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The effect of hygiene communication on emptying of urine diversion toilets

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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

The effect of hygiene communication on emptying of urine diversion toilets*N. Moilwa and M Wilkinson, South Africa*

Diarrhoeal disease is a major concern to the South African government. Understanding the relationship between the lack of water and sanitation and diarrhoeal disease, the government has developed a national initiative to provide poor and rural communities with a basic sanitation facility, one of which is a Urine Diversion toilet. This paper includes assessment of the effectiveness of hygiene messages on vault emptying behaviours and the possible transfer of pathogens to hands during emptying processes. The method involve observation of vault emptying behaviours, interviews with key stakeholders and microbiological analysis of indicator species on hands before and after vault emptying. The results indicated that health and hygiene messages were not actioned by the study group and that there was no significant difference between the E-Coli and Faecal coliforms on the hands before and after emptying. Conclusions from the study were that correct operation and maintenance of Urine Diversion toilet require, health and hygiene education programmes to be ongoing and continue beyond the life of the project.

Introduction

It is estimated that over 40 thousand South Africans die every year from diarrhoeal diseases. These diseases are one of the leading causes of death in the country, particularly of poor black children under the age of 5 (Mara, 2001). Bradshaw et. al., (2000) recorded diarrhoeal disease as fifth on the list of causes of premature mortality in South Africa in 2000.

Understanding the relationship between provision of sanitation services (including health and hygiene education) and the reduction in water-related diseases, targeting the meeting of the Millennium Development Goals, South Africa has embarked on a national initiative to clear water and sanitation backlogs by 2015, if not sooner.

Responsibility for the provision of sanitation service rests with local government in South Africa. This means that the final choice of the type of service rests with the Water Services Authority (WSA) of local government. Local government guidelines for basic sanitation recommend the provision of a Ventilated Improved Pit latrine (VIP) or its equivalent in rural or low-density urban areas and waterborne or its equivalent in dense urban settlements (DPLG, 2005). Basic sanitation facilities which are provided in South Africa range from the dry, on-site systems such as the VIP or Urine Diversion toilet (UD) to waterborne Low Flow On-site Systems (LOFLOS). Selection of the type of facility is dependent on the type of settlement, the financial capability of the WSA and the subsidy availability to a household.

Although slow to be accepted in South Africa the Urine Diversion system is now widely recognized as a viable option as basic sanitation facility. At least four of the nine

provinces in the country are providing these toilets instead of the conventional VIP. Preference is given to the provision of a UD toilet when topographic conditions are unsuitable, financial resource are limited, environmental conditions are incompatible and human resource are constrained. To date, over 40 thousand Urine Diversion toilets have been constructed in South Africa. Most of which are concentrated in Kwa-Zulu Natal province of the country.

The Northern Cape is one of the four provinces which provide a UD toilet as a basic sanitation facility. Although the largest province in the country the Northern Cape has the smallest population i.e. less than 1 million of the 44 million people in South Africa (Statistics South Africa, 2001). Sanitation coverage in the province was 67% in 2001 but has increased to 74% in February 2006 (DWAf, 2006). The province has a strategy of providing "dry sanitation" to all rural households. According to the Department of Water Affairs and Forestry (DWAf), by February of this year 2946 UD toilets had been provided to households in the province (DWAf, 2006). This has increase significantly from the 1500 reported in July 2005 (The Water Wheel, 2005). The UD toilet supplied to households in the provinces is the single vault system. Emptying of these vaults will occur without drying of the contents.

The microbial risk from handling of faecal matter from a single vault toilet is dependent on microbial species present and their count per gram. According to Austin (2000) pathogens die-off in a urine diversion toilet in South Africa, in other words the presence of microbial species and their count per gram is determined by storage time within the vault, pH levels and low humidity within the vault. An elevated

temperature within the vault does not seem to play as great a role. Although pathogen die-off may vary, it is important to note that exposure and thus microbial risk from vault emptying may also depend on a number of other parameters e.g. type of UD system (Single or double vault system); the emptying process; health status of the person using the system and being exposed etc.

The single vault system used in the Northern Cape Province requires the handling of untreated faecal matter. Exposure to pathogenic organisms that have not been reduced to minimum risk levels may pose a health risk to the individuals emptying these vaults (Peasey, 2000). This is supported by Peasey's study which showed that the use of untreated or insufficiently treated faecal matter can pose a threat to human health. A similar study in Vietnam showed that women handling "treated" faeces exhibited lower intensities of hookworm infection as apposed to those who handled untreated human faeces (Humphries et al 1997).

To mitigate the health risks from the emptying of single-vault Urine Diversion toilets in the Northern Cape, sanitation service provision in the rural areas of the province include hygiene related education and training on the safe removal of human waste.

The purpose of this research was to investigate whether pathogens were transferred to hands during the emptying of single-vault Urine Diversion toilet in the Northern Cape Province of South Africa. The investigations objectives included:

1. Observation of behaviours and practices of vault emptying at the study site. Apart from observing the emptying practices of the study group, this step incorporated an assessment of hygiene education messages that were communicated during the sanitation project. These messages were compared to the actual vault emptying practices of the study sample.
2. Assessment of pathogens transferred from the vault content to hands during emptying. This included a microbiological analysis of pathogens levels on hands before and after vault emptying. The microbiological tests were limited to Faecal coliform, *Escherichia coli* and Faecal streptococci.

The research set out to explore two hypotheses; firstly that health and hygiene education messages were not being actioned by individuals when emptying UD vaults and secondly that there would be significant difference in Faecal coliform, *Escherichia coli* and Faecal streptococci on the hands of the individuals before and after vault emptying.

Methods

The study was conducted in Augrabies village in the Northern Cape province of South Africa. According to the DWAF database, 58% (198) of the 685 UD toilets registered within the municipal area are found in this village. The remaining households in the village have conventional flush toilets (22%), flush toilets with conservancy tank (4%) and unimproved pit toilets (16%) (DWAF, 2006). The above statistics show

that Urine Diversion toilets are the main type of sanitation facility in the community.

The provision of a UD toilet to a household formed part of a national sanitation programme. Poor and rural households are given a once-off subsidy for the provision of a basic sanitation service. The basic sanitation service in South Africa includes the provision of a toilet and education relating to waste management, sanitation, hygiene and related practices. The UD project in Augrabies was implemented by an external consultant. The consultant assisted households in constructing the toilets and provided a health and hygiene education programme.

The method used for the study included observation, interviews and laboratory analysis.

The observation study included using a checklist to mark off observed behaviours during emptying of the UD vaults. The observation checklist focused on vault emptying behaviours based on:

1. the equipment used for emptying
2. the use of protective gear by the study participant
3. the means of disposal of the vault contents once removed from the vault;
4. the occurrence of spills during transport of the content and means of disposal of these;
5. whether hands were washed after completion of the emptying exercise; and
6. materials used for hand washing.

The second part of the study included interviews with key stakeholders within this sanitation project. A component of the research was to compare the observed vault emptying behaviours with the health and hygiene messages communicated during the implementation of this project. The purpose was to determine the effectiveness of the vault emptying education given during the health and hygiene education programme. The external consultant that implemented the health and hygiene awareness programme was a key stakeholder in this study. Unfortunately, due to the long timeframe between the completion of the UD project and this study, the health and hygiene education materials, specifically vault emptying information, was no longer available. As a result, the only source of health and hygiene education information was from a telephonic interview with the consultant who implemented the project.

The final component of the research was a microbiological assessment of the levels of Faecal coliform, *Escherichia coli* and Faecal streptococci on the hands of the individuals before and after vault emptying and on the equipment used during this emptying process. The method used for collecting microbiological samples from hands was the immersing of a sterilised swab into 200ml of sterile water; swabbing of the hand including fingertips with the sterilised material; and placing the swabbing material back into the sterile water. The same method was used for the sampling of equipment, with the swabs taken from the handle of the emptying tool.

Samples were kept cool and refrigerated overnight before being submitted to the laboratory for analysis. For Faecal

coliform assessment was carried out using the MMP 3 method. This method included incubation of samples on m-FC medium for 24 hours at 44, 5°C. Faecal streptococci analysis was done using the MMP 5 method i.e. incubation of samples on m Enterococcus agar for 48 h at 35°C. A MMP 8 method was used to analyse *Escherichia coli*. This test includes confirmation of colonies from the membranes used in the test for faecal coliforms (Method MMP 3); inoculated into tubes of tryptone water and further incubation of samples at 44,5°C \pm 1°C for 24 h. After incubation, Kovac's reagent is added. A Wilcoxon signed-rank test for related (dependent / paired) samples was performed on the before and after results of the hand swabs.

It was anticipated that 30 (15%) of the 198 UD toilets in the village could be randomly selected for the study. However, on-site observation revealed that a number of these toilets were being incorrectly operated and maintained. Operation and maintenance of the UD toilet in the village required the adding of a cup of ash or sand to the vault after defecation and ensuring that the vault was water tight. Unfortunately, in many households the vault contents were not dry. Since this study had the specific object of observing vault empty behaviours and not correct operation and maintenance of the toilet, household who managed their UD toilet incorrect were excluded from the sample. This meant that only those household using the toilet correct were included, and therefore the group from which the sample could be selected was that much smaller.

In addition, some of the householders who initially agreed to be part of this study had found temporarily employment on grape farms in the area and were therefore no long available to take part.

Based on these problems, a new sample was selected based on the following criteria;

- Whether the household was operating the UD system correctly i.e. was the vault content sufficiently dry to allow for emptying.
- Whether a representative from the householder was willing to demonstrate the emptying of the vault.

The person from the sample household who emptied the vault will be referred to as the demonstrator in this paper.

Results

Observation of health and hygiene (H&H) messages execution

1. Emptying equipment

The observation recorded what equipment the demonstrator used to empty the UD vault. As shown in Figure 1, two thirds of the demonstrators used a spade and a rake to empty the vault. An additional 24% made use of only a spade. The remainder of demonstrators either made use of only a rake (3%); a combination of a spade, rake and a self-made piece of equipment (3%) or a spade, rake and a garden fork (3%).

2. Use of protective gear

The observation of protective gear such as gloves used

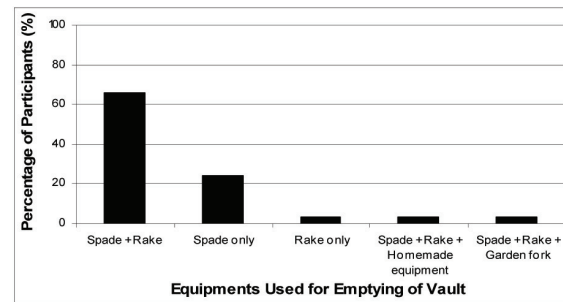


Figure 1. Types of equipment used during vault emptying (29 households).

Source: Moilwa, 2006

during the emptying of the vault was marked off on the observation checklist. From the interview with the H&H consultant the vault emptying education emphasised that the content of the vault should not be handled with unprotected hands. Householders were advised to wear gloves during the emptying and the disposal of the vault content. They were also advised to ensure that children were not present while emptying. However, observation showed that only one demonstrator within the sample wore protective gear. This was a damaged glove on one hand only. The remaining 97% of householders did not wear protective gear while demonstrating the emptying of the vaults.

3. Disposal of vault content

The H&H consultant mentioned that householders were given three choices for the disposal of the vault content; namely

1. The content can be burnt. This is done by pulling the contents towards the back of the vault and burning it. This requires the removing of the vent pipe as it may be damaged by the heat. Removal of the vent-pipe is difficult and may require the assistance of a man;
2. The contents can be composted by placing it on the compost heap;

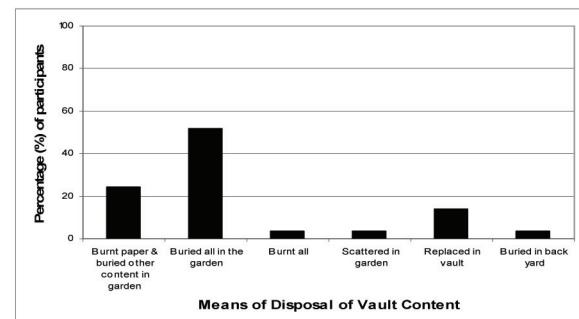


Figure 2. Manner in which demonstrator's dispose of the vault content.

Source: Moilwa, 2006

3. The contents can be buried in the garden.

Figure 2 shows how the demonstrators disposed of the content of the vault. More than half buried the contents in the garden while 24% burnt the paper (cleansing material) and then burying the remains. Interestingly, 14% returned the content to the vault at the end of the demonstration. These demonstrators indicated that they did not want to work any further with the contents. The remainder of demonstrations burnt the contents (3%), scattered it in the garden or buried it in the backyard.

4. Management of content spills

Observation showed that 48% of the demonstrators spill vault contents during emptying. Figure 3 shows that of those demonstrators who spilt the vault contents, over a third raked the spilt content back into the vault; another third left it lying where it had spilt and the remaining 29% mixed it with the surrounding soil. This was despite H&H education emphasising the need to keep the area surrounding the toilet free of faecal material.

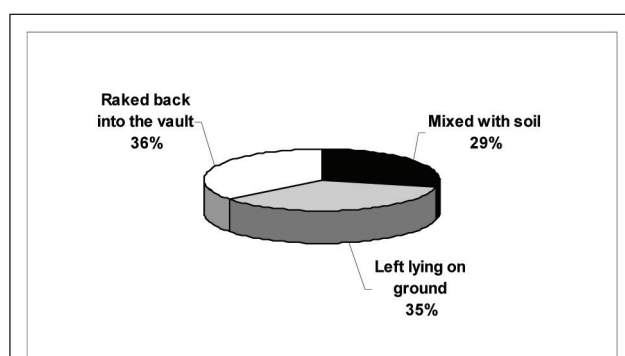


Figure 3. Management of spills from vault emptying.

Source: Moilwa, 2006

5. Hygiene Behaviours and Vault Emptying

After observation of the emptying of the vaults, the study focused on the hygiene behaviour of demonstrators. The purpose of this stage was to determine whether the demonstrator practiced good hygiene by washing equipment and their hands after vault emptying. Observation found that 83% of the demonstrators washed the equipment on completion of the task. Those that did not wash the equipment moved on to other household chores.

The H&H consultant indicated that householders were advised during the health and hygiene programme to use soap to wash their hands after emptying of the vault. Observation of actual behaviours showed that the majority (93%) of demonstrators washed their hands after vault emptying. In addition, two elements of hand washing techniques were observed; namely whether the demonstrators washed their hand with (1) water alone or (2) water and soap. Figure 7 indicates that two thirds of the demonstrators washed their hands with water only, 28% washed their hands with both water and soap and

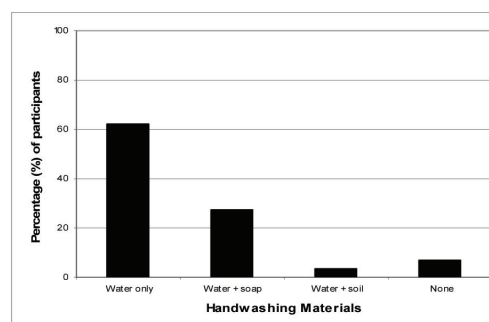


Figure 4. Hand washing behaviours after vault emptying by individuals (29 households).

Source: Moilwa, 2006

the remaining 3% washing with water and soil.

Hands and equipment were washed using a yard tap since this was the level of water supply in the village. Grey water from hand washing was allowed to run onto the ground.

Microbiological assessment of hands

A microbiological assessment of indicator species on the demonstrator's hands was performed in this stage of the study. Hand swabs were taken from the 29 demonstrators and analysed for levels of *Faecal coliform*, *Escherichia coli* and *Faecal streptococci*. The hand swabs were taken before and after the emptying of the vault.

A Wilcoxon signed-rank test for related (dependent / paired) samples was performed on the results from the analysis of the before and after hand swabs. Table 1 indicates that there was a statistically significant difference between the before and after hand swabs for the *Faecal streptococcus* but not for *E coli* and *Faecal coliforms*.

Table 1.: Wilcoxon signed-rank test for related (dependent / paired) samples (Moilwa, 2006)

Organism	p-value	Statistically significant?*
Coliform	0.9116	No
E coli	0.0771	No
Streptococci	0.0024	Yes

Statistically significant if p-value is < 0.05 (a one-tailed test)

Discussion

Health and hygiene behavioural assessment

It was clear from the difficulties experienced in selecting the sample households for this study, that some of the UD toilets in Augrabies village were being incorrectly operated and maintained. Although not a focus of the study, it was clear that information on the correct operation and maintenance of

the UD toilet given during the health and hygiene programme was not being applied by many of the households. Sanitation project that aim to address water-related health problems and which endeavour to meet national and international targets, must ensure that not only do they include the provision of a sanitation facility but that training relating to the sustainable management and operation of the facility is executed by the household. Without correct operation and maintenance, sanitation project will have little or no impact on improving health and preventing pollution of the environmental.

Contrary to what IRC (2006) found in other developing countries where vault empty is viewed as a female responsibility, the Augrabies study found that both sexes played a role in vault emptying. Vault emptying does not have a stereotypical gender bias in this village. Both sexes are exposed to microbial risk from vault emptying.

When emptying the vaults in Augrabies village, equipment such as a rake, a spade, a garden fork or a combination of these tools were used. The combination of spade and rake seems to be the most popular option. Demonstrators indicated that this equipment were the most appropriate for emptying the vault as it was approximately 1 metre below ground-level. This required the vault content to be raked to the back access point before it could be lifted out using the spade. Access to the vault was through the slab at the back of the toilet.

Self-made equipment however, seemed to be more appropriate to the researcher than a spade as it allows for the "scooping" out of the vault content with less spillage. A self-made tool was constructed from a 5 litre oil-can acting as the "scoop" and attached to a long handle.

The H&H education programme emphasized the use of protective gear when emptying a vault. However, only one demonstrator wore a single glove during emptying. This may indicate that householders were either:

1. not putting health & hygiene messages into practice; or
2. not retaining these messages after the completion of the education programme.

If the message were not being put into practices, this may imply that householders had not yet made the link between vault emptying, transfer of pathogens to their hands and sanitation-related diseases. They may not realize, as yet, that the protective gear would act as a primary barrier to the transfer of sanitation-related disease and thus reducing human health risks.

If the householders were not retaining the message after the project had been completed this may indicated that the H&H programme was not effective. This may have been due to a number of reasons such as the use of incorrect methods, tools and material or the message being conveyed at an inappropriate level for the household to understand. However, the study did not investigate the why H&H education message were not being applied but rather whether H&H message were being applied during vault emptying.

The interview with the Health and Hygiene consult-

ant indicated that householders were advised how to safe empty the vault of the UD toilet. Households were given three choices for the disposal of vault contents i.e. burn it in the vault, compost it or bury it. Observation showed that in Augrabies village the majority of demonstrators opted to bury the contents in the garden. This option may have been favoured by demonstrators as there was sufficient space to bury content; the content may not have been sufficiently dry to burn it or as was mentioned by some demonstrators, burning of the content could result in a "bad" smell. Although bury of the content was a option suggested during the H&H programme, if not burying correctly, the content may still pose a health risk, especially to young children playing in the yard. Although no research studies were available as to the best method of bury contents, recommendations are that the content be buried at least 300-500 mm below ground level (pers. comm. L Austin, 2006; pers. comm. T Gounden, 2006). This would ensure that children playing in the area do not come into contact with the material and that animals are not able dig the material to the surface of the soil. Alarmingly, some of the demonstrators scatter the contents over the soil or returned the contents to the vault. Scattering faecal matter within the domestic domain increases the risk of exposure to sanitation-related pathogens especially to children playing within the area. Returning the content to the vault begs the question, what will these households do when the vault are full?

The management of spills from vault reinforces the conclusion that health and hygiene education messages were not being applied or retained by members of Augrabies village. More than two-thirds of demonstrators managed the spills incorrect by either leaving it on the ground or mixing with the soil around the toilet. Leaving the spilt content around the toilet poses the same sanitation-related disease risks as incorrect management of the vault content. Faecal matter lying on the ground may result in transmission of pathogens via flies which land on the faecal matter and carry these pathogens to food and surfaces or through human and animal feet when stepping in the faecal matter. Perhaps more concerning is that children playing in the area may touch or even ingest the faecal material. With each gram of faeces containing millions of viruses, bacteria, protozoa and parasitic worms, the incorrect vault emptying behaviours may result in nullifying the purpose of provision of a sanitation facility i.e. primary barrier to transmission of sanitation-related disease. Studies have clearly shown a link between the incorrect disposal of faeces, particularly children's stools, and diarrhoeal in families (Curtis, et. al., 2000). Traoré, et. al., (1994) report that the risk of hospitalization with diarrhoea in Burkina Faso was a third higher for children who live in areas where human faeces were observed on the ground (Traoré, et. al., 1994 in Curtis, 2000). The likelihood of spillage was dependent on a number of variables i.e. the type of equipment used, the user's ability to handle the equipment and how careful the user is during the process.

Despite a health and hygiene education programme being

implemented during the sanitation project, 17% of individuals did not wash their equipment and 7% did not wash their hands immediately after vault emptying. The latter has the potential for pathogen transfer, especially if food hygiene is not practiced. Of those who were observed to wash their hands, only a small percentage did so with both water and soap. Washing of hands with water and soap is highly recommended as it acts both as a primary barrier through the removal of faecal matter and as a secondary barrier to transmission before preparing food, handling fluids, feeding and eating (Curtis et al, 2000).

The first hypothesis of the study relating to health and hygiene education messages not being actioned by individuals when emptying UD vaults was therefore, retained. It was clear from vault emptying behaviours that demonstrators were either not actioning O&M and health and hygiene messages or were not retaining these messages after the programme had been completed. A study by Gorter et. al. (1998) in Nicaragua showed that there is a consistent relationship between hygiene practices and the incidence of diarrhoea. This relationship was corroborated by Feachem's (1984) review of interventions for the control of diarrhoeal diseases among young children. The review concluded that the promotion of personal and domestic hygiene is an effective intervention for the prevention of diarrhoea. Curtis et. al. (2001) also supported this relationship in their study in Burkina Faso where carefully conceived, executed, and evaluated interventions to promote safe hygiene showed good results in the prevention of these diseases. This has led to researchers concluding that most water- and sanitation-related diseases can be reduced and/or prevented through the improvement of personal and domestic hygiene behaviors, especially in young children. Even though good hygiene behaviours are capable of cutting most, if not all, faecal-oral pathogen transmission, changing these behaviours is complex and an uncertain exercise (Curtis et al, 2001). This is supported by the result of the Augrabies village assessment.

Microbiological assessment

The hand swab results presented in this report show that there was a statistically significant difference between Faecal streptococcus on hands before and after vault emptying. With regard to *E. coli* and Faecal coliform there was no statistically significant difference.

The second hypotheses of the study, namely that there would be significance difference in indicator species on the hands of the demonstrators before and after vault emptying, was discarded. The reason for there being no statistical difference between the levels of *E. coli* and Faecal coliforms on hands before and after vault emptying requires further investigation before any conclusions can be drawn. Initial suggestions are that these results are affected by either:

1. the type of equipment used i.e. the type of equipment may affect the likelihood of pathogens transferred to hands;
2. manner in which the vault content is transported i.e.

transport equipment may remove *E. coli* and Faecal coliforms from hands thus affecting the result; or

3. the laboratory method used in the analysis i.e. improved or alternative methods may need to be applied to confirm these results.

Conclusion and recommendations

Same households within Augrabies village are:

1. Not operating and maintaining the UD toilets correctly;
2. Not actioning vault emptying message that were covered by the H&H component of the sanitation project;

Despite South African sanitation projects providing a subsidy for the communication of health and hygiene education, on completion of the projects there seems to be little hygiene behavioural change within many communities. The problems and experiences from Augrabies village are not unique. To ensure the retention and actioning of hygiene messages and thus, sustained behaviour changes within poor and rural communities, sanitation health and hygiene programmes will need to be reviewed.

These problems could be addressed by ensuring those health and hygiene education programmes are continued beyond the life-span of a sanitation project. These H&H programmes should make provision for ongoing education and awareness and should ensure that personnel are present at the very least during the first emptying of the vault of the Urine Diversion toilets. Safe management of the vault contents also needs to be an ongoing message during the initial H&H programme. Messages need to be repeated and reinforced to ensure that they are retained by householders and are actioned once the sanitation programme is completed.

Review of the impacts of these programmes could provide significant information relating to what do and does not result in hygiene behavioural changes. Impact studies will need to be carried out for health and hygiene programmes for all the possible types of basic sanitation services in the country. It will be important to understand what Urine Diversion H&H education and messages have the greatest impact on behavioural change and to compare these to similar programmes for VIP, LOFLOS and alternative toilet projects.

The impacts study must contribute to the design of norms and standards for H&H education for each type of sanitation programme. Best practices should guide the South African H&H strategy and should inform the H&H education guidelines for each of the project types. However, these generic guidelines for each type of sanitation project should be flexible enough to be able to address the different H&H education needs both spatially and temporally.

AUD sanitation project clearly needs to address key issues such as the correct operation and maintenance of the facilities and the safe handling of the vault content. The H&H programme must emphasise and repeat these messages throughout the project. H&H education should not use scare tactics to achieve behavioural changes and actioning of messages. For example, tell people in the Augrabies village that they

will prevent cholera if they wear gloves while emptying the vaults may not result in the desired behavioural changes as this village has not experienced a cholera outbreak. H&H education should rather incentives behavioural changes. Messages such as wearing gloves may reduce the severity of diarrhoea in children and they will not miss as much school and would free up more time for the care-giver. The latter may be an encouragement for care-givers to wear gloves while emptying. Innovated H&H education and messages need to investigate to ensure the sustained change in bad hygiene behaviours in a community.

Education and awareness programme also need to highlight the links between vault content and human health risks. However, these messages would be delivered at the right level for the audience, should be in the local language and should be based on an understanding of the community situation i.e. diarrhoeal and other disease which are seen as a problem to the community. It is only through the communication of correct messages during sanitation programme; the retentions of these messages by householders and the implementation of these messages that the chief purpose of provision of basic sanitation facilities in South Africa; namely to act as a primary barrier to transmission of sanitation-related disease, can be realized.

Reference

- Austin, L. M., (2000). Investigation of the South African application of certain alternative technologies for disposal of sanitation system wastes. *M.Eng. dissertation in Water Resource Engineering*. University of Pretoria, South Africa
- Bradshaw, D., Groenewald, P., Laubscher, R., Nannan, N., Nojilana, B., Norman, R., Pieterse, D., Schneider, M., Bourne, D., Timaeus, I., Dorrington, R. & Johnson, L., (2003) Initial burden of disease estimates for South Africa, 2000. *South African Medical Journal*. 93:9, 682-688.
- Curtis, V., Cairncross, S. & Yonli, R., (2000) Review: Domestic hygiene and diarrhea – pinpointing the problems. *Tropical Medicine and International Health*. Vol 5, No 1, pp 22-32.
- Curtis, V., Kanki, B., Cousens, S., Diallo, I., Kpozehouen, A., Sangaré, M., Nikiema, M. (2001) Evidence of behaviour change following a hygiene promotion programme in Burkina Faso. *Bulletin of the World Health Organization*, 79 (6)
- DPLG, (2005) *The Municipal Infrastructure Grant, basic Level of Services and Unit Cost: A Guide for Municipalities*, Pretoria, Government Printers
- DWAF, (2006) *Level of supply – Sanitation and Water Supply Summary Tables for maps 20 February 2006*, Pretoria, Government Printers
- Feachem, R. G., (1984) Interventions for the control of diarrhoeal diseases among young children: promotion of personal and domestic hygiene. *Bulletin of the World Health Organization*, 62: 467–476. *Bulletin of the World*
- R. M., Alberts, H., (1998) Hygiene behaviour in rural Nicaragua in relation to diarrhea. *International Journal of Epidemiology* dec;27 (6):1090-100.
- Humphries, D. L., Stephenson, L. S., Pearce E. J., P. H., Dan, H. T., & Knanh, L. T., (1997) The use of human faeces for fertilizer is associated with increased intensity of hookworm infection in Vietnamese women. *Transactions of Royal Society and Tropical Medicine* 91, 518-520
- IRC, (2006) Urine diversion composting latrines. [Online]. Available: <http://www.irc.nl/page22831>
- Mara, I., (2001) Between Diarrhoeal Diseases and HIV/AIDS Debates in South Africa. [Online] Available: <http://www.hst.org.za/news/20011021>
- Moilwa, N., (2006). *A social and microbiological study of the health risks during emptying of urine diversion toilets in South Africa: A case study of Augrabies village in the Northern Cape*. Pretoria: CSIR
- Peasey, A. (2000) *Health Aspects of Dry Sanitation with Waste Reuse*. Well. London
- Personal Communication. L Austin. (2006). CSIR Built Environment, Pretoria, South Africa. Tel +27 12 841 2568, email: LAustin@cir.co.za
- Personal Communication. T Gouden. (2006). Ethekweni Metro Water Services, Durban, South Africa. email: TeddyGo@dmws.durban.gov.za
- Statistics South Africa. 2003. Census 2001. Census in Brief. [Online]. Available: <http://www.statssa.gov.za> [12 February 2004]
- The Water Wheel, (2005). Ecosan: In search of a Sustainable Solution. [Online] Available: <http://www.wrc.org.za/downloads/waterwheel/July-aug%2005/Ecosan%20p22-24.pdf>
- Traore, E., Cousens, S., Curtis, V., Mertens, T., Tall, F., Traore, A., Kanki, B., Diallo, I., Rochereau, A., and Chiron, J.P. (1994) Child defecation behaviour, stool disposal practices, and childhood diarrhoea in Burkina Faso: results from a case-control study. *Journal of Epidemiology and Community Health*, Vol 48, 270-275

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