1.1 to E-1.4

E-1.1 INTRODUCTION

The term "land disposal" is used to mean the final disposal of waste by depositing it on the ground. The term "dumping" is not used because this suggests that disposal is carried out in a careless way. Conversely the term "landfilling" is not used because this carries the connotation that the waste is deposited at a planned and prepared site in accordance with the principles of sanitary landfilling. In order to keep the scope of this chapter as general as possible a title has been chosen that includes all types of disposal operation from dumping to sanitary landfilling.

Many travellers and tourists learn something about waste disposal in Mumbai before they set foot on Indian soil. As their plane prepares to land from the east, passengers on the right side can see a large derelict area with smoke rising from a number of places. This is the Deonar landfill. Or is it? Can such a disposal operation be described as a landfill?

The Deonar site is the largest disposal operation in Mumbai. It is often referred to as a dumping ground, but it is better than an uncontrolled dump. Each incoming load is logged at the gatehouse. Contractors' vehicles are directed to one unloading area and municipal vehicles to another. Waste is levelled by bulldozers. A breakdown vehicle is on hand to help vehicles that become bogged in the waste.

Yet it cannot be described as a sanitary landfill. It is unsanitary in a number of ways. No measures have been taken to prevent pollution of underground and surface waters. The site is bordered by a sea water creek, so although there are signs of pollution at the edges of the creek, drinking water supplies are probably not threatened, since the groundwater supplies in Mumbai were contaminated long ago, and water supplies are brought long distances from surface sources. The waste is not covered, but there is no serious problem from windblown paper and plastic. The most obvious environmental problem is the smoke emerging from many smouldering fires, and complaints about the smoke have been received from residents, and orders from the Pollution Control Board. Little is known about the plans for the site when no more refuse is brought to it. This is fairly typical of the disposal operations of the major cities of India. Is this a sanitary landfill? To many officials it is. If this is sanitary landfilling then a new term is needed to describe a land disposal operation that is run according to the best international practice and in such a way that pollution and nuisance are minimised, and reuse of the site is possible. Ideally the new term should have the words "engineered", "environment-friendly" and "disposal to land" in it, but such a term would be too cumbersome to become popular. Suggestions are invited.

It would appear that many municipal officials believe that such a land disposal operation is the best that is possible. If this is the case, then it is not hard to understand why there is so much interest in alternatives to land disposal. Some alternatives are discussed in chapter E-2. Better management of land disposal sites is possible, but the improvements depend on the technical staff who are on site, and the resources devoted to improving the operation. Improvements are suggested in this chapter, and the problems of staffing landfill sites are discussed in chapter G-1.

Mumbai is a group of islands that have been joined together to form a long peninsula. Land is scarce, so the benefits of reclaiming land from the sea and low-lying areas are obvious. Much has already been done to increase the area of land that can be built upon, especially around the business area near the end of the peninsula. Is a landfill or dump a suitable place to build? Some information on buildings located on past disposal sites has been gathered. The living conditions of those who have illegally built dwellings near the Deonar site are also described briefly.

E-1.2 DISPOSAL QUANTITIES

There are four disposal sites in Greater Mumbai, namely Chincholi (or Malad), Mulund, Gorai and Deonar. Their locations are shown in figure A-3.1. Records obtained at these sites are summarised in table E-1.1 and used to estimate the amount of waste delivered to the different disposal sites in Greater Mumbai.

Table E-1.1: Disposal quantities in Greater Mumbai

	Truck loads	Tonnage brought by MCGM	Tonnage brought by contractors	TOTAL		Site area	Start of operations
	per day	tons/day (1)	tons/day (2)	tons/day	percent	hectares	
Deonar	650 (3)	840	1540	2380	62	200	1892
Chincholi	230	350	480	830	22	12	1964
Gorai	100	150	210	360	9	12	1965
Mulund	75	110	160	270	7	16	(no data)
TOTAL	1055	1450	2390	3840	100	240	
percent		38%	62%				

Notes
(1) Assuming that 30% of the vehicles are MCGM trucks, including compactor vehicles, bulk refuse carriers and tipper trucks. An average load of about 5.0 tons is considered.
(2) Assuming that 70% of the vehicles are open trucks of private contractors, carrying about 3.0 tons per load.
(3) Including about 90 loads of debris per day (drain cleaning, construction waste). This material is usually collected by private contractors. 4.0 tons per load are assumed.

The values shown are not precise, but indicate an order of magnitude. Commercial and industrial wastes are included in these figures.

Deonar is by far the largest site, and may provide a long-term solution for waste disposal for Mumbai, especially if it is decided to place the waste up to a significant height in order to make a gently sloping hill. Because of the importance of this site priority should be given to planning the use of the site and considering various options for the final state of the site. Already some of the area of the site had been lost to encroachment as unauthorised huts were built (probably by rag-pickers) and storage sheds for recovered recyclables were erected.

The other sites are relatively small, and have a short life span. They are seen mainly as land reclamation projects rather than waste disposal sites. If it is intended to build housing on these sites after they are no longer used for refuse disposal, extra care should be taken in how the site is operated - hazardous industrial wastes should not be deposited there and care should be taken to ensure that the waste is deposited is as compact and uniform way as possible. Part of the Chincholi site was being used for composting in the semi-mechanical process discussed in chapter E-2.

Considering that the total amount of waste delivered to the landfill sites is approximately 3480 tons per day (excluding debris at Deonar) and the total population of Greater Mumbai is about ten million, the daily per capita collection rate is about 0.35 kg, including domestic, commercial, industrial and institutional waste.

E-1.3 OPERATION AND MANAGEMENT OF DISPOSAL SITES

a) Manpower and machinery

Table E-1.2 shows the machinery and manpower that were allocated to the four sites in 1993. The table calculates the ratios of equipment and staff to waste quantities. The work expected of the bulldozers (which are about 15 tons) seems reasonable, but it would be useful to study further how the bulldozers are used and to ascertain the instructions that are given to the bulldozer operators. (For example, the bulldozers should not be used to transport the waste - pushing it over a long distance - but to level it and compact it to some extent.) At Gorai and Mulund there was only one bulldozer at each site - sufficient for the work, but a breakdown of the only bulldozer could lead to a total failure of the operations.

Table E-1.2: Manpower and machinery at land disposal sites

	Loads per day	Incoming waste	Bulldozers		Labour		Supervisors	
		(tons/day)	number	tons/veh	number	trucks/cap	number	trucks/cap
Deonar (1)	650	2380	6	400	63	10	15	43
Chincholi (2)	230	830	3	275	12	19	8	29
Gorai (2)	100	360	1	360	6	16	8	13
Mulund (2)	75	270	1	270	6	13	8	9
TOTAL	1055	3840	11		87		39	
Average				320		12		27

Notes: (1) operating three shifts per day (2) operating two shifts per day

The staffing ratios varied considerably. It was unclear why so much labour was required at the large Deonar site. Further investigations of their duties and efficiency and rates of absenteeism might be instructive.

b) Record keeping

At peak periods trucks were arriving at Deonar at the rate of up to one hundred trucks per hour. At such times there was such pressure on the staff in the gatehouse so that it was difficult to keep records and the trucks were delayed, waiting for their loads to be recorded. An alternative arrangement for the entrance to this large site is shown in figure E-1.1 This proposal has two gatehouses, one for municipal vehicles and the other for contractors' trucks.

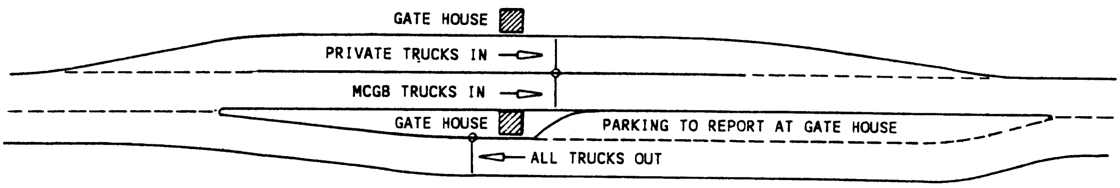

Figure E-1.1 Proposed modification of entrance arrangements at Deonar disposal site

c) Prevention of fire

As has already been mentioned, there are usually fires at the Deonar disposal site. These fires are blamed on rag-pickers who were said to set fire to piles of waste in the evening or early morning, and then sift though the ashes looking for pieces of scrap metal with powerful magnets. This burning was causing serious air pollution which aroused complaints from the public and was also harmful to the health of the workers and drivers on the site. Some of the components in smoke produced by this low temperature burning are linked to cancer and other respiratory complaints. It was said that most municipal staff working at Deonar die before they reach retirement age; the smoke and dust that they breathe each day must be the most likely cause of, or at least a contributing factor to, many of these premature deaths. The staff had been issued with dust masks, but they had found them inconvenient to use and so had stopped using them.

Various steps had been taken to stop this nuisance. The Assistant Head Supervisor in charge of the site had tried confiscating the magnets, and had a large cupboard full of them, but this had not stopped the fires. There was a water tanker on site, and this was used from time to time to extinguish the fires, using a hose. Armed policemen were stationed at the site in order to prevent rag-pickers starting fires, but they seemed unable to stop the burning.

An alternative approach to prevention of burning is suggested in figure E-1.2. It is more difficult to set a level surface on fire than to start a fire in a pile of waste or a sloping surface. The suggested approach involves restricting the area of unloading as much as possible, and levelling the waste as soon as it is deposited. At the end of the day the waste should be covered with a layer of inert material; the most suitable material for this task may be decomposed waste dug from elsewhere on the site. (The reuse of decomposed waste is discussed later in this chapter.) It may be necessary to combine this approach with several other measures because disposal site rag-pickers can become violent when they see their livelihood threatened. The bulldozer drivers may need a police guard. It would be helpful if some alternative source of income could be found for the people who are stopped from burning the waste and sorting through the ashes, but there are many reasons why the municipality cannot become involved in this type of job creation. Such an approach may not be effective immediately, but perseverance combined with other efforts may yield results. When the burning is stopped, the site will become a healthier place to work, and this may lead to other improvements, as discussed in (e) below. The water tanker would then be free to be used to control dust, perhaps taking the highly polluted water from shallow wells in the site and spraying that over the deposited waste where the trucks are operating.

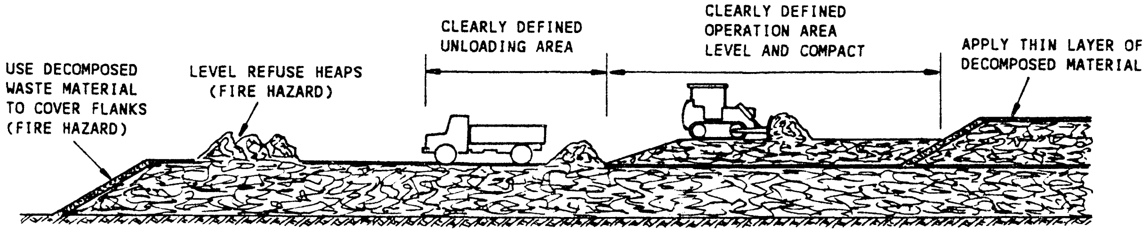

Figure E-1.2 Levelling and covering waste to discourage burning

d) Disposal of slaughterhouse waste

There was a large slaughterhouse near the Deonar disposal ground. Condemned carcasses and unusable parts of the animals, and the contents of the animals stomachs were brought to the disposal site in open trucks and unloaded in one part of the site that was not used for other types of waste. The working conditions of the manual labourers who were shovelling this waste off the trucks were revolting, and the deposited waste was very unpleasant in sight and smell, except to dogs, flies and some birds. Using the machinery already available on the site it would be possible to improve this situation radically, as shown in figure E-1.3. The approach is simply to dig a trench using a 360° excavator, or even a backactor on a JCB. The waste would be unloaded into or beside the trench, and the excavated material would be bulldozed back over the trench at the end of every day, or more frequently, if convenient. Close supervision would be needed to ensure that this procedure was carried out every day.

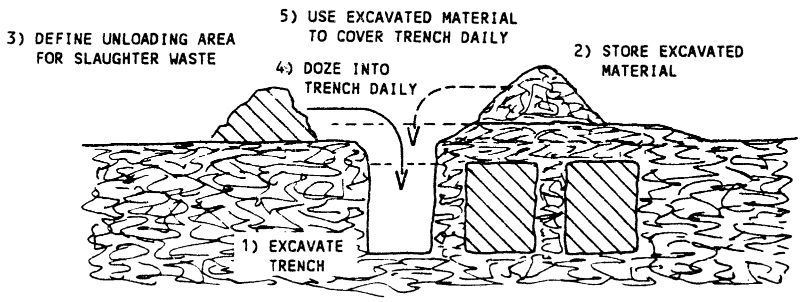

Figure E-1.3 Improved method of disposal of slaughterhouse waste

e) Management

Improvements to large disposal sites do not happen by themselves. The permanent staff at the disposal sites mentioned here were not technically qualified, but responsible for administrative work, and concerned with supervision of labour and maintenance of records. It is unrealistic to expect that plant operators or administrative supervisors would take initiatives to make improvements in disposal operations because

◊ they are already busy with their appointed tasks
◊ they have no authority to make changes in the operation of the site, and
◊ they lack the necessary engineering and environmental training to take appropriate action.

Engineers are reluctant to work in such unpleasant environments, at tasks that they feel are below their status, and they may not have had any training in sanitary landfilling principles. The problems of motivating engineers to work on landfill sites are discussed in chapter G-1. Engineers in Europe appreciate the challenges, importance and rewards of creating a sanitary landfill, so efforts should be directed towards encouraging Indian engineers to work on India's disposal sites, to turn them into acceptable and sanitary operations.

E-1.4 BUILDING ON OLD LANDFILL SITES

a) Should construction be allowed on sites that have been reclaimed with municipal wastes?

As already mentioned, land in Mumbai is in short supply, and there is great interest in reclaiming land from the sea and low-lying marshy areas. Municipal solid waste has been used for this purpose, but there are several reasons why it should not be used:

◊ Most municipal solid waste in India has a high proportion of biodegradable organic material, which is a very unsuitable foundation material because of its low bearing strength and the settlement that results from its low strength and from bacterial decomposition. The bacterial decomposition may take decades to be complete, and may largely stop if there is a shortage of moisture in the waste, only to start again if the material again becomes moist. Often the settlement is not spatially uniform
 ⇒ because of uneven burning of the waste (cavities may form in some places but not in others as a result of localised fires),
 ⇒ because of different degrees of burning, so that waste that has been thoroughly burned has less organic matter and so compacts less as a result of decomposition than unburned waste,
 ⇒ because fine materials may be washed away and soluble materials leached, and
 ⇒ because of variations in the waste itself - a truckload of soil settles very little compared to a truckload of vegetable waste from a market.

◊ Constructing foundations in old disposal sites is difficult. Foundations should be piled down to firm ground below the waste, but even then there can be problems as the leachate in the waste attacks concrete or as the waste settles, dragging the pile down with it. Drilling or piling through waste can be difficult, depending on the materials encountered.

◊ The decomposition of organic waste in the absence of air produces methane gas, which can be explosive. A number of cases of damaged or destroyed buildings have been blamed on explosions of methane gas from landfills. This is particularly a problem where methane is able to concentrate in confined spaces, such as rooms with little ventilation. The climate of Mumbai may have helped to prevent such explosions since good ventilation is necessary for comfort during most of the year.

◊ Building on land where toxic wastes had been dumped caused birth abnormalities and many other illnesses at Love Canal in North America. Other cases of building on contaminated land have caused illness and outcry. If land is to be used for building at a later stage care must be taken throughout the life of the site to prevent such hazards.

b) Investigations in Mumbai

Four buildings constructed on land reclaimed with solid waste were identified as showing signs of damage, and so were investigated.

♦ Building 11 had been vacated. Columns and beams were being replastered since the building was declared not fit for use according to the Housing Board because the steel was visible. This problem was probably not related to the fact that it was built on reclaimed land.
♦ Building 18 had cracks in the walls - probably a result of differential settlement.
♦ Building 39 had a visible tilt on one side, and on the other side it had settled in the middle. Cracks were visible at the corners and at junctions between columns and beams.
♦ Building 71 had already been demolished in 1973 because of uneven settlement.

It was said that the area was built on as soon as the depositing of waste finished, that no time was given for the waste to settle before construction was started.

Dharavi - a large slum area (described in chapter A-2) - was previously a dumping ground. The foundation cost in this area was said to be 40% more than for normal foundations.

c) Recommendations -

◊ Records should be kept of all sites where waste has been dumped, so that it is clear in which areas special attention should be given to foundations. Only small buildings should be erected on such sites.

◊ Ideally, a closed landfill area should not be built on immediately, but a period of twenty years should be allowed to pass before the site is used for construction. In the intervening period it might be used as a park, or for agricultural purposes. In Mumbai and many other Indian cities it is very likely that such an area would quickly be covered by slum housing, if it were not used immediately or tightly controlled.

◊ Consideration should be given to the problem of methane gas. The best solution would probably be to construct the buildings in such a way that there are no enclosed spaces for methane to accumulate (but sometimes owners or residents close in spaces that were intended to be open). To build a gas control system would be very expensive and it would require very careful operation.

◊ If a site is to be used for construction at a later date, the type of waste brought to the site should be carefully monitored, so that hazardous materials are not present, and every effort should be made to lay the waste as densely and uniformly as possible.

◊ There is no doubt that it is better to avoid building on sites where organic waste has been deposited. A more suitable fill material that is readily available is discussed in the next section.

E-1.5 REUSE OF DECOMPOSED WASTE

by Manfred Scheu and J K Bhattacharyya

The landfill site at Deonar has been is use since the turn of the century and so holds a very large amount of waste, much of it at an advanced state of decomposition. This section is concerned with investigations into the reuse or mining of this decomposed material.

a) Observations

A group of about twelve labourers was observed extracting decomposed material from one part of the Deonar site. The waste in this area and depth was thought to be between 4 and 12 years old. After allowing the decomposed material to dry in the sun, it was thrown against a sloping screen with apertures of about 8 mm. (The operation is shown in one of the photographs on the cover.) The fine material was bagged and removed from the site. The coarse material was left where it was.

It transpired that two companies were involved in this work, having started in 1989. The Municipal Corporation was paid Rs 100 per ton as a lifting charge and Rs 6 per truck as a weighing charge. Estimates of the amount of screened material removed in this way varied from 15 to 20 truckloads per month to 30 tons per day.

The fine material was taken to the contractor's premises where it was mixed with cow dung, dolomite, gypsum, and neem cake (the residue after the extraction of oil from neem seeds) and sold as a mixed fertiliser. The company, which also sold agricultural chemicals, marketed the product in an attractive way, claiming that it would

◊ increase root aeration,
◊ increase yield,
◊ reduce pest and weed nuisance (because neem cake is a pest repellent, and because the organic content is fully cured - unlike uncured cow dung which is often used and which contains viable weed seeds);
◊ increase microbial activity
◊ correct micronutrient and secondary nutrient deficiency (since it contains trace quantities of micronutrients like copper, zinc and boron, and secondary nutrients like calcium and magnesium);
◊ increase water retention;
◊ increase fertiliser use efficiency

The analysis of the blended product, according to the supplier, is shown in table E-1.3

Samples of decomposed waste, similar to those used by the contractor, were taken from the site and analysed. The composite sample, weighing 53.9 kg, was taken from four different locations from a layer of decomposed waste that was about 2.5 m thick . The age of the sample could not be determined precisely, but the date on packaging within the sample indicated that at least part of the sample was less than five years old. The results of a simple analysis of this decomposed waste sample are given in table E-1.4.

Table E-1.3 Analysis of reinforced decomposed waste soil conditioner

Source: Fertiplant Engineering Co. Pvt. Ltd. Mumbai

Moisture	10% to 12%
pH (dilution 1:10)	7 to 8
Organic carbon	15% to 17%
Organic matter (assumed 2 x organic C)	30% to 34%
Nitrogen as N	0.9% to 1.3%
Phosphorus as P_2O_5	1.5% to 1.9%
Potassium as K_2O	0.5% to .08%
Sulphur as S	0.55% to 0.7%
Calcium as Ca	5% to 7.5%
Magnesium as Mg	0.5% to 0.8%
Copper as Cu	200 ppm
Zinc as Zn	900 ppm
Iron as Fe	900 ppm
Manganese as Mn	250 ppm
Boron as B	120 ppm

Table E-1.4 Results of tests on sample of decomposed waste 21.11.94

Description	Result	Notes	
Density of wet sample	960 kg/m^3		
Percentage passing 8 mm mesh	63.5%	Sample from this taken for analysis	
Stones greater than 25 mm	31.5%		
Other materials	3.9%		
Evaporation and sieving losses	1.1%		
Moisture content, fine material	14%	Determined by drying in sun	
Organic matter, fine material	14.5%	Sample 10.80g, I hour at 650C	
Constituents of 3.9% “other materials”		Sample weight 2.1 kg	
Plastic (soft)	0.2 kg	Percentage of total weight	0.4%
Rags	0.6 kg		1.1%
Glass and ceramic	0.5 kg		0.9%
Metals	0.2 kg		0.4%
Rubber and leather	0.3 kg		0.6%
Coconut and wood	0.3 kg		0.6%
Further laboratory tests on fine material		Conducted at GLA, Munich, Germany	
pH	7.2		
Organic carbon	5.8%		
Nitrogen	0.5%		
Sulphur	0.4%		
Calcium carbonate	12.6%		
Soluble aluminium	1000 ppm		
Soluble manganese	270 ppm		
Soluble iron	4800 ppm		

A grain size analysis of the fine sample was also performed, and it showed a relatively straight line on a logarithmic plot from 0.6 mm to 6.5 mm. The material was said to "well compactable if at least 20% of coarse material is mixed." Since there were stones making up 31.5% of the sample, the material qualifies as "well compactable", meaning that the material can be used as fill material for land reclamation, though it should not be used to support the foundations of large buildings (but large buildings should never be built on backfilled material).

It is interesting that the percentages of "other materials" such as plastic, glass and metal were so small, particularly considering that much of the organic material had been lost to decomposition - and probably also to burning. This suggests that the work of rag-pickers at different stages of collection and disposal had been very effective.

b) Recommendations

◊ Consideration should be given to increasing this practice, because it not only provides useful materials but it also increases the life of the disposal site by releasing more void space for incoming waste. The constraints that limit the size of the contractors' operations should be investigated to see if these companies can be encouraged to increase their throughput.

◊ The excavated material can be used for land reclamation. It is much better suited to this purpose than fresh solid waste because the decomposition processes within it have virtually finished, so settlement will be less and gas generation negligible. Large buildings should not be constructed on areas reclaimed in this way unless they have piled foundations that penetrate the filled material.

◊ The sieved material would be suitable as a final cover material on landfill sites because it would cover the wastes and would probably be suitable for supporting the growth of ground cover plants which help to prevent erosion and help to make the site blend in with the surroundings. There is a very slight risk of the presence of pathogens in the material which might be made airborne by the passage of trucks, particularly when the cover is dry; such pathogens might be inhaled by site workers. (It is very probable that the risk is very much less than the risk posed by trucks driving over fresh waste.) The pathogens of main concern might be TB and certain moulds. Before recommending the use of this material for intermediate cover it would be advisable to investigate how the concentration of respiratory infection pathogens in decomposed waste compares with the concentration in fresh waste and in soil.

◊ It is recommended to investigate the feasibility of using empty open trucks (that have just unloaded their waste at the disposal site) to transport the waste back towards the city. To save time the trucks should be loaded by a wheeled front-end loader or 360° excavator. One of the key issues to study would be the willingness of the drivers and crews to undertake the unloading of the material (unless large quantities were going to one place in which case labourers could be hired at the unloading points to empty the trucks). A supplementary payment for this extra work would probably be the best solution. It is likely that the feasibility of the utilisation of the return trips of the trucks would depend on the quantities of sieved material required at any one site, favouring the sites where large quantities were required, because of the administration and the delays experienced by the drivers in looking for unknown sites.

◊ The scale of the operation could easily be increased by using a rotating drum screen instead of the fixed, sloping screen. This scaling up would be feasible if the demand for the screened material could be increased, perhaps by supplying it at no charge. Market research would be needed to identify uses for the material, the price that users would be willing to pay, and the requirements of potential customers in terms of quality and delivery service.

◊ The coarse reject material could be used as fill material, or, if the recyclable materials were removed, it should be very suitable for the construction and maintenance of site roads. It is worth paying careful attention to the condition of the site roads on a disposal site, because poor roads lead to extra vehicle wear, delays (if the trucks become stuck), extra dust, and unloading in unauthorised places (if the drivers think that it is too difficult or uncertain to unload the waste in the correct place because of the poor site roads).

◊ Good records of site operations are useful in that they help the site operator to know the age and depth of waste, to enable excavation of the waste after it has had sufficient time to decompose and stabilise.

◊ Mumbai has a heavy rainfall each year, and so there is ample opportunity for the waste to receive sufficient moisture to allow its decomposition. In an arid zone the decomposition may proceed at a slower rate, so more care should be taken to ensure that the waste is decomposed before it is extracted. Preliminary results in Gaza (Palestinian Territories), which has a fairly arid climate, suggest that the moisture in the waste is sufficient to promote rapid decomposition, but in arid areas where the waste has a low moisture content, it would be wise to be aware of this possibility.

E-1.6 RAG-PICKERS AT DEONAR DISPOSAL SITE

by Dr P K Makwana and Adrian Coad

a) Environmental conditions at the site

Many of the rag-pickers who sort through the deposited wastes at Deonar live within the perimeter of the site, in temporary shelters made with plastic sheeting, and without any sanitation facilities.

A preliminary survey was undertaken amongst twenty rag-pickers who were living at the edge of the Deonar site, and amongst five of the municipal workers employed to work at the site, to gain some understanding of their perceptions of the health and environmental situation at the disposal site.

Air pollution was said to be the main problem; both the dust and the smoke were complained about. It must be remembered that the fires were started illegally by the rag-pickers, so if some of their community are concerned about the smoke, a public education campaign might have some effect. A report from the local health centre claimed that 90% of the population in this area suffered from respiratory infections, particularly in the winter.

All those interviewed complained about the noise, especially the noise of vehicles operating on the site at night. All of the sample also complained about the presence of large numbers of flies in the area.

Injuries from discarded sharps from hospital wastes were mentioned by two of those interviewed.

The other problems that caused complaints and the percentage mentioning each problem are shown in the list below:

Rats	80%
Smell	20%
Insect and dog bites	16%

In addition the site staff complained about a lack of safety precautions.

Doctors at the local health centre claimed that 80% of the children of the area had been immunised against TB, polio, typhoid, tetanus and diphtheria and measles. The main health problems among the slum dwellers were said to be malnutrition, anaemia, drug addiction and alcoholism. In addition to the health centre, a Rotary club was also working amongst the slum dwellers of the area.

b) Control of unauthorised people at Deonar disposal site

Many of the problems associated with the Deonar disposal site are related to the activities of the rag-pickers. It is easy to recommend measures such as fencing to keep rag-pickers off the site, but in practice fences would not keep them out because they depend on the waste for their livelihood and so would take whatever measures that seemed necessary to ensure that they have access to the waste deposited at the disposal site every day. Even armed police had not been a sufficient deterrent. It was reported that a truck driver had been attacked by a rag-picker with a knife because he was not prepared to drive his truck to the place where the rag-picker wanted him to do stop for unloading.

The problem of rag-pickers needs to be solved, and perhaps the first step is to understand their perspectives and situation. Prof. Sneha Palnitkar of the All-India Institute of Local Self Government in Mumbai has done some useful work in this field. Municipal officials are reluctant to employ rag-pickers as municipal workers, even on a casual basis, because labour laws are such that they might try to claim all the rights and privileges of municipal employees. In Zimbabwe there was a scheme in which contractors were engaged to collect recyclable materials from disposal sites, and they employed people who were already working illegally at the sites, providing them with uniforms and identification without which they were not allowed on the sites. In this way the contractor takes some of the responsibility for the conduct of the rag-pickers. A long-term, and possibly utopian, solution to the problem of rag-pickers on disposal sites is to segregate recyclables so thoroughly at the source that there is nothing of any value left in the waste when it reaches the disposal site. It is good to start working hard for this ideal, but it is not realistic to expect such widespread co-operation from the households of India within a decade, unless there is a national movement led by someone with the stature of Mahatma Gandhi.

The problems of land disposal of wastes in Mumbai are not easy - possible shortage of land area, air pollution, unhygienic practices, and others - but many of the problems can be solved and conditions can be improved if there is the political will at a high level and if there are enthusiastic engineers working at the sites.

Chapter E-2

Alternative disposal methods

E-2.1 INTRODUCTION

Amongst municipal officials and politicians there seems to be a great desire to develop alternatives to land disposal. Sometimes it seems that officials are ready to spend money on *any* proposal for disposal, if it is not landfilling. Why is this? Some possible answers are:-

- ◊ Public officials are not aware that land disposal can be much better than open, uncontrolled dumping. They think of land disposal as scattered piles of smouldering waste covering a large area, causing serious air pollution, harbouring rats and flies, and spoiling the landscape. They are not aware of the techniques of modern sanitary landfilling, and since money is not made available for the development of such facilities, they may never become aware of the benefits of engineered land disposal - unless they see them in operation in another country.
- ◊ Most alternatives to land disposal have a financial yield - a material is produced that can provide energy or be sold. The promoters of such options emphasise the potential for generating revenue from the sale of the product, and immediately the officials start thinking of turning solid waste into profit - a very attractive prospect. Land disposal, on the other hand, is seen as pure loss. It usually happens that the income from the sale of products is much less than the operating costs, so that the "profitable" alternative costs more than sanitary landfill in the end.
- ◊ No-one wants a landfill near their house, let alone in their backyard! Planners feel that a modern plant that processes waste will attract much less public opposition than a sanitary landfill, and so it will be easier to find a convenient site for the plant. In fact, some waste processing units produce unpleasant smells, make considerable noise, and attract flies and rats, and because they are often closer to houses or factories, cause more nuisance to the public.
- ◊ Land disposal is seen as old-fashioned, whereas processing waste to make a saleable product is modern. Factors such as economy and reliability seem to be less important.

In fact a land disposal facility is always necessary because there are always rejects from every processing unit, and wastes must be disposed of when reprocessing units are inoperative because of failure or maintenance.

Perhaps the main challenge to the development of alternatives to land disposal (or waste processing facilities, as they will be called from now on) is that the waste is heterogeneous, being composed of a wide range of items and materials that are not affected by any one process in the same way. Some wastes float in water, others sink. Some wastes decompose, others are inert. Some adhere to surfaces, others abrade surfaces. Some items found in solid waste can easily be broken up or cut into small pieces by a hammermill or shredder, but others (such as a length of fabric or a roll of carpet) resist these processes. Some materials can only be cut by a sharp knife, but lumps of concrete and large car engine components simply damage the knife blades. Some materials burn to produce heat, others absorb energy because of their high moisture contents, and others still are inert and so are unchanged by high temperatures. Some materials explode at high temperatures, some give off toxic fumes, and others melt. Some materials are beneficial to the soil, others are toxic to plant life. Developing machinery that can handle such diverse materials in a reliable and economical way, and produce a useful output is a task that tests the ingenuity of mechanical and chemical engineers to the full. No machinery should be accepted for a full-scale plant until it has proved reliable with real wastes over an extended period at the pilot scale. (The term "real wastes" refers to wastes that contain the full variety of components that are found in the type of waste that is to be treated - not an idealised synthetic waste made from a few materials that are suited to the process in question.)

India already has a sustainable and well-proven alternative to land disposal for part of its solid wastes - the separation of recyclable materials by rag pickers and reprocessing by many small factories. The drawback of this approach is the exposure of the rag-pickers and sorters to health hazards from their close contact with the wastes. Perhaps the best way of reducing the quantities of wastes that must be landfilled is to improve this informal sector of the economy, by increasing the degree of segregation of wastes in the home and improving the practices of the rag-pickers. Here, the challenge is for the sociologist, not the engineer.

An interesting financial point that is related to waste processing is the price of the solid waste. A number of municipal officials in India indicated that they thought that waste processors should pay the municipality for the waste that they use as a feedstock for their process. They argue that the waste has a value for the plant operator, as does any raw material for any industrial process. An alternative view is found in some European countries. Here it is argued that a ton of waste that is reprocessed is a ton of waste that does not need to be landfilled or incinerated, and so the waste management agency has saved the disposal costs for this ton of waste. If it costs $15 to dispose of one ton of waste, then a waste disposal authority should pay a reprocessing industry the $15 for every ton of waste that is accepted for reprocessing, as *avoided costs* (that is, expenditure on waste disposal that has been saved). Of course the processor should pay the waste disposal authority $15 (or whatever the landfilling charge is) for every ton of rejects that he wishes to dispose of. Disposal costs are currently very low in India because very little is spent to dump the waste in an insanitary way, so the question of avoided costs is of little consequence. As disposal charges increase, the question of who should pay will become less philosophical and more financial.

E-2.2 INCINERATION

Incineration is high-temperature combustion under controlled conditions. Modern large incinerators produce heat or electricity which can be sold to offset some of the operational costs. A modern incinerator was built in New Delhi, and although it is a type that works well in northern Europe, it has not been used after the commissioning trials, because the waste that was brought to it had a calorific value (that is, the amount of heat that is produced when it burns) that was too low for it to burn properly alone, so that a large amount of fuel was required to maintain a satisfactory temperature. The incinerator was designed to save fuel by generating energy, but, because of the type of waste it was required to burn, it was actually consuming large amounts of fuel. The incinerator continues to absorb expenditure as it is being kept in good order by a maintenance crew, but it processes no waste.

Small incinerators may be found at housing colonies, and used for treating medical wastes, condemned food, infected animal carcasses and confidential wastes. In general, such incinerators, unless they are sophisticated and well operated, produce unpleasant odours and harmful pollutants because the combustion temperatures cannot be controlled adequately, and the installations lack the necessary gas cleaning equipment. Problems with such incinerators are mentioned in part F.

The open burning of waste at a dump site cannot be described as incineration. The wastes burn slowly or smoulder at low temperatures, and produce large quantities of harmful and unpleasant smoke. Such a practice should be stopped.

E-2.3 COMPOSTING

> Aerobic composting is a natural process by which micro-organisms convert food and garden wastes, and cellulosic materials like paper, into a stable, non-polluting humus or soil-type material. The final product - compost - is beneficial to all types of soil, and contains small quantities of the nutrients needed by plants. Compost is not generally regarded as a substitute for artificial fertilisers, but helps in the retention and utilisation of artificial fertilisers. The main benefits of compost are to improve the condition of the soil by reducing erosion, improving water retention, improving root aeration and making the soil easier to work. The process is generally though to take between three and ten weeks, and involves control of the air and moisture contents of the material, and arranging and mixing of the mass so that all of the waste is processed, and the naturally-generated temperatures are high enough to kill disease organisms and insects.

The biochemical process of composting has been known for a long time, but throughout the world many large mechanised composting plants have failed. The failure of these composting enterprises suggests that the engineering and business aspects of composting are more problematical than the biochemistry.

The decomposing remains of many large composting machines can be found in many of India's major cities. For example, a plant was commissioned in Mumbai in 1979, but it ran for less than four years. Figure E-2.1 shows one view of the plant at the time of the study. The experiences of other plants were similar. One may guess at the enthusiasm and motivation that inspired the creation of these large factories - perhaps the desire to reduce the dependency on uncontrolled dumps, the desire to see organic wastes put to good use in improving the quality of the Nation's soil (thereby helping to improve the lot of rural Indians and preserve their heritage - the soil). Others may have been concerned to reduce the pollution of water and air from dumped waste. Another benefit would have been seen as the opportunity to reduce the costs of solid waste management by generating income from the sale of the product. All these are laudable aims. Why were they not realised?

Before reviewing the reasons for the failures of these plants, it is important to ask what can be learned from such retrospection. Are there lessons for today? Is it possible that the same mistakes could be made, or are being made, again? Yes, there is a strong possibility that some of these mistakes could be repeated, and so it is can be very beneficial to review the causes of failure of India's large, mechanised composting plants and consider how these causes might be repeated in the programmes of today. The list in the box below comprises *suggested* reasons for failure, because the writer has not had the opportunity to study the case histories of many plants in India. The list is based on the observations of others and experiences in other countries. A more detailed investigation of the reasons for the closures of these plants would, no doubt, produce some instructive conclusions.

Figure E-2.1 A view of the abandoned composting plant at Deonar, Mumbai.
The photo shows the covered area where the compost was formed, and the travelling augers used for mixing and aerating.

Many of the factors that determine the success of mechanical composting plants are also relevant to other waste processing technologies, such as those discussed in other parts of this chapter.

A private company which has a large premises in Mumbai, had become involved in producing compost. The company had already been producing agricultural chemicals for some time and so had good links with the agricultural sector, which would be of benefit in terms of marketing the compost. The company had started with a small pilot scale operation on their factory premises, and after gaining useful experience at this site they set up a plant beside the Malad disposal site. At the site waste was being piled in windrows and turned by a front loader (JCB) every 15 days. Water was brought to the site in a tanker. The operators added an inoculant which included cow dung slurry, and claimed that this quickly stopped the production of odours (even from fish waste) and accelerated the process. When the microbiological processes were complete the rough compost was brought to a

Suggested reasons for the failure of mechanised compost plants

No time to learn *Very few inventions have no need of development. Translating an idea into a reality generally takes time, as the prototype is made and tested, its weaknesses are discovered, and ways are found of overcoming the weaknesses. In chemical engineering, there is first the bench scale demonstration of a process (perhaps producing a few grams of product), then the pilot plant (the output of which can be measured in kilograms), then a small experimental full-scale plant (producing a few tons per year), and then one large full-scale plant, producing quantities on an economic scale. During each stage it is expected that problems will be discovered, and ways will be found of solving these problems, and the process is operated under realistic conditions successfully for a time before the next stage is attempted. When the large, full-scale plant is working well, other plants can be considered.*

Compost plants are complex in that they are required to handle wastes that are inhomogeneous (containing a wide variety of materials and forms) and varying (having different compositions on different days and in different seasons). The design of the machines to handle and refine such an input is not an easy matter, and so long-term trials are needed to identify and solve design and operation problems. If the machinery goes from the drawing board to the full-scale plant in too short a time. it will probably not be trouble-free or reliable.

Market problems *Is composting a method of waste disposal or the production of an agricultural product? Should a composting plant be the responsibility of a municipality or the Ministry of Agriculture? Should the decision as to the size of a composting plant be made on engineering and financial grounds, or on the basis of the market demand?*

A common reason for the failure of a composting operation is the lack of a market for the product. The following factors can affect the demand for the product:-

- *The type of agriculture or horticulture. Growers of high-value crops may be more prepared to invest money and effort into applying compost than farmers having large fields of wheat.*
- *The distance that the compost must be transported. The cost of transporting the compost may be significantly more than the price it is solid for at the factory gate. Compost should applied in large quantities, so large volumes must be transported. Large plants may hope to serve a large farming area, but farmers near the outside of the proposed area may be reluctant to pay for transport.*
- *Farmers may prefer to use alternatives , such as animal manure or even imported composts.*
- *Quality is a frequent problem. If compost is made from mixed waste it is likely to contain fragments of glass and plastic, and significant amounts of toxic heavy metals (which may adversely affect plant growth if the compost is applied in large quantities). For this reason, most new composting operations in Europe are using only segregated waste - that is organic material from gardens or from houses where the organic wastes are not mixed with the other types of solid waste.*
- *Managers of composting plants are more likely to be municipal engineers than experts in agricultural marketing. Marketing skills are needed in a variety of ways, including choosing the name of the product, determining how it should be packaged, what grades of refining are appropriate, and how the product(s) should be advertised and distributed.*

Financial realities *No-one should expect that a large mechanised compost plant will make a profit. Income from the sales of compost and any salvaged material helps to reduce operating costs, but sanitary landfilling is usually cheaper than composting.*

screening plant where the material was passed though rotating screens in order to separate out plastic, glass, metal and other contraries (that is, material that is not desired in the final product). Rag-pickers collected these materials for recycling. The compost was bagged for sale. The whole process was said to take 6 weeks. One hundred tons of solid waste were said to yield about 25 tons of saleable compost. Trial plots having different soil types had been used to assess the effectiveness of the product.

There are differences of opinion amongst compost experts regarding the need to add bacteria as an inoculant, but this particular company was very convinced about the practice, and made enthusiastic claims about the benefits of cow dung slurry.

In 1995, the same company was operating a 150 ton/day plant in Bhopal and a 70 ton/day plant at Ahmedabad, and constructing a 100 ton/day plant at Gwalior. It was claimed that the compost made in Mumbai was transported up to 300 km (perhaps in trucks that had brought produce to Mumbai and would otherwise return empty to agricultural areas).

The selling price in 1995 was Rs 1300 /ton. A fee of Rs 15 was paid to MCGM for every ton of compost produced. Table E-2.1 shows estimates of the capital costs of different components of this type of composting operation, for plants of different sizes. It would be useful to combine these costs with operating costs in order to evaluate the cost of producing one ton of compost, but this information may be regarded as confidential, and it may require further operating experience before such figures can be estimated with a reasonable degree of confidence.

Table E-2.1 Capital costs for semi-mechanical composting plants of different sizes in India

Source: Excel Industries Ltd, Mumbai 1995

Costs in lakhs of Rupees

Plant size - throughput in tons per day	**500**	**300**	**100**	**50**	**20**
Item					
Project feasibility/survey etc.	15	12	5	3	1
Site development and infrastructure	100	60	30	11	2
Plant machinery					
De-fouling, waste treatment facilities	50	20	10	4	2
Fermentation, aeration, material preparation	50	35	22	16	4
Separation, grading	60	48	25	10	2
Sieving, finishing	30	25	14	6	1
Blending, packing	30	22	12	4	1
Other electrical items, quality control	35	28	12	6	2
Total	370	250	130	60	15

This semi-mechanical approach to composting had many positive points:-

◊ A private company with a concern to make the project succeed and a readiness to employ the needed professionals
◊ An organisation with good links to the agricultural sector and marketing ability
◊ Experience based on gradual growth, starting with a pilot -scale operation
◊ Relatively simple and well-tried technology

It was not possible to assess the commercial success of the operation - private companies are generally reluctant to divulge technical and financial information - but it did appear that the screening plant was operating at considerably less than its rated throughput on the day of the visit.

E-2.4 VERMICOMPOSTING

Vermicomposting or vermiculture is the processing or organic waste by worms. Under the right conditions of shade and moisture worms feed on the food and vegetable waste, and their excreta, or *casts,* form a very valuable soil conditioner. The moisture content should be in the region of 30 to 40 per cent, and , in addition to shading by trees, a roof or sacking, to keep the temperature below 25C, the worms should be protected from rats and ants. This technique has been used on a small scale in a number of places in India. Proponents claim that the worms neutralise toxic components and pesticides, and that the product has a useful carbon to nitrogen ratio. It was estimated that the process takes three months.

Some small-scale academic research into vermicomposting had been carried out at in Indian Institute of Technology in Mumbai, encouraging the Municipal Corporation to invest in a large scale (Rs 35 lakhs) vermicomposting operation. Nine large enclosures were constructed on a part of the Deonar disposal site which was no longer being used to receive waste. Each enclosure was formed of low walls (about 0.8 m high), and was 40 m long and 10 m wide. The concept was that colonies of the appropriate types of worms would be introduced into each enclosure and selected solid waste - market waste with the plastic and stones taken out of it - would be deposited in each at a rate that would suit the requirements of the worm colonies. It was anticipated that waste could be deposited in each enclosure at the rate of two truckloads a day for ninety days. A research student would control the operation, based in an office and laboratory building adjacent to the enclosures.

The site was visited by the writers on two occasions, and it seemed that the facility was not operating. It was not possible to find any worms, and on the second visit it appeared that no solid waste was being provided. It seems that the investment in construction was wasted.

It is always easy to be wise after the event, and looking back it is clear that it was unwise to take such a big step at one time. The preliminary trials were in enclosures that were perhaps smaller than ten square metres in area, under carefully controlled conditions. To jump to an installation of 3600 m^2 was too big a step. This huge size made it difficult to control the type of waste being offered to the worms, to control the moisture and to provide sufficient shade. It may also be true that a landfill is not a good site for a vermicomposting operation because of the settlement of the underlying wastes causing structural problems, the generation of methane gas, and the probable presence of large numbers of rats.

E-2.5 PELLETISATION

Pelletisation is the production of fuel pellets, often known as refuse-derived fuel, which are in the form of cylinders of dried, compressed solid waste, with a diameter of about 20 mm.

There is a pilot pelletisation plant in Mumbai. A plant in Baroda had been making a fuel using petroleum sludge, but that had closed. The press had reported the construction of a large plant in Madras that would make fuel pellets from municipal solid waste which would then be used to generate electricity, but no information is available about that site. The Mumbai pilot plant will be discussed briefly here. (The information presented here was supplied by the staff, and there was no opportunity for independent verification.)

The plant was conceived as a pilot plant by the Department of Science & Technology and started production in 1993. The plant was designed to receive waste at the rate of 100 truckloads per day and produce 100 tons per day of fuel pellets (i.e. an output of 15 to 30% of the waste received). The first step was to spread the waste on the ground so that it could dry. The partially dried waste was then raised by a conveyor belt where manual separation was done. (One little problem is that coconut shells were not carried up the conveyor because they simply rolled down.) The waste was then fed to a rotating screening drum fitted with cutters and hot air was supplied for final drying. The material was then fed to a hammermill which converted the waste into a cotton-like material which was fed to the compressing machine, together with the required amount of water, and this material was forced through a die with a large number of holes to form the pellets. The pellets were then bagged and sold. The plant was designed to work continuously - 24 hours a day and seven days a week (but at the time of the study in 1995 it was only working one shift.) The water consumption was 300 litres per day and the power requirement 750 kW. The work force was 35 persons per shift. The capital cost of this plant was Rs 2 crores, but no information was obtained about the running cost. The land was provided to the plant at a nominal lease.

The calorific value of the pellets was about 4000 cal/g and the selling price about Rs.1000/ton. To allow comparison the calorific value of coal was 4500 cal/g and its price varied from Rs.1750 to Rs.2000 per ton. The burning characteristics are different from those of coal - in general such pellets tend to burn very quickly.

About 70 per cent of the material that could not be used in the pellets was fed to a small incinerator which supplied the heat for drying. Only inert material was discarded. Coconut shells were separated at the conveyor belt. In the waste there was too much straw. Petroleum sludge was used as a binder as 4 to 5 per cent of the final product.

The pellets were said to be suitable as a substitute for coal in boilers for steam generation. In the monsoon season the pelletisation plant could not operate, and this disruption of supply made the pellets unsuitable for some customers, nevertheless the pellets were being sold to paper and textile mills and the sugar industry. Another problem was the regular replacement of the die which was wearing out after three to four days' use. The plant was also finding it difficult to get personnel for working in the plant. The municipality was not getting any revenue for supplying the waste continuously to the plant. It had been concluded that such plants cannot be run for profit and so such projects cannot be considered to be economically viable.

E-2.6 ANAEROBIC DIGESTION

Anaerobic digestion is a technique that had been used on a large scale for decades for the treatment of wastewater sludges and strong industrial wastewaters. In the absence of air and in carefully controlled conditions (temperature, mixing, acidity) anaerobic bacteria digest the waste, reducing its solids content, making it more stable, and producing gases - mainly carbon dioxide and methane. The methane can be used as a fuel. In large wastewater treatment works, the gas produced by the process is usually enough to fuel generators that provide a major part of the electricity needs of the whole treatment facility.

This is the same process as is used on a small scale in biogas digestors, which have been widely promoted throughout India for the treatment of animal wastes and the production of biogas as a source of energy. The Tata Energy Research Institute of New Delhi has recently been experimenting with the extension of this approach to wastes from a restaurant.

Anaerobic digestion takes place within a modern landfill, provided that there is some moisture in the deposited wastes. Large sanitary landfills produce large quantities of methane, which may be collected

(i) to avoid posing a threat to adjacent housing (there have been cases of houses being damaged or demolished by methane explosions), or
(ii) because methane is much more harmful as a greenhouse gas than carbon dioxide, or
(iii) to provide energy for electricity generation or heat supply.

However, the form of anaerobic digestion that is exciting most interest in India is the processing of mixed municipal wastes in large tanks to produce methane which will be used for electricity generation. The driving force that is vigorously promoting this technology is the large company called Western Pacques India Ltd.

Hitherto most anaerobic digestors have been fed with wastes that are reasonably homogeneous and uniform in composition. The bridge that must now be crossed is the development of a technology for handling inhomogeneous and varying wastes. A pilot plant operated by the parent company at Breda in the Netherlands has been using market and yard wastes, but the plants planned for India expect to accept all types of non-hazardous municipal solid wastes.

The first step was the construction and operation of a pilot plant in Pune, rated at five tons per day, and commissioned in March 95. The next step was seen to be the construction and operation of a number of large plants in India and elsewhere; the plant in Pune is to be capable of a daily intake of 300 tons of municipal solid waste

The company has agreed to take responsibility for all expenses, provided that the Municipal Corporation provides the land and solid waste at no cost.

More detail about the process is shown in figure E-2.2

Reception, weighing	
Storage	Incoming waste does not arrive at a regular rate, but in pulses, so storage allows the rate of feeding into the reactor to be uniform.
Picking belt (manual sorting)	**Output**: large items, plastics, cans
Drum sieve	55mm mesh **Output**: rejects which are shredded and sent to the reactor
Mixing and settling	**Output**: dense materials such as stones
Reactor	The waste is mixed with water, and floating material is periodically pushed under the surface. The slurry is also agitated. **Output**: Methane and carbon dioxide and small quantities of other gases. The gases are sent to a gas engine or flare. **Output**: Some of the water is decanted and recirculated or treated
Screw press	This reduces the water content of the digested solids, greatly reducing the volume of the residue. **Output**: Wastewater that requires treatment
Solid residue dried or spread	The digested solids are thought to have value as a soil conditioner

Figure E-2.2 Flow chart for solids through anaerobic digestion plant

The digestion of the wastes takes place in the floating layer reactor. At the inlet end of this long, covered tank there is a hopper-bottomed sedimentation stage where dense material sinks to the bottom and is removed. This would include mineral matter (which does not produce gas) and steel and glass packaging items that have not already been removed and that have little air inside them. The organic waste, having a density close to the density of water, is carried along slowly through the reactor. A novel feature of the reactor is the dunkers which push the floating waste down into the water to ensure that this material has plenty of contact with the bacteria in the water. The produced gas goes first to a storage unit, then to a hydrogen sulphide scrubber (which removes this toxic and unpleasant gas) before being passed to the gas engine which drives the electricity generator. If the power generation unit is not being used because it is being maintained, the gas can be burned off safely in a flare. The hot exhaust gases from the engine could be used for mixing or warming the contents of the reactor, or for drying the solid residue.

There are some issues of concern regarding the residue. In any reactor there is a degree of short-circuiting - that is, some of the material goes through the reactor in a shorter times than other elements of the material. The solids that go through the reactor in a short time will not be fully digested or stabilised, and so will continue to decompose after being withdrawn from the plant. This material may produce unpleasant odours and take nitrogen from the soil, in the same way as immature compost. The solid residue is likely to have a high water content, even after passing through the screw press, and this water will add to the weight of the residue, and the difficulty of transporting it. It has yet to be determined whether there will be a sufficient demand for this material from farmers. Another consideration may be the survival of pathogens and weed seeds since the temperature in the digestor is comparatively low and the short-circuiting material may spend a relatively short time in the process. These are questions which may already have been answered by the company, or may still need to be investigated.

Table E-2.2 shows the expected composition of the solid residue from the process, and compares it with the composition of compost produced in the semi-mechanical process described in section E-2.3. Comparison is difficult without more knowledge about how the determinations were carried out and reported. There are other items of concern, such as the contents of toxic metals.

Table E-2.2 Comparison of compositions of aerobic compost and residue from anaerobic digestion

	Percentage composition	
	Aerobic compost	**Anaerobic residue**
Moisture content		70 - 80
Organic matter		45 - 60
Organic carbon	14 - 18	
Nitrogen	1.5 - 2.0	1.3 - 2.9
Available phosphorus	1.25	
Phosphates		0.3 - 1.0
Potassium	1.05	0.3 - 0.7

Sources: Aerobic compost: Dr S R Maley, Excel Industries Ltd
Anaerobic residue: Western Pacques India Ltd

Notes: Apart from moisture content, results for anaerobic residue are quoted on a dry weight basis, whereas the basis for the results for aerobic compost is not specified.

The installation includes a wastewater treatment plant comprising an aeration tank and clarifier. It is clear that the operation of such a facility will involve a well-trained workforce and management team.

A plant capable of handling 450 tons of municipal solid waste each day requires a land area of about two hectares, and a daily water supply of about 50 m^3. It would be expected to produce up to 2.8 MW of electrical power, of which about 20% will be needed for powering the plant. In addition it would produce 80 to 90 tons of organic residue each day.

All the information that has been quoted here comes from the company that is promoting these projects; there had been no opportunity for independent verification. Some of the operational data cannot be known with confidence until a full-scale plant has been operating for some time. It is hoped that the development of this process will be undertaken in a considered way, to allow the lessons learned from one stage to be incorporated into the next larger stage, so that the errors that caused the failures of the mechanised composting plants are not repeated.

Chapter F

Management of hospital wastes

by G P Vora, Dr C H Nagarabett
and Dr L S Reddy

F-1 INTRODUCTION

Hospital wastes are generated in the process of investigation of disease or treatment of patients. The wastes may be in either solid or liquid form. Wastes arising in hospitals may be classified into two categories: - *hazardous* wastes which pose a particular threat, and *general* wastes which are no more hazardous than ordinary domestic wastes.

Hospital wastes	
Hazardous waste	**General wastes**
human organs and tissues	canteen waste
used needles and syringes	floor sweepings
microbiology wastes (culture dishes etc.)	discarded drinks containers
discarded chemicals and medicines	cardboard
radioactive wastes	waste paper from offices etc.
blood, sera, sputum, cerebro-spinal fluid, urine, often in pads , swabs and dressings	

Some of the hazardous clinical waste is dangerous because it may contain pathogens like bacteria, viruses, protozoa, helminths and fungi. Some waste materials such as medicines and used chemicals from laboratories are toxic and pose threats if used wrongly, if they contaminate containers, or if they are discharged to bodies of water. Some wastes are regarded as very offensive because of their appearance or smell. Incidences of recognisable human body parts being carried around by dogs or birds are not easily forgotten.

Syringes with needles attached are probably the most dangerous of all hazardous clinical wastes for the following reasons:

- ◊ They may contain blood which can harbour and sustain the deadly viruses of hepatitis and AIDS;
- ◊ The sharp point of the needle can easily puncture the skin and introduce the infective pathogens into the bloodstream;
- ◊ Syringes are in demand by drug addicts, who use them for injecting drugs into themselves, by children who like to play with them, and with unscrupulous or untrained medical practitioners who wish to use them to save the cost of purchasing new ones

Because of these hazards it is essential to isolate dangerous wastes and dispose of them is a way that safeguards the public; often this requires some form of treatment before final disposal.

Another type of medical waste that is not hazardous in itself, but which may pose a threat to the public, is medicine containers. Bottles and other reusable containers that have been used for medicines may be filled with spurious materials and sold as the original medicine (Grover, 1997). This problem is made more difficult to control by the fact that medicine containers are discarded from private homes as well as medical establishments. Perhaps the best means of control is specifying the type of container that may be used for medicine, such that they cannot be resealed, and a public awareness campaign. There is also a trade in bottles outside hospitals, leading to a risk that infection may be transmitted if the bottles are filled with medicines, or that specimens may be wrongly diagnosed if the bottles are not clean.

Incineration is generally regarded as the best means of disposal of hazardous and offensive wastes, but the word *incinerator* can mean many different things, from a simple combustion chamber to a large and sophisticated plant with two combustion chambers in series and sophisticated gas cleaning equipment. In some countries air pollution controls require that very sophisticated incinerators be used, and that the incinerators be operated with great care. It was reported that the Pollution Control Board at Delhi had objected to the pollution caused by a clinical waste incinerator, and air pollution problems had been experienced with a crematorium in Mumbai.

It is likely that many of the problems mentioned in this chapter have been addressed by the authorities, and so the observations made here should be regarded as historical, not current. They serve as a useful guide to techniques of investigations in general, and examples of conditions that may be found.

F-2 INVESTIGATIONS

In order to study the practices that are being followed in some of the hospitals and to suggest methods for safe disposal, three hospitals were visited to discuss the issues with senior personnel and observe how wastes were managed. One hospital was run by the Municipality, one was an urban health centre in a poor suburb, and the third was a privately-run hospital. The municipal hospital had 1345 beds; 36 wards and 17 operating theatres.

a) Municipal Hospital

When the team visited the premises of the municipal hospital it is found that the refuse storage area constructed within the premises of hospital was full of waste containing both clinical and general waste of all sorts, including dressing wastes, plastic bottles, glass bottles, injection needles, cardboard boxes, bottles used for blood samples and other samples, etc. The team tried to determine whether there were any dust bins provided for storage of hazardous waste and found that there were no such containers.

The team met the Dean of Hospital and the Assistant Medical Officer (AMO) and visited various wards with the AMO and investigated how the different wastes were managed.

The procedure adopted in Microbiology Department appeared reasonably satisfactory. The person in charge explained the system adopted for disposal of the clinical (hazardous) waste. Used syringes and needles were found cut into two in a small piece of equipment called a syringe and needle destroyer, making the needles and syringes unfit for reuse. After being cut in this way the syringes and needles were disinfected with sodium hypochlorite before being sent to garbage bins for disposal.

Comment There is some doubt about the effectiveness of sodium hypochlorite as a disinfectant of needles, because of the lack of penetration of the disinfectant into the bores of the needles.

Samples of blood, serum, stools, urine and cerebro-spinal fluid were said to be autoclaved at 125° C at a pressure of 15 to 20 lb./inch^2 for a period of 15-20 minutes before their disposal to the refuse storage bin.. The studies revealed that both the Medical Officer and the staff were well aware of the health implications of untreated clinical waste but they were able to implement safe practices only to the extent that infrastructural facilities were available. It was estimated that an average of 3 to 4 kg of clinical waste was generated in this ward each day.

The team then visited the Biochemistry Department where the waste was found to have been disposed of as ordinary waste into the common storage facility. Discussions revealed the fact that the health officer in charge and the staff were of the opinion that the waste they were dealing with was not hazardous since their activities were confined to chemical analysis. In this ward also about 3 to 4 kg. of waste per day were thought to be generated.

The investigators were astonished to know that samples of blood taken from a person having a serious infectious disease were treated differently by different departments - in one ward the sample is treated as hazardous waste, in the other no special care was being taken. This shows a lack of co-ordination between the two departments.

The team also visited the Anatomy Department and had discussions with the Medical Officer in charge. The waste generated in this ward comprises discarded human parts, amputated limbs, body wastes generated in operation theatres and also dissected parts of human bodies from practical studies of the medical students. As these wastes may not only be hazardous but may also be aesthetically offensive, they need careful and safe disposal. It was found that all these wastes were being sent to incinerators where they were assumed to be completely burned prior to disposal.

The team also visited the Pathology Department to which the organs removed in the operation theatres were sent for histological studies. Tissues of tumours, glands etc. of in-patients and out-patients were also sent for histological analysis to this ward. During discussions with the professor it was learned that all samples after analysis were being stored carefully in a container and later sent to the incinerator in a polythene bag for final disposal. On an average nearly 10 kg of such waste were generated from the department each day.

The team also visited the other wards and premises and found that no special care was being taken anywhere to segregate the clinical waste and ensure satisfactory storage and disposal, all the waste being deposited in the common bin.

The team also visited the crematorium.. The premises were not enclosed by any form of fencing. The system adopted was satisfactory but more care should have been taken to ensure complete burning.

In total the hospital waste generated per day was estimated to be about one metric ton from all the wards and laboratories, out of which about 25 kg waste was being incinerated, and the rest of the waste was being thrown into the general garbage bin from whence it was taken by municipal vehicles to the dumping site along with other wastes of the city. It was also observed that recyclable articles were being segregated at the common refuse storage point and taken away by a private agency. There was no supervision of the private agency workers to ensure that they were taking away only recyclable material and no item hazardous to health.

b) Health Centre

The team also visited an Urban Health Centre which also was managed by the Municipal Corporation of Greater Mumbai. This hospital had both out-patient and in-patient wards, with a total of 100 beds. The waste generated in this hospital was not segregated at any stage, all the waste being thrown into common refuse enclosure before it was ultimately taken away by a Municipal Corporation vehicle once every two days for disposal at the dumping ground. The total waste generated per day was estimated to be 150 to 175 kg. Here it appeared that no special care was being given to the disposal of waste and also it appeared that neither the doctors nor the staff were concerned about the safe disposal of the hospital waste.

c) Private Hospital

After completing its studies in public sector hospitals, the team decided to study the systems adopted in a private hospital and therefore visited a large private hospital and medical research centre in Mumbai. The hospital is a well maintained 294 bedded hospital with facilities for out-patient treatment also. The hospital had facilities for treatment of all cases except for maternity and prolonged cancer treatment. During discussions with the Senior Executive, Marketing, and the Manager of House-keeping Department, the team learned that they were using two colours of plastic bags for storing and disposing of clinical and non-clinical wastes. Black bags were used for hazardous waste and green bags for general waste. Every ward was provided with both the bags and the staff had been trained to segregate the waste at source and deposit the different wastes in the appropriate bags. The black bags containing the clinical waste were tied and carried in a separate lift to the 5th floor where there was an incinerator is good working condition. On average 40 to 45 of these black bags were incinerated each day suggesting a daily weight of 200 kg to 225 kg. Nothing was done to render the used syringes and needles unusable before their disposal in the incinerator.

The wastes generated in each ward and in the research centre were segregated so that all sharps such as needles, syringes and blades, were stored in plastic containers. These containers were also taken to the incinerator together with the black bags. At the incinerator, it was observed that the black bags were thrown in as a whole whereas only the contents of the plastic cans were thrown into the incinerator. It was found that, on average, 800 g of clinical waste was being generated per bed per day.

The team also visited various wards and premises with the Housekeeping Manager, whose duties were exclusively the supervision and up-keep of the premises and the disposal of the waste. The non-clinical (or general) wastes generated in the wards and the kitchen were being stored in green bags which were provided in the kitchen, in each ward and in public places within the hospital. On an average day an estimated 2 to 2.5 tonnes of wastes were generated from these various sources. The wastes thus collected in green bags were carried by the house keeping staff to a separate shed constructed for the purpose and stored there. According to the need, the private contract vehicle which the hospital authorities had engaged was called in once or twice a day to collect all these wastes and take them to a municipal disposal site.

It is useful to know the quantities of waste generated by hospitals. Using the data for the municipal hospital mentioned above, the rate for all types of solid waste comes to about 0.7 kg per bed each day. The rate for the urban health centre was about 1.5 kg per bed each day, but here there may have been a larger proportion of the total number of patients who were outpatients and so did not use a bed, so the weight generated per bed would have been higher. If the total weight of waste generated each day at the private hospital was 2 tonnes, this represents a generation rate of 7 kg per bed, which is ten times the figure for the municipal hospital. The amount of *hazardous* waste for the private hospital was estimated to be 0.7 kg per bed each day. As is often the case, it is very important not to accept figures without ascertaining how they were determined. The figure of 7 kg per bed was based on a total figure of 2 tonnes per day, which may have simply been a figure guessed by someone looking at a pile or estimated by a driver or loader who is accustomed to handling much denser materials. The generation rate for private hospitals is likely to be higher because private concerns often have more money to spend on disposable paper and plastic items whereas municipal hospitals may have to rely more on reusable items made from cloth and glass.

The team made determined efforts to obtain information from both the private and public hospitals about incidences of diseases or injuries to staff handling infectious wastes. Unfortunately no such data were available with the any of the hospitals. It was observed that even though 90% of the doctors and staff in Municipal Hospitals were well aware of the implications of handling hazardous hospital wastes, no efforts appeared to have been made to remedy deficiencies for the reason that this issue was though to be outside their control.

F-3 SUGGESTIONS

a) **Colour coding:** It is always advisable to minimise the risk of persons accidentally coming into contact with hazardous waste, and this risk can be reduced by always putting hazardous wastes into containers of a particular colour. Such containers, suitably labelled, should be provided in every operating theatre, ward and laboratory where such wastes may arise.

b) **Sharps**:

◊ Sharps such as needles, syringes, blades etc. are to be stored in a metal box or rigid plastic container till they are finally disposed of. The walls of the container should be strong enough that they are unlikely to be pierced by the contents. Plastic bottles made for carbonated drinks have been used successfully. The container should be destroyed or buried with the sharps - the containers should not be emptied and reused. It is probably better to use a cheap container (such as a soft drink bottle) and discard it with the sharps still inside than to use a specially designed sharps container repeatedly, emptying out the contents each time.

◊ Sharps, especially syringes with needles, often have a resale value, and may be reused by certain (often unlicensed) medical practitioners, by drug addicts, or by children. Such reuse poses the most serious threat to public health because viruses of AIDS and hepatitis can survive in blood within the needles and infect those who use them. Whilst every effort should be made to prevent the public from gaining access to these items, the best protection is provided by cutting the needles and syringes immediately after use so that they are not reusable. This places a heavy weight of responsibility on ward staff and those who train and supervise them.

◊ Before disposal all sharps should either to be autoclaved or disinfected chemically. Simply dipping these items into sodium hypochlorite may not be effective in killing pathogens within the needles or within deposits adhering to the outsides.

◊ If sharps cannot be incinerated they should be buried in a secure way such they cannot be recovered. One method may be to deposit them in a pit within the hospital grounds; the pit should be covered with a heavy concrete slab into which a steel pipe is embedded so that the needles and blades can be dropped down the pipe into the pit. (Coad, 1994)

c). **Other items of concern**

- Medicines are also a cause for concern since they may be used wrongly by people trying to treat themselves or by unscrupulous or untrained practitioners. Of particular concern are cytotoxic drugs used to fight cancer because they are so potent and so dangerous when used without a high degree of supervision. All unused medicines in medical establishments should be returned to the pharmacy for reuse or safe disposal. Pharmacies may seek the assistance of the suppliers of the drugs and chemicals. The prospect of unauthorised people selling unused or expired drugs makes the need for strict security much greater.

- Containers, particularly bottles, pose a risk if they are not fully cleaned and disinfected after being used to hold chemicals or infected samples. Patients are often required to bring bottles with them so recycled bottles are often for sale outside hospitals and medical centres.
- Radioactive material is another cause for concern because people handling such material may not be aware of the risks. It may be satisfactory to incinerate or bury low level solid wastes (such as discarded protective clothing - which again has a resale value), but medium and high level wastes need specialist attention. Radioactive liquid wastes should not be flushed down drains without confirming with specialists that such a practice is acceptable.

d) Less hazardous wastes Other clinical waste which is less hazardous to health, if it cannot be incinerated, should be disposed of in landfills in a such way that access by any person or animal is denied. To achieve this a pit may be dug within the garbage fill and the waste deposited in it and then covered fresh garbage that will be filled as the next layer.

e) Code of practice In view of the importance and responsibility to be exercised in disposing the hospital waste, mere recommendations or instructions from time to time from the governing authority to the implementing authority will not solve the problem. To ensure improvements it is necessary to implement a code of practice which defines the individual in each hospital or health centre who is responsible, and imposes legal penalties on defaulters. One method of instilling a sense of responsibility in ward staff is to insist that every bag or container of waste is marked with a label to show which ward it has come from; if this is done then any failure to comply with mandatory procedures (such as a loose needle and syringe in a bag) can be traced back to the person responsible.

f) Monitoring The monitoring authority as well as the authority responsible for the management of hospital waste should be identified by means of legislation empowering the monitoring authority to initiate legal action under the criminal law against any defaulter. There are agencies like the State Pollution Control Boards, State Health Authorities and Local Body Health Authorities which are capable of monitoring the safe disposal of the waste under Pollution Control Acts, the Environment Protection Act 1986 (E.P. Act, 1986) and the Public Health Act, but which could not monitor hospital waste effectively due to the lack of legislative powers. Laws should be enacted empowering the monitoring authorities to initiate action against a defaulter, - the one person being designated as responsible for safe disposal of waste in every hospital.

g) Training Even though doctors are well aware of the importance of safe disposal of wastes, the system outlined above would not work unless effective training and guidance is given to the lower levels of staff. In fact the same opinion was also expressed by doctors. Therefore it is necessary to conduct training and refresher courses periodically for all medical and paramedical staff including doctors and unskilled manual workers, and all grades in between, Doctors, nurses and administrators need to be kept informed about the latest developments in hospital waste management and the legal implications in case of failure to discharge their duties of safe collection, transportation and disposal of hospital waste. Other staff, such as orderlies, cleaning staff and porters need to understand precisely how they should handle all types of waste, and should be supervised to ensure that they play their part effectively and conscientiously. If the waste must be transported away from the hospital premises, and treated and disposed elsewhere, this should be done by a special team of trained workers under strict supervision.

This being said, the crucial factor is motivation - how to make the individuals in every link of the chain **want** to protect the community and the environment from hazardous hospital wastes.

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Chapter G-1

The reluctant managers

Based on investigations by Dr S P Kulkarni,
T K Raveendran and Miss Dhanjyoti Mukhia

We, the unwilling,
led by the unknowing
are doing the impossible
for the ungrateful
(part of a lament found on office walls and noticeboards in England)

G-1.1 IS THERE A PROBLEM?

This chapter is concerned with the plight of the solid waste management engineer in India. The motivation for including this chapter, and the observations included herein, have come from contact with a very small sample of people, and so it is not possible for the authors to make general statements for the whole of India. However, it is very probable that some of the observations are true about the situation in many of the larger cities. Nevertheless, the chapter starts with a number of questions, and if the answer to all of them is "yes", the reader is advised to spend his or her time on something more relevant - this chapter is only for readers who must answer in the negative to at least one of these questions.

◊ Does the solid waste management organisation operate according to the principle that the workforce (including the engineers) are its most valuable resource?

◊ Could most of the engineers and managers within the solid waste management section be described as well-trained and experienced in the many aspects of this subject?

◊ Are most or all of the solid waste management engineers working in this field because they have deliberately chosen to do so?

◊ When given the opportunity to transfer to another section, do most municipal engineers prefer to stay within solid waste management (provided this does not mean sacrificing promotion)?

If the reader must answer "no" to one or more of these questions, then there may be an idea or suggestion in this short chapter to indicate the way to making an improvement.

Why does it matter if engineers are reluctant to work in solid waste management?

(Please note: The masculine pronouns "he", "him" and "his" are used as a shorthand to refer to both male and female managers. Women are taking senior management responsibilities in the solid waste management industries of many industrialised countries, and the shorthand use of the masculine pronouns is not intended to suggest that this field of management should be dominated by men.)

Most people deliver their best work if they are enthusiastic about what they are doing. A reluctant manager is more concerned to find ways of arranging a transfer to another responsibility than to develop his skills and work in the best way possible. Enthusiasm is a vital quality for good leadership, and leadership is an important part of the solid waste manager's job because large workforces are involved. A relatively long-term commitment is necessary to encourage the manager to put in the necessary effort to increase his knowledge of the tasks facing him, since very little of the necessary knowledge would have been acquired during a university course. For all these reasons, reluctant managers cannot be as good as committed managers.

Why is solid waste management viewed unfavourably?

(These comments are based on interviews conducted with engineers currently and previously involved in waste management, and on observations.)

There are many answers to this question - some are obvious and some more subtle. Nothing can be done about some of the reasons, but definite action can be taken about others.

Some of the more obvious reasons why engineers seek to avoid solid waste management are that:

◊ Solid wastes are unpleasant and potentially hazardous to health, and this is widely understood by all of the community. (In contrast, wastewater is more unpleasant and hazardous, but since the general public are less aware of it, and are less likely to see wastewater engineering in practice, it may excite less antipathy in the public mind.)

◊ The manual collection of solid waste is associated with the lower socio-economic strata, and so the whole operation is viewed in a negative way as a result.

◊ Solid waste management is rarely taught in university courses at anything more than a very superficial level, and so it may be seen as an activity which is not really engineering, and less than professional. (In fact it is a challenging and multi-faceted subject, as shown by the failures around the world, and the growth of the solid waste management industry in the industrialised world.)

◊ To many people solid waste management is a simple business. This is partly because many refuse collection operations are in the full view of the public. Members of the public often regard themselves as experts in the subject, not realising the technical and management challenges that it poses. This gives them a low opinion of the discipline of solid waste management.

It is possible to do something about some of the other reasons. Amongst these reasons for the unpopularity of waste management as a career are:

- Senior municipal managers may have, and transmit ,a low impression about waste management. Some engineers complained that solid waste management seemed to be given the lowest priority in terms of allocation of funds, provision of staff housing, and staff recruitment. In one case that was investigated, overtime payments were not made to engineers except at the lowest grade, with the result that drivers who worked overtime could earn more than engineers with a university training, also working many hours of overtime themselves.
- The working conditions of professionals in the solid waste management sector may be worse than in other engineering disciplines. For example:
  - ⇒ Staff may be required to work long and unpopular hours. Refuse collection operations often start early in the morning, often well before office workers think about leaving their beds. In congested cities it is often necessary to operate three shift working, 24 hours a day. A good manager will feel obliged to be familiar with all aspects of the operations for which he is responsible, and so this will require working for long hours and at unpopular times.
  - ⇒ Any solid waste collection and disposal operation must be prepared to receive complaints. The complaints may be the result of shortcomings of the staff, action by the public, unavoidable mechanical problems, inadequate resources, or even weather conditions. Many organisations have developed offices to handle complaints, and give a high priority to taking action on these complaints and informing the public about what has been done. However in some countries - and India may be one of them - the residence telephone numbers of solid waste managers are available to the public, and senior municipal officials and representatives are in the habit of contacting waste management and transport engineers at any time, at their homes or offices, about something which could be handled in another way, through a more formal procedure. Such phone calls, coming at night or early in the morning, add to the stress of the job, and so make it less acceptable.
  - ⇒ Solid waste management is a labour-intensive industry and often heavily involved with labour unions. These two factors combine to make the task of managing the labourers difficult and time consuming. Comparisons, presented in earlier chapters, between the salaries of municipal labourers and those in the private sector testify to the strength of the unions and the struggles with municipal authorities that they have won. The working hours of municipal labourers are also much less than those in the private sector, again suggesting that there have been many industrial conflicts and strikes. Engineers, often at quite a junior level, are often the first point of contact when a dispute arises - or, to use more confrontational language, the front line of the management side. Often they are not equipped to handle such situations. The theoretical training that an engineer receives makes him familiar with mathematics and machines, but not with conflict resolution. This is another reason why engineers may seek to avoid solid waste management. (This is not an argument for employing medical doctors for managing waste collection and disposal, as is the practice in some places - an engineer with experience on a construction site is more qualified to handle labourers than a medical doctor - apart from the technical aspects. The point is that any

science or technology graduate has not learned skills of negotiation from his university course.)

⇒ The physical working environment may be unpleasant. An engineer required to work on a dump site may find himself in an atmosphere of smoke, dust and odours until he is able to effect improvements. Mechanical engineers may find themselves in old and poorly equipped workshops and garages, perhaps without the necessary facilities and equipment.

- Transport is a major component of solid waste management. This is emphasised in Mumbai by the fact that all municipal transport is under the Solid Waste Management Department. Mechanical engineers may feel frustrated by problems such as bureaucratic procedures regarding the procurement of spare parts, and by the difficulties of maintaining a wide variety of complex vehicles. If some of these vehicles were purchased against the advice of the engineer, or without referral to him, he is likely to feel even more frustrated and discouraged.
- Engineers complained that they were required to spend too much time on paperwork. They may begrudge the time they need to spend on routine form-filling that could be done by a clerk, and the effort devoted to the writing of reports that no-one seems to read.
- The lack of training was mentioned as another problem; new machinery was acquired but no training was provided concerning how to maintain it.

Having defined the problem, and reviewed briefly some of the reasons why engineers try to avoid solid waste management, it is necessary to identify possible solutions.

G-1.2 WHAT CAN BE DONE?

Perhaps the first step should be to make a more thorough investigation of the situation, to see if the factors suggested by this very introductory investigation are indeed significant. Such a study would have to be conducted with a high degree of anonymity, so that engineers and managers would feel free to speak openly and honestly, and might be conducted by graduate students at a college of management. Such a study might be helpful in convincing top management that action should be taken, and in suggesting the steps that should be taken.

It could be beneficial for some senior executives to study the waste management industries in a number of other countries. In some European nations and in the USA, waste management is one of the major industrial sectors. The majority of professional staff in this field are probably happy to consider that they will be working in solid waste management for the rest of their careers. There are professional associations dedicated to solid waste management. There are conferences and exhibitions. The majority of solid waste management professionals in many such countries are working in the private sector; it would be useful to investigate whether the public sector is able to provide working conditions similar to those offered by large private sector organisations in such countries.

At first, the subject area of greatest need is engineering - engineers are needed both to operate and maintain machinery and to construct landfills. As the industry develops there will be growing needs for geologists for landfill location and design, chemists for hazardous waste management, social scientists for creating more public awareness, economists, general environmentalists and even marketing specialists. However, in this chapter the term "engineer" will be used to represent any professional specialisation.

In seeking to suggest solutions, first some general aspects will be considered, and then more specific points.

A key objective is that engineers should want to devote all, or a large part, of their working lives to solid waste management. This may seem like an impossible aim, but with a combination of incentives, support and motivation it may be possible.

Incentives may be seen as a way of catching the engineer's interest. The most obvious incentive is pay. Compared to the solid waste management budget, or even the money that can be saved by good management, the pay of the engineer is tiny. If it is not possible to pay at a higher basic rate, there should be a special allowance payable. The pay and benefits package should be attractive in comparison with what is offered by the private sector. Apart from the value of the money itself, a person's salary is a statement of the value the organisation attaches to the individual. Other incentives include the provision of attractive housing and a car. A volunteer soldier is better than a forced conscript.

Support takes many forms, and mostly comes from senior officers. One of the major problems faced by many waste management engineers is managing the labour force. In this task they need support in terms of training and advice in labour relations and conflict resolution, but they also need the active support and involvement of their superiors during times of crisis, such as when a strike is threatened. It has been suggested that labour officers should be more involved in labour disputes, leaving the engineers to spend more time and energy on the technical matters for which they have been trained.

Support can be provided by a superior only if he knows how to provide that support. Many senior personnel, never having had this kind of support themselves, will need to learn how to support their subordinates, and so effective management training may be needed at a high level.

Support includes training. Training should aim to impart skills as well as knowledge. Training will be received more effectively by someone who knows that he will need the benefits of the training over a period of many years (rather than someone who is hoping to be transferred to a different posting very soon), and practical training is best given by someone with many years of experience, so for both reasons it is important to attract engineers to make a career in waste management. Training should be closely related to the needs of the job and to the actual working situation - many courses seem to be very general and theoretical. In addition to developing skills, training can also increase confidence and communication skills, which are essential if an engineer is to convince a senior decision-maker concerning a technical decision.

Motivation is the heart of the issue. Staff can be motivated to some extent by money and fear, but job satisfaction and the best results are obtained when a person is working *because he believes in the importance of what he is doing, and that he is able to do the work well.* Some of the ways that the importance of a staff member's contribution can be communicated are:-

◊ Helping the engineer to appreciate the health, social and environmental benefits of good solid waste management;

◊ Expressions of appreciation from superiors;

◊ Clear and (when possible) positive reactions to reports and suggestions;

◊ The gradual giving of responsibility, as the ability of the individual to take such responsibility develops. Responsibility is a two sided coin - one side is authority to take decisions, and the other side is appreciation or blame for the results of these decisions. It might be useful for municipal corporations to review the authority that they give to their professionals - often the authority invested in managers of a certain rank is quoted as the amount of money they can spend, and these amounts may be very small in relation to the work they must do. Expenditures should always be accounted for and should be scrutinised at intervals, but the authority to make decisions on spending should be increased in many cases. It is useful to consider the costs involved in keeping a refuse collection vehicle in the garage when it is needed on the streets, and to use this as a guide to the authority that a garage manager should have. Delegation of authority means that people must be allowed to make mistakes; when a mistake is made guidance should be provided so that the same mistake is not made twice. Mistakes are virtually inevitable. Even senior decision-makers make mistakes from time to time.

◊ Input into decisions A clear way of showing appreciation for the skills of the engineer is to invite him to participate in decisions which are related to his competency and experience. It is not enough to have a token engineer on a committee for specifying or selecting equipment, it is important that the committee have the benefit of practical knowledge of the equipment under consideration. Operations and maintenance engineers should have the opportunity of evaluating the equipment under consideration before the decision is made. Real weight should be given to the technical considerations presented by the engineer. In this way the engineer will understand that his contribution and skills are valued by the organisation he works for.

Other points

- It would be useful to review the official telephone calls that are received by engineers and managers in their homes outside office hours, and also those received in the office during working hours, to determine whether an unnecessary burden could be removed from managers by routing complaints to a special department, and by managing requests for transport from senior officials in a more efficient way. It may be possible to protect managers from many official calls at their residences by employing a duty officer to take calls and meet emergency transport needs outside normal office hours, or to provide managers with answering machines.
- Consideration should be given to the physical environment in which managers are working. Two particular aspects of this are waste disposal and maintenance facilities.
  - ⇒ An uncontrolled dump cannot be turned into a sanitary landfill without the on-the-spot guidance of a trained engineer or technician. However, because the environment at a dump site is so unpleasant, no engineer wants to work there. This situation has two results - one is that the dump is not improved, and the other is that large sums of money are spent (and mostly wasted) on expensive and unsuccessful alternatives to land disposal. One solution may be to provide an acceptable working environment for the engineer, such as an air-conditioned office (necessary since natural ventilation is not possible on a dump site because of the dust and flies) and an air-conditioned off-road vehicle.
  - ⇒ Careful attention should be paid to the requests for equipment from maintenance engineers. It may be possible to reduce the time required for certain maintenance tasks, and therefore achieve higher availabilities for the refuse collection vehicles, by providing basic equipment such as an overhead crane or an item of testing equipment.
- Time spent on paperwork and meetings often seems to be time wasted. It is important to have a clear concept of the purpose of each bureaucratic procedure, and the lowest level at which it can be performed. Requirements for form-filling and reporting should be reviewed periodically in order to check whether the information that is being provided is really needed and used. Part D mentions some of the reports and records that are part of a good solid waste management operations and maintenance section, and it also contains suggestions as to how recording systems could be simplified to reduce repetition and improve management effectiveness. It is always a great encouragement to a report writer to know that his report has been read, and to receive comments and suggestions. If there is no feedback concerning reports and records, it seems to be a waste of time to prepare them, and demoralisation sets in..
- Job descriptions are a useful management tool if used well. A thorough review of the tasks and responsibilities of managers, and the preparation of agreed job descriptions, can increase the effectiveness of professional staff, provided that the job description is seen as a tool to be used rather that a piece of paper to be filed.

Fortunately, India already has some solid waste management enthusiasts - people who see the existing and potential problems caused by solid wastes, people who know what can be done, and who want to do something to change the situation. If some of the recommendations of this chapter are carried out, there could be more of these people. As the number grows, so will the need for a mechanism for sharing news and information. There will be a need for an association of solid waste management, which would serve to encourage professionals to develop their expertise, by providing opportunities for meeting and sharing experiences and information. Such a body would benefit from links with organisations such as the International Solid Wastes Association - which currently is mostly involved with the North America, Japan and Europe, but which is concerned to be more involved with countries that are economically less developed. A newsletter, which could later grow into a journal, would also be a vehicle for disseminating ideas and information; in its early days it would need a sponsor since subscription income from a relatively small number of subscribers would not be sufficient to make it financially self-sustaining. If these recommendations are taken up, and an association is formed, it would not only improve the flow of information, but it would help to promote the concept of the solid waste management specialist as a motivated and fulfilled professional rather than as an unfortunate engineer who is obliged to serve a short length of time in the post that nobody wanted.

Chapter G-2

Non-Governmental Organisations and waste management

Most of this chapter is based on information collected by R P Pal, B B Uppal and V P Rao; section G-2.6 is based on the investigations of Jaiwanti Sheokand, S Chatterjee and A K Gurung

The purpose of this chapter is observe how a small number of non-governmental organisations developed their roles to include solid waste management. The aim is not to advertise or promote any particular organisation and so the names of the organisations will not be given. The abbreviation "NGO" will be used throughout to refer to the organisations under consideration, some of which might be more accurately referred to as community based organisations or voluntary agencies.

G-2.1 CASE 1 A WOMEN'S ORGANISATION IN AHMEDABAD

This organisation has been described as a trade union of retrenched women - women who had been working in the textile industry. It was started in 1972 and subsequently expanded its activities into the co-operative movement, promoting women-oriented entrepreneurship. It organised support services for self-employed women from amongst the rural and urban poor, in the fields of banking, social security, insurance, health care, legal aid, skills training, literacy and other aspects of awareness. The activities of the group spread to surrounding towns and even a neighbouring state. Membership was broad-based, including many from slum communities, mainly manual workers and hawkers. In 1993 there were 54,236 members.

This NGO had organised a hitherto unco-ordinated and exploited sector of poor women and children into an effective informal sector group. Together they had provided health education, and campaigned against exploitation by middlemen and for a higher degree of acceptance by the government, by society and by other service organisations.

The chairperson of this organisation was a member of the National Council of States. The NGO had an established office in the heart of the city, where both bureaucratic and field work were handled. It had been negotiating various issues directly with the highest executives of both the State and National Governments.

The **mission** of the organisation was

a) to provide a labour union for unorganised women workers,

b) to set up co-operatives for women workers, and

c) to provide support services to them in banking, legal aid, health insurance, negotiation with Government etc.

In the field of solid waste management, the organisation had taken up the cause of rag-pickers, organising them into registered co-operative societies, in order

- to prevent their exploitation by middlemen,
- to bring them within the reach of labour laws, and
- to protect them from harassment by civic authorities.

They were seeking to oppose the public perception of rag-pickers as a nuisance, to give them some power over their own work and income, and to win for them recognition as a significant force in the local economy.

This NGO also has an environmental component to its mission because it was involved in promoting improvements in the sanitation and general environment of slum dwellers and other poor inhabitants.

Method of operation The organisation recruited rag-pickers through its existing workforce in the slums and poor localities. The advantages of joining the organisation were explained to potential recruits by existing members. Rag-pickers who wished to join were then provided with large sacks, protective equipment and identity cards by the organisation. (The identity card helped to reduce police harassment.) They then would go to the roadside community bins as well as to the disposal sites to pick up recyclables. The rag-pickers took their wastes to godowns where their collections were weighed and kept for ultimate sale as feed stock to industries; in this way exploitation by middlemen was avoided. The rag-pickers were paid cash according to the weight of the material they had collected. Average daily earnings of rag-pickers in this system were said to be Rs 30 to 35 as compared to the Rs 12 to 15 that was commonly paid by middlemen.

Some of the organisation's rag-pickers had been deputed to households which were segregating their refuse into non-degradable recyclables and biodegradable components. They were also integrated with segregation schemes launched by other NGOs. This approach (household segregation) has liberated members from unhygienic manual sorting work at mixed garbage heaps and, at the same time, reduced their actual working hours dramatically. Rag-pickers involved with such schemes were now free to engage in additional alternative occupations to increase their income, and more opportunities are anticipated as more schemes for the source segregation of domestic waste take wings.

The NGO had been filling in tender forms on behalf of rag-pickers to enable them to bid for the disposal of used government stationery. It had been considering the setting up of a waste paper recycling plan similar to a scheme in Himachal Pradesh, such that it could be run by the rag-pickers' co-operatives.

Since 1981, sixty-five co-operatives of rag-pickers had been set up. Five thousand large collection bags had been distributed to member rag-pickers. (Each bag costs around one hundred rupees.) It was actively considering approaching institutions like banks and service organisations such as the local Rotarian and Lions clubs, to ask for sponsorship of more collection sacks for the rag-pickers.

It had also been distributing collection equipment to its member rag-pickers, some of which however was not favoured by the rag-pickers, due to its design. For example, after consultation with rag-pickers it was determined that one of the tools given out - a bamboo stick with a long pin at one end - would need modification.

At the time of the study this NGO had not yet launched any awareness programme amongst slum households for segregation of domestic refuse, nor had it approached the local bodies to promote a policy directive to households oblige them to segregate domestic waste for recycling. There had been no training programme for member rag-pickers to help them improve their work practices in terms of efficiency and hygiene.

Evaluation Two rag-pickers, who were registered members, were interviewed. They spoke well of the organisational support they received, and they appeared clean and conscientious. Two women from a slum spoke favourably about the organisational support they were receiving from the NGO. An official admitted that a lot more had still to be done regarding awareness programmes about solid waste management in the slum communities. Though the organisation had done considerable work in the fields of low cost sanitation, health care programmes and financing of self employment, there seemed to be more scope for strengthening the rag-pickers co-operatives in terms of better training, better equipment and better marketing of their products. The relationship between the NGO and the local Municipal Corporation was in need of positive joint efforts rather than the existing state of passive tolerance. The Corporation's scheme of assistance to private primary refuse collectors had not been taken up by the NGO for its rag-pickers.

Conclusions and future needs The organisation was broad-based and committed to assisting poor women in both urban and rural areas. It had not yet given high priority to programmes of solid waste management, but the involvement may increase as the role of the private sector is expanded. Its training and awareness inputs in connection with solid waste management had been low, as compared to other inputs on self employment, entrepreneurship and opposition to social evils. The management of domestic solid waste in slum households needed sustained training and education inputs - this organisation had a sufficient infrastructure to provide these inputs, but had yet to get seriously involved. It could move into a number of aspects of solid waste management, such as the private cleaning of slum roads and recreation zones, by dovetailing its own assistance with the efforts of the Corporation. (For example, some slum areas did not have community bins on the main roads. The NGO has good leverage with the local body and the Government, but its intervention on such small but crucial issues was found lacking.) Rag-pickers could be assisted by the NGO with, say, tricycles for primary collection in localities where households were ready to make nominal contributions. This was in their plan, yet to be launched.

The rag-pickers from slums needed to organise collection of recyclables from the rich and medium-income localities of the city. The organisation had the standing to seek the support of the rich and high income colonies for the rag-pickers, and so it was suggested that it should launch an action programme towards this end, without delay.

G-2.2 CASE 2 A RELIGIOUS ORGANISATION IN AHMEDABAD

This particular NGO was linked to a minority religion; the same foundation was also running a school. It was receiving financial support from overseas, but none from the local Municipality.

The organisation had 27 committed members which included lawyers, teachers, doctors and health workers. It was reaching poor slum dwellers through facilitators drawn from the slum who were paid some compensation as a token of appreciation by the Society. There were 25 trained slum dwellers working as health workers. The volunteers were basically ex students of the associated school.

Objectives The organisation aimed to have a holistic approach to urban development of slum communities. Its work was segmented into four inter-related parts, as follows:

a) Organisation To develop union associations, leadership and pressure groups.

b) Education Non-formal classes, sewing classes, a legal aid service and public awareness-raising about rights and how to achieve them.

c) Health and sanitation The Community Health Improvement Programme (CHIP) was both preventive and curative; public hygiene programmes were organised in slums and designed according to the habits and habitat. The importance of safe drinking water and toilet facilities were stressed. The residents were advised to contact the Municipal Corporation or a loan agency for funding for sanitary improvements. Doctors and nurses visited these sites for ante- and post-natal health care check-ups.

d) Environment Slum dwellers were instructed about the use of smokeless chullahs (burners), cookers, sanitation, plantations and herbal medicine.

Solid Waste Management was not considered as a subject on its own, rather it was being promoted through informal education in sanitation, hygiene and environmental development. The NGO did not aim to do more since it considered that it did not have sufficient resources, in comparison with the Municipality. Anyone interested in household segregation of waste or recycling was advised to contact another NGO.

Method of working Specialists were running training sessions. In some matters slum residents were encouraged to contact Corporation officers, or Corporation officials were invited to the slums. A variety of public awareness media had been used. Volunteers were trained at intensive training programmes (camps) and then these volunteers would organise late night meetings for slum dwellers.

Since the Municipality did not provide civic services in the particular slum, the NGO had arranged for sweepers to serve the community privately on payment of some amount on a weekly basis, and also in kind. However, the system was failing due to the absence of municipal bins for storage of waste at an identified site. Solid waste was being dumped in an open space along the road where children were playing and since it was not being removed by the municipality, this area was becoming just like an open dumping ground. The streets had not been swept, but soon after the arrival of the team of investigators municipal sweepers started to clean the area. (This may have been a special provision by the Municipality because of the visit of the investigators, or it may have signified that sweepers had been deputed to the area but that supervision was inadequate.)

An adjoining slum colony had no arrangement for waste disposal; in that area people were throwing their wastewater and refuse into a river. No social worker was visiting this area. In another area people were throwing solid waste into a public toilet. The Municipal Corporation was not providing a sufficient service, but the residents were also not doing what they could to help.

Evaluation The work of this NGO covered a much wider scope than solid waste management, and so should not be evaluated only on the basis of the impacts in this field. Clearly the benefits of its work relating to waste management were seriously reduced by the failure of the municipality to remove the waste that had been collected by the NGO's sweepers. There were other environmental and health problems in the area, particularly relating to the condition of the public toilets. The work of this NGO was evaluated periodically by the foreign organisations that provided some of its funding.

G-2.3 CASE 3 A GOOD MODEL BUT BAD POLITICS, AHMEDABAD

This is the case of an NGO that started well, made some good progress, but was killed by the opposition of a politician.

The organisation was registered in 1978 with 30 members from the local community and 20 professionals. It was concerned with both urban and rural communities, and with men, women and children.

Objectives This NGO aimed to operate at two levels to improve living conditions - (i) working in the slum communities, and (ii) planning and research to develop a model for finance generation and administration within the slums. It was concerned with sanitation, health care and housing improvements.

Method of working Slum communities were divided into units of 100 families. The approach was summarised by four features:

S Supervision, done by women from the community (30 from each unit)

I Incentive - a salary for sanitation workers, partly from a levy of Rs2/- per family per month

T Training at a sanitation training school

E Equipment - tools were provided to sanitation workers.

The responsibilities of the sanitation workers included toilet cleaning, solid waste collection, spreading of insecticide and maintenance of water supply taps. Half of the salaries of the sanitation workers was paid from the community levy, and half by the NGO. Later the municipal corporation adopted the scheme and paid the 50 % contribution for a second scheme.

Evaluation A criterion by which the programme was evaluated was the impact on children's health, and this indicator showed the work to be a success. The model for financial administration seemed to work well and the municipal corporation showed its support with a financial contribution.

The downfall The scheme was killed by opposition and accusations from the incumbent (sitting) political member. The first mistake by the NGO seems to have been an invitation to a senior political figure from a different faction of the incumbent's own party. The second seems to have been that a leading member of the NGO became too prominent within the community and was perceived as a threat to the incumbent member.

Postscript The history of this NGO may have been more complex than this brief treatment suggests - political power struggles often are very complex and screened, so that it is very difficult to find out exactly what happened. It is to be hoped that the lessons learned by the community from this particular NGO have lived longer than the NGO itself.

G-2.4 CASE 4 THE NGO WITH THE NAME OF A COMPANY, IN AHMEDABAD

This organisation was headed by a businessman and some non-resident Indians of USA, and was drawing on the skills of engineers and technocrats. It had been started less than a year before this survey was undertaken.

Objectives The group was a social service organisation providing a wide range of services to the community. It was involved in the following activities:

- Legal aid to the community against harassment by civic and taxation authorities.
- Water conservation through the use of wells for recharging underground aquifers. It was proposed to segregate domestic sullage from sanitary sewage and allow the sullage to infiltrate from pits. In addition to continuous recharging of groundwater this practice would also reduce the load on the sewerage systems.
- Segregation of refuse in primary collection. The segregation of wet and dry solid waste was being promoted at household level to reduce the volume and weight of domestic solid waste reaching the community bins and landfill sites. The aims were expressed as
  - ⇒ *Zero garbage on road* - all domestic waste collected house -to-house in plastic bags, and no street waste, and
  - ⇒ *Zero landfill operation* - all waste reused or recycled in some way so that there was no need for a landfill. This objective was seen as the way to minimise the environmental problems caused by solid waste and to provide an opportunity of income generation for the poor.

Method of Operation To achieve the solid waste management objectives there were two approaches - a public awareness campaign and a pilot scheme to encourage segregation of recyclable materials at household level.

The awareness message was proclaimed from hoardings, posters, handbills and advertisements, and use was made of TV and children's painting competitions. Social gatherings of Rotary, Lions and other clubs were used to propagate the message.

Two types of plastic bags - one for the household and other for community storage of dry refuse - were distributed to the community for facilitating impersonal collection by a rag picker. The rag-pickers collected the recyclables from these bags and the green waste (or wet waste, including kitchen waste) was transferred to the community bins by the residents. This early removal of recyclables from the waste stream reduced the volume of waste, but also facilitated the work of rag-pickers, so that they could collect all the recyclables from a given area in a much shorter time than was needed when they had to separate these items from mixed waste. A further result was that their work became much cleaner, so that they claimed that incidences of sickness had reduced since the advent of the new system.

Around 20,000 bags had been sponsored by the State Bank of India Employees Association and other organisations out of which more than 5000 had been distributed at the time of the investigation. Both types of bags were intended to be reused till they were worn out. Though the bags had been distributed free of charge in the first instance, residents would be asked to pay Rs 5 or 6 for subsequent bags. Since system was appreciated by the public, institutions were coming forward to sponsor more and more bags and industries like BPL also offered support for the programme.

A number of study groups had been set up to investigate particular aspects of solid waste management and make recommendations for future programmes. The topics for the different groups were:

- Clinical waste
- Public awareness
- Trained volunteers
- Resources and fund raising
- Media development
- Co-ordination with the local body and other NGO's

Evaluation Discussions with a small number of residents and rag-pickers indicated satisfaction with the new arrangements. Two rag-pickers who were interviewed expressed their pleasure at the new procedures because they no longer needed to put their hands into dirty garbage. Both women showed their hands as a gesture to indicate that they were so clean. Their general cleanliness level had improved. The locations where the new bag system was in operation appeared clean. Very little recyclable material was seen around the community bins.

Other points to note

- The proposal to crush or macerate the green garbage and send it down the sewers was rejected as inappropriate in the Indian context as it would increase the load on wastewater treatment plants and perhaps cause blockages in sewers..
- Availability of funds was not seen as a constraint because of the large number of willing sponsors.

Anticipated developments The co-operation of another NGO in the same city was being sought for propagating the messages of this programme This readiness to work with other NGOs and avoid duplication was seen as a very positive point.

Since this system had only been adopted amongst only a fraction of the total population in low, middle and high income sectors, and was still in the early stages, it would be a challenging task to introduce the same approach in the slums where more than 40% of the city's population was residing.

G-2. 5 GENERAL OBSERVATIONS FROM AHMEDABAD

Observations concerning interviews for data collection Many slum residents do not give a true picture of conditions or needs or the services rendered by government. It would be appropriate to contact each group - men, women, children, politicians etc. - separately.

- Politicians have their own versions and interpretations - which may be very different from those of others;
- Men usually do not remain at home hence they may not give an accurate picture of some aspects of the life of the community;
- Women and children generally comment without bias. NGO workers may tend to exaggerate but housewives and children are less likely to do so. They may be prepared to speak the truth when alone, whereas if they are in group they may say something else.
- Generally slum dwellers appear to want everything from government. Even if they are prepared to participate, their leaders may not allow them to say so because the leaders want free services from government.

G-2.6 NON-GOVERNMENTAL ORGANISATIONS IN MUMBAI

The problem of solid waste management is so big that all available help is needed, so the inputs of NGOs - however small - should not be despised. In 1995 it appeared that non-governmental organisations in Mumbai had not played a major role in solid waste management in that city, but the examples mentioned below indicate that they have made impacts in a number of different ways, helping small groups of people and initiating socially orientated pilot projects.

a) Examples of NGOs in Mumbai

1. One NGO that had been working in Mumbai for the previous twenty years had been concerned with slum dwellers living in inadequate housing near the main disposal site. Most of the inhabitants of these slums worked as rag-pickers. (It was estimated that there were about 50 000 rag-pickers in Mumbai, recycling 10% of the waste, with no formal link to the MCGM.) Rag-pickers are generally very poor, illiterate, and unaware of the risks posed by waste. This NGO encouraged them to form a group, organised health camps and provided some educational opportunities.
2. Another, sponsored by the Rotary Clubs of Mumbai and Toronto, was one year old at the time of the survey. Its basic objective was to train street children who were at least 14 years old in business skills. Rag-pickers were also encouraged to get a better deal from traders. In total thirty NGOs in Mumbai were involved in this project. They selected the children who would receive training. Rag-pickers can do little during four months of monsoon, so the NGO proposed that

MCGM should provide storage facilities to help rag-pickers during the monsoon period. There was also a plan to study the economics of recycling activities.

3. Another NGO, with a focus on youth, had been trying to promote recycling by encouraging residents of an affluent part of Mumbai to separate recyclables from wet waste, so that the recyclables could be collected separately from the wet waste (which would continue to be picked up by municipal vehicles in the normal way). At the time of the survey the scheme did not appear very successful because of the lack of co-operation of the residents. The organisation was considering trying to improve participation by running a summer environmental school for students from two prestigious local schools. The programme would seek to promote separation in the household as well as wider environmental issues, with a view to encouraging them to propagate these ideas. They also planned to use cable TV to motivate the public.
4. Another began work by organising the cleaning of a slum community, converting a dumping site into a playground and providing 160 toilets. The residents were involved in cleaning their surroundings. This work was stopped because of lack of funds. This same NGO switched its attention to cleaning up a very popular sea beach, where large numbers of people congregate every evening for recreational purposes. The Municipality was approached for financial assistance, and they suggested that the owners of the hotels alongside the beach might provide the necessary cash. Fifteen hotels agreed, and supported the work for four months. The beach was cleaned and maintained by 40 workers from slum communities, working two shifts. The Municipality provided tractors and trailers to transport the waste that was collected in this way. After four months, the support from the hotels began to dry up and the beach returned to its previous littered state. Under public pressure the NGO renewed its efforts to find funding, and obtained permission from the Municipality to generate some of the necessary finance from advertising hoardings. The success of this scheme led to the start of a similar operation at another beach not far away, this time with financial support from local residents. Since much of the waste is derived from hawkers and restaurants, the NGO is arguing that there should be effective legislation to ensure the provision of containers for waste and to punish traders who leave waste on the beaches.
5. Another organisation that was contacted was concerned to improve the appearance of the city by planting trees within the urban area and running environmental education programmes for teachers and schoolchildren.

b) Suggestions based on these investigations:

- The Municipality should be more proactive in encouraging the involvement of NGOs in solid waste management, and have clear policies regarding their attitudes to NGOs.
- Municipalities should co-ordinate the work of NGOs by organising periodical meetings and keeping up-to-date lists of contact persons and telephone numbers, and the field of activity of each NGO. Co-ordination between NGOs and Municipalities should be at the Ward level.
- The Municipality could seek to develop ways of improving recycling and provide back-up support (such as transport).
- NGOs need to have good links with both elected and official members of Municipal Corporations.
- Both NGOs and Municipalities need to be flexible and prepared to modify strategies according to experience.
- Citizens have a great inherent potential to improve their own situations; this potential should be recognised and encouraged.
- Municipalities and NGOs should co-operate in environmental education programmes.
- The good work done by NGOs should be publicly acknowledged, since appreciation is a great encourager.
- The experiences and fortunes of NGOs should be studied and recorded, so that current organisations can learn from successes and failures.

G-2.7 CONCLUSIONS

General conclusions

The size of the sample of NGOs and the shortness of the investigation period does not allow the drawing of firm conclusions, but some tentative conclusions are suggested. It would be useful to bear these observations in mind when conducting further investigations or making plans for NGO involvement.

a) Solid waste management is a new area for some organisations, so it cannot be expected that a well tried and tested programme of waste collection or recycling will be found wherever an NGO is working. Some schemes may be at a very rudimentary stage.

b) It is likely that there is a need for information dissemination amongst NGOs in India. Many organisations may be setting out to do similar things in different slum communities and in different cities, and making mistakes and learning as they go, unaware of others that have already gone through the same processes and who would be able to help by sharing the benefits of their experience. It is not known what channels of communication exist between NGOs throughout India, but it is likely that there is a need for better communication and sharing of ideas and experiences.

c) NGOs cannot do everything themselves, but they can form a very useful interface with the outside world, helping where literacy is lacking, liaising with the municipal authorities, and making financial and contractual arrangements.

d) Care should be taken when replacing a well-tried component in business arrangements, such as the scrap middleman (or dealer in recyclable material). These middlemen are usually characterised as greedy, taking excessive profits, but in some cases they do exercise considerable expertise in finding markets and knowing what quality of material and what degree of sorting and processing of scrap (or recycled) material is necessary to get the best price. If an NGO takes over their trade, one must expect some opposition and obstruction from displaced middlemen as they try to win back their business. Finally, the trading arrangements that replace the middleman should be sustainable - if the system only works with the aid of considerable external resources supplied by the NGO, there may be serious problems if the NGO removes its support or changes its emphasis.

e) Political factors must always be kept in mind. Some individuals may get involved in NGO development work to win a following and ensure a grateful block of voters when elections come. Others who do not have political ambitions may be opposed by those who do, if the would-be politicians fear that the affections of the voters are being won by the NGO staff.

f) As slum-dwellers become accustomed to NGOs providing for some of their needs, they may tend to develop a helpless or passive mentality, and stop trying to do things for themselves, waiting instead for an outside agency to meet their needs. They may also try to make the strongest impression on NGO and municipality staff by adjusting their story and their facts according to who is listening, so sometimes a little scepticism and cross-checking are required when interviewing potential recipients.

g) As in almost every activity and endeavour, it is worthwhile to consider the motivation of all involved. The motivation of leaders of NGOs is no exception. Whilst there is often an altruistic motive - wanting to help those who are less privileged, to make a contribution to society, to use one's talents and training for the benefit of others - other motivations may also be present from the start, or may creep in as the work continues and grows. In addition, one should be aware of others looking in from outside who may be asking what motivates a leader, and be wise to prevent them from arriving at a wrong conclusion. Some, as has already been shown, may be accused of using NGO involvement to seek political power. Others may be accused of seeking self-promotion or publicity. Some may seem to be involved with an NGO for financial gain or in order to obtain a privilege from the municipality, such as the right to use a piece of land, or a favourable decision from a municipal body.

G-2.8 WHAT SHOULD BE THE ROLE OF AN NGO?

The following roles are suggested:

- Public awareness
- Model preparation/experimentation/research
- Bridging between government and society, organising residents as pressure groups
- Acting as a buffer zone between the community and the municipal authorities

G-2.9 DOs AND DON'Ts FOR NGOs

The authors realise that they are not experts in the subject of non-governmental organisations, but as a result of this brief investigation of the experiences of a few NGOs, the following suggestions are offered in the hope that some of them may be of some benefit:

- **Do** keep away from political activity
- **Do** consider carefully what can be done with available resources. Though an NGO may like to take a holistic approach, at the same time it should not spread itself too thinly in many directions since it will lose control and effectiveness.
- **Do** try to evolve a system of self-help rather than depending on the municipal corporation.
- **Do** aim at co-operation rather than confrontation with the municipalities.
- **Do** keep in contact with other NGO's in the area to avoid duplication of work.
- **Do** encourage the target groups to focus more on their duties and less on their rights.
- **Don't** arouse too many expectations otherwise failure to fulfil them all may lead to withdrawal or disappointment.

Chapter G-3

Views of officials and elected representatives

Based on investigations conducted
by R S Chavan and R R Pal

In proposing modifications to existing systems, it is very important to know the opinions and attitudes of both officials and elected representatives, so that the programme of recommendations can be designed according to what is feasible and achievable, and so that the presentation of the programme can be in a way that is most persuasive and appropriate to the views of the decision-makers.

This brief chapter presents the findings of a small exercise that was concerned with finding out the views of senior figures in Mumbai. Information was collected by personal interviews; this is a time-consuming process because it can be difficult to get appointments with such people, and a considerable amount of time is spent travelling. Little time was available for this survey, so the samples are very small. The results should not be taken as representative of the views of all officials and elected representatives, but simply as the opinions of a small group of individuals.

The following people were interviewed:

Municipal officials	Elected representatives
Additional Municipal Commissioner	The Honourable Mayor of the Corporation
Deputy Chief Engineer (SWM)	Opposition leaders of the Corporation
Ward Officers	Elected representatives of the Corporation

The questions asked, the answers and the investigators' comments are shown below. Numbers in brackets refer to the number of people answering in the way indicated.

1. What priority do you give to solid waste management in Mumbai?

Municipal officials	Elected representatives
Second position [3]	First priority [4]

Comment: Although it is the tendency of political figures to always state that the current topic of discussion is their top priority, it is nevertheless interesting that both groups rated solid waste management so highly.

2. To what extent are you satisfied with the present system of collection, transport and disposal?

Municipal officials	Elected representatives
90% satisfied [3]	90% satisfied [4]
	The public expects more [2]

Comment: It would be difficult for municipal officials to be critical of the system for which they are responsible. It would be interesting to know precisely what, in their opinions, the shortcomings were.

3. Do you feel it is necessary to introduce modernised systems of collection and transportation?

Municipal officials	Elected representatives
Yes [3]	Yes, but in stages, without retrenchment of labour [4]

Comment: It is hard to imagine officials answering "No" to this question because to most people modern = good. However the opposition to retrenchment of labour (that is, a reduction in the workforce) is an important qualification to the answer, because nearly all modern systems have as their objective the reduction in labour, in order to reduce costs and make the work less unpleasant. So the answer from the elected representatives must be seen as "Yes, but no". Bitter experiences of strikes and the opposition of the labour unions makes the reduction in the labour force an issue to be avoided.

4. How do you protect your sanitation workers? Do you have any welfare scheme for them?

Municipal officials	Elected representatives
Yes [3]	Yes, there is a housing scheme in which housing is allocated on the basis of seniority. [4]

5. What is the effect of slum dwellers on solid waste management?

Municipal officials	Elected representatives
They are a nuisance [5] They are indisciplined [3] They should be removed from the areas they have occupied and their huts should be demolished [1]	They are a nuisance [4] They could be disciplined by education [4] The 2.5 FSI scheme * will improve their living conditions

Note: *The 2.5 FSI [Floor Space Index] scheme is designed to attract builders to create housing for slum dwellers. Land is given at no charge to private builders and housing societies on the condition that part of the building they construct is made available for slum dwellers.

Comment: It is important to note the difference in attitude between the two groups. The municipal officials are most aware of the difficulties caused by the slum dwellers, whilst the elected officials see the slums as a "vote bank" with considerable power in municipal elections. The municipal officials were perhaps thinking of the Rs 4.5 crores that they were spending each year on cleaning solid waste out of nullahs [drains] in the slum areas.

6. How do you feel about the participation of the public and their awareness of environmental issues?

Municipal officials	Elected representatives
There is no participation or awareness; the public lack civic sense and will never improve [3]	It is possible to develop participation and awareness by education at primary school level and by frequent appeals in the media. [4]

Comment: The municipal officials seemed very discouraged by the attitude of the public, whereas the elected officials were somewhat optimistic. There is no doubt that campaigns to raise the awareness of the public need time and money, inspiration and perspiration.

7. What is your opinion on the introduction of privatisation in solid waste management?

Municipal officials	Elected representatives
Privatisation has already been partially introduced. Privatisation would be welcomed if introduced in stages. [3]	Privatisation has already been introduced in transportation of waste. Privatisation is welcomed, provided that it does not cause labour retrenchment. [4]

Note: Contractors were providing trucks and drivers to collect a significant proportion of the solid waste from Mumbai, and virtually all of the drain wastes and construction debris. (There are more details in Chapter B-6.) They were being operated with labourers of the MCGM according to the norms agreed with the unions (usually six labourers per vehicle and one trip per shift.) The operation of these trucks was reported in the previous book *(Observations of solid waste management in Bombay 1992)*, in which it was seen that collection by these contractors' trucks was more expensive that the collection service provided by municipal vehicles.

Comment: The condition demanded by the elected representatives - no reduction in the work force - has a great impact. In general the private sector is more economical because it can operate with smaller workforces and at lower wage levels. A prohibition on retrenchment effectively kills the option of reducing the costs of the service by privatisation. It appears that there is not even the option in Mumbai for reducing the workforce by natural wastage (that is, by not replacing workers when they retire) since there is an agreement that guarantees a job to a relative if a worker retires for health reasons before he is due for normal retirement, and this arrangement is used to maintain the size of the workforce.

8. How is your relationship with the Union?

Municipal officials	Elected representatives
Cordial relations are maintained by always listening to their requirements [3]	Listening to them and discussing their needs keeps the relationship cordial

Comment: It appears that his is a very sensitive issue, and that care is taken to maintain a good relationship with the labour unions.

9. What do you feel is the role of rag-pickers in solid waste management?

Municipal officials	Elected representatives
They are a source of nuisance and undisciplined [3]	They are a source of nuisance but it is possible to keep them under control if they are brought under an NGO or a social organisation [4]

Comment: Some of the MCGM officials appeared to have a more positive attitude towards rag-pickers, as evidenced by an arrangement that was made that certain rag-pickers should maintain the area around the container where they were working in a clean condition, in return for the right to take recyclable materials from that container. The general hostility towards rag-pickers was no doubt caused by the habit of many rag-pickers to pull waste out of containers and leave it scattered over the ground after they had finished sorting through it.

Any manager of solid waste services knows that it is important to understand the thinking and objectives of the elected representatives. This short survey has touched on some of the issues, and suggested some of the conflicts and problems that municipal officials live with.

APPENDIX 1 WORD LIST AND ABBREVIATIONS

Indian usage	General usage, other terms	Definition or description
	articulated	Also known as semi-trailer - a trailer with wheels at the back is pulled by a tractor which is similar to a short heavy truck.
	availability	The percentage of time that a vehicle or piece of equipment is in a serviceable condition and ready to be used.
chowki	muster station	Municipal office to which labourers report at the beginning and end of the day's work
colonies	housing estates	One or more multidwelling building(s) erected and managed by an organisation
conservancy	sanitation department	Originally concerned with the management wastes from bucket latrines, but now, as bucket latrines are phased out, conservancy departments are concerned with solid waste and cleaning of public toilets
crore		ten million (Rs 1 crore is roughly US$ 300 000)
dumper-placer	container hoist truck, skip truck	Truck which lifts container off ground by means of chains, for transportation and emptying by tipping; container rests between lifting arms.
dumping ground	dump, tip	Place where solid waste is deposited as a final resting place, that is not controlled and where no attempt has been made to minimise pollution
dustbin	solid waste container	This term can be used for a wide range of types and sizes of waste containers in India, including masonry enclosures.
godown	warehouse, store	Used to describe warehouses of conventional construction, but also used for rough shelters used to store salvaged items that are to be recycled.
halalkhore	toilet cleaner	Responsible for cleaning excreta, not other types of solid waste, from toilets, roads or elsewhere
kabariwallah	Itinerant waste buyer	Person going door-to-door to buy clean materials such as newspaper or glass, that have been kept separate from the solid waste that is discarded
lakh, lac	one hundred thousand	Rs 1,00,000 is approximately US $ 3000.
motor loaders	vehicle crew	Labourers who load waste into collection vehicles
mukadam	foreman	The lowest level of supervision, in charge of up to about 15 labourers, not expected to do manual work
nullah	drain	Usually an open, natural drainage path
pelletisation plant	RDF plant	Plant for producing cylindrical pellets of dried , combustible waste for use in boilers as a substitute for coal. (RDF = refuse-derived fuel)
peon		Lowest grade of administrative employee in administrative organisations
pipe bin		Enclosure for waste without floor made from a section of iron, steel or concrete pipe

Indian usage	General usage, other terms	Definition or description
rag-picker	scavenger	Man, woman or child who sorts through waste at a community storage point or disposal site, looking for items that can be sold, reused or recycled.
roll-off	hook lift, *or* arm roll, *or* roll-on, roll-off	Truck-mounted system for lifting containers onto the back of a flat-bed track by a hydraulically-operated hook or by cables; containers are emptied by tipping.
scavenger	sweeper	Person responsible for emptying bucket latrines, street sweeper.
trolley bin	wheeled container	Steel, trough-like bins that roll on three steel wheels, capacity 1m^3, emptied by hydraulic mechanism on compactor trucks (photograph 7)
wheel barrow	handcart	Also known as pushcart, here used to refer to a cart with two, three or four wheels, that is propelled by the effort of the labourer

List of Abbreviations

AMC	Ahmedabad Municipal Corporation
BMC	See MCGM
BRC	Bulk refuse carriers - large trucks used to carry waste from a transfer station to a disposal point (Chapter B-1)
ESI	Employees' State Insurance
FRP	Fibre-reinforced plastic also known as glass fibre.
J.O.	Junior overseer - supervisor above the level of mukadam
MCGB	See MCGM
MCGM	Municipal Corporation of Greater Mumbai - the local government body responsible for running the City. During the time of the study the name *Bombay* was used, so the Corporation was known as MCGB. Before that it was known as BMC (Bombay Municipal Corporation). The current formal name for the MCGM is Brihan Mumbai Mahanagarpalika.
MTS	Mahalaxmi transfer station - the large split-level transfer facility in Mumbai (chapter B-1)
NEERI	National Environmental Engineering Research Institute, Nagpur
RMC	Rajkot Municipal Corporation, Gujarat
SI	Sanitary inspector - employee of the Health Department of a Municipal Corporation, with supervision responsibilities at the Ward level.
SSI	Sanitary Sub Inspector - under a Sanitary Inspector, also at Ward level.
STS	Small transfer station as described in chapter A-3

Exchange rates

The value of the Rupee varied during the three years of study reported here, but an approximate exchange rate of Rs 30 to US$ 1 gives a reasonable guide to the international value of the Rupee.

APPENDIX 2 ACKNOWLEDGEMENTS AND LIST OF CONTRIBUTORS

The number of people who have helped with this compilation must be over one hundred. The contributions in this book arose from a series of courses running from 1993 to 1995, and many people contributed to the success of these courses in many ways. It is inevitable that some of those who played a important role in some activities leading to the production of this book are not included in the list below, and they are asked to accept my apologies. It is also difficult to rank the importance of the contribution of each member of the team that helped with this project, so no attempt at ranking the contributions is made; there is no significance in the order in which the names appear. It has been a remarkable fact that all concerned with the preparation of this book have been pleasant and helpful, so that I can truly say that it has been a great pleasure to work on this project. To all who have helped in any way, I am very grateful.

The material for this book was prepared while I was a staff member at the Water, Engineering and Development Centre, and so I pass on my sincere thanks to the whole WEDC team, but particularly to Professor John Pickford, OBE, who encouraged me to develop my interest in solid waste management, and who has provided so much inspiration and leadership over the years. My special thanks to Kathy Brown and Rowena Steele for all their hard work and secretarial support.

Each course had a component in UK and a component in India. Our "home" in India was the All India Institute of Local Self Government, in Mumbai, and Professor Sneha Palnitkar was the reason why the India components were so successful, valuable and enjoyable. Her talents as a team player helped us out time and again.

Manfred Scheu (currently working for GTZ in Gaza) played a major part in developing the courses, particularly the practical field work which led to the chapters of this book. His thoroughness, high standards, hard work and companionship are like a foundation to the whole exercise.

Manus Coffey made a valuable contribution throughout the programme, both in terms of his practical knowledge of waste management and his development of computer software, but in the 1995 course his contribution was much greater in that he was a tutor for the India component.

David Jackson has had an important "behind the scenes" role, encouraging the development of the course, providing valued lecture inputs and leaving the legacy of enriched understanding and attitude in the minds of many Indian engineers with whom he worked on his visits to India.

The Overseas Development Administration (now known as the Department for International Development) sponsored and administered the training programmes, and have generously funded the preparation of this book. The British Council has been heavily involved in co-ordination and organisation, and two allies in Delhi, whose consistent help has been much appreciated, are Dr G S Gujral and Leela Imam.

The course participants have, of course, played a very significant part in the preparation of this book. They came from a variety of backgrounds - engineers, administrators and scientists - and they all contributed to the experience of the course and to the knowledge that benefited all participants. It is they who collected most of the information within these pages, sometimes getting up early to be at a muster chowki before the crews arrived, or working in slum areas collecting all kinds of data, or spending days on unpleasant disposal sites, or collecting data in other ways, and then working under considerable time pressure to prepare a written report and a spoken presentation to pass on what they learned. It is unfortunate that (because of time constraints) it has not been possible to publish all of their work in this compilation, but the efforts and friendship of all of them are gratefully acknowledged. A list of the course participants (or study fellows) is presented on the next page.

Amongst participants from the series of courses, four stand out because of their ongoing contributions to training in Mumbai. They are G P Vora, M T Bondre, V K Rao and S A Bargir, all of the Municipal Corporation of Greater Mumbai. In spite of their heavy workloads and responsibilities they were always ready to share their knowledge and expertise with subsequent courses.

Course Participants (Study Fellows) 1993 - 5

Most of the information presented in this publication was collected and written up by participants on training courses conducted in the period 1993 to 1995. The names of the course participants are shown below, according to the course they attended and showing the positions they held at the time they participated in the training programme.

Name	Position at the time of making the contribution
1993	
S A Bargir	Assistant Engineer, SWM, R&D section, MCGM
N Bandyopadhyay	Executive Engineer, Municipal Affairs Dept., Govt. of West Bengal
B Majhi	Public Health Engineer, Urban Development, Orissa
Dr C H Nagarabett	Medical Officer of Health, Bangalore City Corporation
Prof (Mrs) S A Palnitkar	Director, (International Relations/Research) All India Institute of Local Self Government, Mumbai; Course Co-ordinator
Mrs P R Singh	Assistant Appraisal Officer, HUDCO, New Delhi
G P Vora	Chief Engineer, (SWM), MCGM
K V Ramarao	Executive Engineer, PHED, Govt. of Andhra Pradesh
V S Rao	Municipal Engineer, M&PHED, Andhra Pradesh
Dr L S Reddy	Environmental Engineer, Andhra Pradesh Pollution Control Board
P S Pahade	Executive Engineer, MCGM
1994	
Dr D C Bhandari	Health Officer, Jaipur Municipal Corporation
J K Bhattacharyya	Scientist, SWM Division, NEERI
R S Chavan	Dy. Director General, All India Institute of Local Self Government, Baroda
Dr P K Makwana	Medical Officer of Health, Ahmedabad Municipal Corporation
R R Pal	Administrator, Dept. of Urban Development and Municipal Affairs, Goa
R Ramanathan	Superintending Engineer (SWM), Corporation of Madras
V P Rao	Addl. Dy. Commissioner/Administrator, Municipal Corporation, Delhi
A K Sarkar	Deputy Chief Engineer, Calcutta Municipal Corporation
T M Shantaram	Medical Officer of Health, Bangalore Municipal Corporation
N H Waghela	Deputy City Engineer, Rajkot Municipal Corporation
B B Uppal	Assistant Advisor (PHE), CPHEEO, Ministry of Urban Development
1995	
S Chatterjee	Assistant Advisor, PHE Section, Ministry of Urban Affairs and Employment
B M Desai	Municipal Engineer, Surat Municipal Corporation
A K Gurung	Divisional Engineer, PHED, Gangtok
J B Kagathara	City Engineer (Special), Rajkot Municipal Corporation
Dr S P Kulkarni	Additional Health Officer, Ahmedabad Municipal Corporation
Dr (Miss) G B M Mihsill	Health Officer, Shillong Municipal Board
Miss D J Mukhia	Under Secretary, Urban Development & Housing Dept., Sikkim
M Patel	Executive Engineer, Municipal Corporation, Baroda
V B Pawar	Ward Officer, F/N Ward, Mumbai
T K Raveendran	Secretary, Calicut Corporation
P Roychowdhry	Executive Engineer & Member, SWM Unit, CMDA, Calcutta
Mrs Jaiwanti Sheokand	Director, Local Bodies, Chandigarh

During the India components of the courses, we visited many sites and projects, mainly in Mumbai, but also in Ahmedabad, Rajkot and Pune, sometimes all together and sometimes as small teams. We met so many people were willing to spend time to explain, to show, and to pass on data and information, and the support of such people made the visits and investigations useful and stimulating.

Most of the visits were in Mumbai, mainly with the Municipal Corporation of Greater Mumbai, and to them we owe a huge debt of gratitude, not only for the visits, but also for the transport. In Ahmedabad we were treated to the best programme of site visits that I have ever experienced, and helped in many other ways by Mr P U Asnani, then Deputy Municipal Commissioner. In Pune the Deputy Medical Officer of Health, Dr R R Pardeshi, showed us many of the interesting developments in his city. Our time in Rajkot was special because of the hospitality and efforts of the Municipal Corporation, and the current and previous study fellows from the Rajkot Municipal Corporation.

Amongst those in Mumbai who helped us were (in alphabetical order):-

- Mr Barve, Assistant Engineer, Municipal Workshop
- Mr Chitale, Assistant Engineer, (SWM)
- Mr Gawali, Sub-engineer, Santa Cruz Garage
- Mr S V Parkale Sub-engineer, Prabhadevi Garage
- Mr Prajapati, Sub-engineer, (Bandra Garage)
- Mr J M Shetty, Assistant Engineer, Prabhadevi Garage
- Mr Shinde, Assistant Engineer, Santa Cruz Workshop
- Mr S L Soni, Executive Engineer, Santa Cruz Workshop
- Mr Thanekar, Junior Engineer, Bandra Garage

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- Excel Industries Limited, [Dr S R Maley, Vice President (Bio-tech)]
- Western Pacques India Limited, [C L Kale, Executive Director]

Finally, there is one special person to whom I owe a great debt of gratitude - my wife Elisabeth - who has encouraged me in this work from beginning to end.

Adrian Coad
July 1997