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Arsenic an Emerging Issue: Experiences from Pakistan

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Arsenic contamination has emerged as a serious public health concern in Pakistan. In Punjab over 20% of the population are exposed to arsenic contamination of over 10 ppb in drinking water while nearly 3% of the population are exposed to over 50 ppb. In Sindh, the situation is even worse with 36% and 16% of population exposed to arsenic contaminated water over 10 ppb and 50 ppb respectively. Both shallow and deep sources have arsenic contamination. A recent study on prevalence of arsenicosis confirmed presence of 40 cases in the study population giving a prevalence 140/100,00 for established and borderline cases. The purpose of this paper is to share experiences gained in implementing an arsenic mitigation programme in the country.

Many countries in the world especially in South Asia e.g., Bangladesh, India, Nepal, Vietnam, China and Myanmar are facing an arsenic problem and it has been recognized as a big threat and challenge to public health. Pakistan, following the arsenic crisis in Bangladesh and other neighbouring countries, has recognized the need of assessing drinking water quality for arsenic contamination. In this regard, the Government of Pakistan has been undertaking many initiatives with assistance from UNICEF since 1999. As a result of these initiatives, the presence of arsenic contamination has been recognized and consequently an arsenic mitigation programme, though not at national level, has already been launched by the government of Pakistan with assistance being provided by UNICEF. During this process experiences have been gained related to planning, implementation, monitoring and management of arsenic mitigation. This paper aims to share this experience as well as report on important data on arsenic contamination in Pakistan for the first time.

Preliminary Investigations (1999-2000)

From Nov. 1999 to Jan. 2001, the Pakistan Council of Scientific and Industrial Research (PCSIR), and the Pakistan Council of Research in Water Resources (PCRWR) of the Ministry of Science and Technology, with technical and financial assistance from UNICEF carried out a preliminary investigation on prevalence of arsenic in drinking water sources. Six districts in Northern Punjab: Jhelum, Chakwal, Attock, Rawalpindi, Sargodha and Gujrat were selected based on the following criteria:

- Areas draining coal and/or iron mining areas,
- Areas where geothermal waters are known to occur naturally,
- Areas with reducing groundwater, where compounds like dissolved iron, hydrogen sulphide, or methane are found,
- Areas draining crystalline igneous rocks such as granites or basalts.

During the investigation, 308 samples were collected from these 6 potentially high risk districts taking one sample each from a grid size of 100 km2 based on district maps prepared by Geological Survey of Pakistan. The minimum distance between the sampling points in the adjacent grid was greater than 2 km. These samples were processed at laboratory using a Hydride Generation Atomic Spectrometer. Analysis of the samples revealed that 14% of samples had arsenic concentration of over 10 ppb (WHO guideline value as well as proposed guideline value for Pakistan) and 3% (i.e. 6 samples/sites) above 50 ppb (a guideline valued adopted by most of the developing countries including Bangladesh). Table 1 shows specific results of the six sites where contamination level was found to be above 50 ppb (PCSIR, 2000).

Table 1. Arsenic Contamination in ppb at the six worst sites

Province	Site 1	Site 2	Site 3
Gujrat	111	96	
Jhelum	70		
Sargodha	136	73	100

Further analysis of data with respect to water table indicated no clear relationship between arsenic contamination and depth of water table, that is both shallow and deep sources had contamination.

A second round of similar preliminary investigation was conducted in order to re-confirm and further authenticate the findings of the previous study (PCSIR, 2000). During the study, 96 samples (16 each from a grid of 100 km2) were collected selecting a grid size of 6.25 km2 (1 sample each from a grid of 2.5 km x 2.5 km) from all the 6 sites shown in Table 1 where arsenic contamination was above 50 ppb. Two replicate samples were taken from each site where previous results were above 50 ppb as given in Table 2. Analysis of samples using similar techniques as adopted in the first round confirmed previous findings except one site in Sargodha where arsenic contamination was found to be 5 ppb as compared to 136 ppb detected earlier. The inconsistency between the results for the 6th site obtained in 1st and 2nd rounds is not known. It could be that the arsenic level in the said locality might have changed or there was human error in locating the exact position of the site during the 2nd round or in processing the sample in the laboratory. Of the 96 samples taken, 26% and 11.5% were found to be contaminated with over 10 ppb and 50 ppb respectively. These results (i.e., the overall prevalence) are 2 to 4 times higher than those obtained in the 1st round for above 10 ppb and 50 ppb respectively. Comparison of results with those obtained in the 1st round is presented in Table 2 along with data for new sites identified (shown in parenthesis).

Table 2. Arsenic Contamination in ppb (results of two replicate samples from 2nd round and new sites identified are shown in parenthesis)

Province	Site 1	Site 2	Site 3
Gujrat	111 (63,68) & (55,61,95, 51) new sites	96 (44,43) & (71) new site	(71) & (74) new sites
Jhelum	70 (61) & (61) new sites	(60) new site	
Sargodha	136 (5, 5)	73 (75, 63)	100 (68, 73)

National Survey (2001)

Based on the findings of the preliminary investigations, described in the above section, UNICEF extended technical and financial support to the Public Health Engineering Department (PHED) and Local Government and Rural Development (LG&RD) to launch an intensive and extensive national survey to further assess the level of arsenic contamination beyond the 6 districts considered during the preliminary investigation. This time one-third of all districts in the country (i.e., 35 of 104 districts) were selected from all the four provinces: North West Frontier Province (NWFP), Balochistan, Punjab and Sindh.

Methodology

The sampling strategy adopted was to select 5 samples from different water sources at Union Council (UC) level covering all the UCs in the selected districts. Before initiating the survey, training of relevant government officials (hereafter called field workers) was carried out to give them skills forsample collection, analysis of samples for arsenic contamination using the Merck field testing kit and recording the results. Another category of government officials (hereafter called monitors/supervisors) were also provided with similar training with an overall objective of enabling them to monitor and supervise of the work carried out by field workers. One of the crucial responsibilities of the monitors/supervisors was compulsory field testing of 10% of water sources already tested by field workers to ensure validation. In addition they were trained for their responsibilities in supervisiing and additional responsibility for field workers. Another strategy was to collect 10% validation samples for processing at laboratories of PCRWR and PCSIR in Islamabad. The field results obtained by Merck kits could then be compared with the Atomic Absorption Spectrometer (AAS) data. A total of 8,712 of samples were analyzed in the field using Merck field testing kit while 848 samples at laboratories using AAS as mentioned above.

Results and Discussion

Of the 8,712 samples, 9% had arsenic above the WHO guideline value of 10 ppb and 0.70% of samples had arsenic concentration above 50 ppb. However, analysis of 848 validation samples (10% of total samples) by AAS revealed that almost 30% of samples had arsenic concentration over 10 ppb and 7% above 50 ppb. It should be noted that lab results analyzed by Atomic Absorption Spectrometer are thought to be more accurate compared with those analyzed using Merck field testing kits. The breakdown of results by province are presented in Table 3.

Table 3. Results of National Level Survey for Arsenic Contamination.

Province	Total Samples (No.)		>10 ppb (%age)		>50 ppb (%age)	
	Field	Lab	Field	Lab	Field	Lab
Balochistan	619	71	1.30	1.40	0.0	0
NWFP	1560	156	0.30	22.0	0.0	0.6
Punjab	4315	428	12.2	36.0	0.60	9.0
Sindh	2218	193	11.0	26.0	1.40	10
Total	8712	848	9.0	28.0	0.70	7.0

As can be seen from Table 3, arsenic contamination is mainly prevalent in Punjab and Sindh provinces where over 11% of field samples revealed an arsenic level above 10 ppb and 0.6 to 1.4% samples over 50 ppb. NWFP and Balochistan had comparatively little arsenic contamination except one district in NWFP (i.e. Mardan) for which lab results indicated presence of arsenic over 50 ppb. It is interesting to know that similar results were also reported by PCRWR in 2002 while carrying out national water quality monitoring of 21 major cities in Pakistan. However, the provincial level consolidated data shown in Table 3 does not show the significant variation in arsenic level existing at district level. In Punjab, three districts viz., Multan, Rahim

Yar Khan, and Bahawalpur (located in Southern Punjab) had the highest level of arsenic contamination where 35%, 14%, and 9% of water sources had arsenic concentration over 10 ppb and 1%, 2.3%, and 0.6% over 50 ppb respectively. Similarly, in Sindh province, over 1% of water sources had arsenic contamination of over 50 ppb. These cases occurred in 4 of the 9 districts with 5% being affected in district Dadu followed by 3% in district Khairpur. In 2 of the 9 districts only 0.4% and 0.5% had arsenic contamination of over 50 ppb. In Dadu and Khairpur 18% and 21% of samples had arsenic contamination over 10 ppb respectively.

Results of laboratory analysis of 848 samples using AAS are shown in Table 3 along with field data. As can be seen from lab results, the degree of arsenic contamination in Pakistan seems to be much worse than one could judge in the light of field data. Overall 28% and 7% of samples had contamination over 10 ppb and 50 ppb as compared to 9% and 0.7% respectively for field data. The large deviation between laboratory and field results could be attributed to many factors including the higher level of accuracy of the laboratory method, inherent instrumental factors, weakness and loopholes on the part of field workers in collecting, analyzing, interpreting, and recording field samples, and deviation from standard protocol for field testing etc. The overall findings of the national survey led to the conclusion that some of the areas in Pakistan do have serious arsenic contamination and there is a serious need to further quantify the problem and to take remedial measures.

Arsenic Mitigation (2002-04)

Following the national survey for arsenic (see above section), a UNICEF team visited Bangladesh in order to learn from the the experience of Bangladesh in the area of arsenic mitigation. With assistance from UNICEF, this experience was then applied in Punjab by local governments and in Sindh by NGOs in coordination with local governments. The major activities undertaken under the arsenic mitigation programme included:

- Capacity development of government officials and NGOs;
- Blanket testing/screening of water sources in the 4 districts (Dadu, Khairpur, Nawabshah, and Tharparkar) in Sindh province which ranked highest in arsenic contamination during the national survey;
- 1st round of village level surveys for arsenic contamination in 3 districts of Punjab (Multan, Rahim Yar Khan, and Bahawalpur) which had ranked highest for arsenic contamination in Punjab followed by 5 more districts (i.e. DG Khan, Layyah, Muzaffargarh, Sargohda, and Jhang) in Punjab in the 2nd round of focussing;
- Blanket testing in Multan, Rahim Khan, and Bahawalpur in Punjab based on results of focussed survey;
- Research at PCRWR on development of low-cost household filters for treating arsenic contaminated water;
- Research at PCRWR on development of local field testing kits;
- Social mobilization and advocacy;
- Awareness raising based on the results of blanket testing; and
- Epidemiological study in Punjab on prevalence of arsenicosis.

Most of the above activities have been completed while some are still in progress. The following sections will give brief accounts of the above major activities especially those that are completed.

Capacity Development

Before the implementation of blanket testing, capacity of government officials, NGOs, and volunteers were developed in various skills such as collection and analysis of samples using field testing kits, recording results, collecting samples for validation at laboratory, effect of drinking arsenic contaminated water on human health, and identification of safer water options. However, development of capacity in the areas of case diagnosis and management is still to be done. In March 2003, Taluka Municipal Administration (TMAs), were trained in all those districts where UNICEF was assisting the Government of Sindh with providing drinking water and sanitation., They were trained on the use of arsenic field testing kits to ensure pre-testing of water sources, for example, before installation of hand pumps. The said TMAs then adopted the policy of making arsenic testing compulsory .

Blanket Testing/Screening of Water Sources

As mentioned earlier, the national survey (i.e. Union Council as a sampling unit in selected districts) indicated that the highest arsenic contamination was in Khairpur and Dadu districts in Sindh province. In the 1st round, six Talukas (Tehsils) were selected for blanket testing (i.e. screening of all water sources for identification of safe and unsafe water sources). Over 20,000 water sources were screened using Merck field testing kits and almost 2,000 validation samples (10% of total samples) were processed at PCRWR laboratory at Islamabad using an Atomic Absorption Spectrometer. The process of blanket testing led to identification of over 1000 unsafe (over 50 ppb) water sources in all the six Taluka/Tehsil in both the districts. The results for blanket testing including lab samples are summarized in Table 4. The field results showed 21% and 5 % of water sources had arsenic contamination over 10 ppb and 50 ppb while lab results showed much more higher contamination level i.e., 36% and 16% of water sources had contamination over 10 ppb and 50 ppb respectively. In 3 of 6 Talukas, almost one third of the water sources were contaminated with arsenic above 50 ppb. In Union Council (i.e., Agra in Taluka Gambat in district Khairpur) almost 75% of water sources had contamination over 50 ppb and 93% over WHO guideline value with highest recorded concentration of 972 ppb. The 2nd round of blanket testing in the remaining Talukas of districts Khairpur and Dadu, one Taluka of Tharparkar, and all Talukas of district Nawabshah is in progress. Over 45,000 'three-step approach') is recommended while for short term project/funding, the 2-step approach is suggested for areas where some indication of arsenic contamination has already been established.

Table 4. Results of Blanket Testing in Sindh Province for Arsenic Contamination						
Taluka	Total Samples (No.)		>10 ppb (%age)		>50 ppb (%age)	
	Field	Lab	Field	Lab	Field	Lab
Khairpur	1498	420	3.8	13.6	0.9	1.9
Gambat	4075	388	27.1	54.4	6.0	26.3
Kotdiji	3117	307	1.1	3.0	0.1	0.7
Dadu	5976	595	38	59	10.6	27
Sehwan	1400	139	30.4	44	5	28
Johi	1392	140	16.7	23	1.5	3
Total	20158	1989	21	36.2	5.0	16.0

Village Level Arsenic Survey in Punjab

Based on the findings of the National Survey, village level focussed arsenic testing (i.e. village as a sampling unit in the selected district). In the 1st round, all villages/wards in 3 districts of Punjab (Multan, Bahawalpur, and Rahim Yar Khan) were covered for arsenic testing. Five different water sources from each village were tested for arsenic contamination. About 11,975 water sources were tested in the field while 2,395 samples were analyzed at PCRWR (PCRWR, 2003a). As can be seen from Table 5, lab analysis by AAS revealed that approximately 23% and 3 % of water sources had arsenic contamination over 10 ppb and 50 ppb respectively while field results by Merck kit were 14% and 2% respectively above 10ppb and 50 ppb. All those villages/wards having arsenic over 50 ppb (as per field kit or lab analysis) were selected for blanket testing (i.e. screening of all water sources for mitigation purposes).

The second round of village level survey is in progress in selected areas of DG Khan, Layyah, Muzaffargarh, Sargodha, and Jhang districts of Punjab where over 9,000 water sources will be tested for arsenic contamination.

Table 5. Results of Village/Ward Level Focussed Survey in Punjab for Arsenic Contamination						
District	Total Samples (No.)		>10 ppb (%age)		>50 ppb (%age)	
	Field	Lab	Field	Lab	Field	Lab
Bahawalpur	3790	758	9.7	18.3	2.24	3.2
Rahim Yar Khan	5580	1116	7.9	18.6	0.98	2.9
Multan	2605	521	34.2	37.6	3.5	2.9
Total	11975	2395	14.2	22.7	1.92	2.8

Advocacy, Social Mobilization and Awareness Raising

The results of these surveys has indicated that arsenic is a serious issue in Pakistan. Accordingly, various government agencies, and other stakeholders including UN agencies and NGOs have started the process of alliance building to address the issue. The Local Government of Punjab and Sindh took the lead of holding provincial level seminars-cum-workshops to publicly share data on the status of arsenic in Pakistan for the first time and to outline an action plan for arsenic mitigation in Pakistan. These seminars provided formal basis for social mobilization and awareness raising at various levels starting from national to household levels. It is very encouraging that local and national media (newspapers) have very recently started to give coverage to the arsenic issue in the country and highlighted arsenic mitigation activities being carried out in affected areas.

At the community level, the process of awareness raising is in progress where representatives of NGOs (SAFWCO and SHED in Sindh) and (HRDS in Punjab) are busy marking water sources with green paint (to indicate safe sources) and with red paint (to indicate sources unfit for human consumption), sharing basic information with communities on arsenic, and showing posters. Arsenic mitigation in Pakistan is still in its embryonic stage, and there is need to develop a sustainable and effective mechanism for behavioural change communication (BCC) within the government structure such as health, education, and social welfare etc. with support from the media and civil society. This current level of awareness cannot be regarded as satisfactory.

Development of low-cost treatment technology & field testing kits

Pakistan Council of Research in Water Resources (PCRWR) and UNICEF collaborated in developing low- cost household level filters for treating arsenic contaminated water. Considering the socio-economic background of rural and urban populations in the arsenic affected areas, three options of low cost arsenic removal technologies (i.e. clay-pitcher, plastic gravity flow, and ceramic cartridge arsenic removal filters) have been developed (PCRWR, 2003b). Monitoring of these filters in a laboratory for a period of six months indicated that the clay pitcher arsenic removal filter was the most feasible technology with respect to arsenic removal efficiency, life of media used, estimated cost as well as simplicity and ease of use. It reduced arsenic from an initial value of 300 (before treatment) ppb to 0.2 ppb (after treatment) at the beginning of the monitoring period and reduced it to 50 ppb at the end of about six months thus determining the maximum useful life. The clay pitcher has a volume of about 20 litres. The clay pitcher has small holes: approximately there are 10-12 holes of 1 mm diameter sufficient to maintain the flow within the required range. The cost of the filter, as estimated during the experimentation, is Rs. 400-600 (i.e., 7-10US$). However, it is believed that it may reduce substantially on mass production at local level because production of a few units for the laboratory is expensive due to high fixed cost. This new technology requires promotion in the areas where there is no alternative safe, arseni- free water available. In addition, more research needs to be carried out to provide a wide range of technologies meeting varying needs of consumers.

Availability of a locally-made, cheap and reliable testing kit for measuring arsenic is one of the important elements of success of mitigation measures at community and household level. With assistance from UNICEF, PCRWR has initiated a project to develop water quality kits for field testing of arsenic, bacteria and other basic parameters. Initial findings of the research work are very encouraging.

Epidemiological Study in Punjab

The Institute of Public Health (IPH), Govt. of Punjab, with support from UNICEF, carried out a comprehensive epidemiological study of prevalence of arsenicosis due to ingestion of arsenic through drinking water in seven districts of Punjab (i.e. Bahawalpur, Layyah, DG Khan, Multan, Muzaffargarh, Rahim Yar Khan, and Jhang). During the study, of 38,794 people, 28,545 individuals were screened for arsenicosis including analysis of finger nail samples for arsenic level. For the screened population, 40 cases of arsenicosis (i.e. 3 clinical arsenicosis and 37 borderline) were detected giving the prevalence of clinical arsenicosis and borderline arsenicosis to be 11 and 130 per 100,000 respectively (IPH, 2003). The mean arsenic concentration in nails among the persons consuming water for 10 or more years was found to be almost 70% (i.e. 0.086 mg/kg) higher than those consuming from the stated sources for less than 10 years while mean arsenic in nails among the persons consuming water with arsenic more than 50 ppb was 0.1964 mg/kg which was about 250 % higher than those consuming water with arsenic less than 50 ppb. The study acknowledged arsenic contamination in drinking water to be an emerging public health problem in Pakistan. It was concluded that though prevalence of dermatological lesions related to arsenicosis was low, yet a large proportion of the population was at risk of developing arsenicosis if it continuously remained exposed for a longer duration to the existing high level of arsenic in water. It should also be noted IPH with assistance from UNICEF conducted a similar study in Northern Punjab (Jehlum, Gujrat, and Sargodha) as a follow up to the preliminary investigation on arsenic contamination described earlier. The combined figure for clinical and borderline dermatological arsenisosis for all 10 districts came out to be 92/100,000 and 242/100,000 respectively. There is a dire need of carrying out similar studies in Sindh where arsenic contamination is much worse than Punjab and where unconfirmed cases reported by non-governmental sources are increasing.

Analysis of Reliability of Field Data

The data presented in Tables 3-5 indicates that the overall results given by AAS were consistently higher than those given by field kit. Here the basic question of reliability of field data arises. To what degree can we expect field data to be consistent with AAS data? What will be the consequences and implications of this on decision making related to operational aspect of arsenic mitigation? For example, identification and marking of drinking water sources as 'safe' (i.e. within maximum permissible limit of 50 ppb) or 'unsafe' (above 50 ppb) requires critical decision-making. Therefore, we analyzed lab and field data for false negative, false positive and matching results. Table 6 shows summary of such analysis.

Table 6. Accuracy Analysis: Field Kit Vs. Lab Method (n = 4275)

	Total Samples	
	Number	% age
False Negative (Field Kit giving less than 50 ppb for which actual value by AAS is greater 50 ppb)	244	5.7
False Positive (Field Kit giving over 50 ppb for which actual value by AAS is less than 50 ppb)	66	1.5
Matching results for above 50 ppb	127	3
Matching results for 0-50 ppb range	3838	90
Accuracy level (i.e., both AAS and Merck Kit giving consistent results)	3965	93

As can be seen from Table 6, results of field kits are valid and accurate for almost 93% of cases. There exists a discrepancy of slightly over 7%. Of the total discrepancy, 80% are false negative and the rest are false positive. Thus there is a probability of 1.5% in marking a safe source unsafe and 5.7% chance of considering arsenic contaminated source of over 50 ppb to be a safe one. However, for practical purposes an accuracy level of 93% is well within the acceptance level for identifying sources that have risks of causing arsenicosis. It should be noted that if human errors in analyzing, reading, and recording are minimized and if the standard method is adopted for collecting samples, an even higher accuracy level is expected. Secondly, using lab method (AAS) is not only costly but also time consuming and thus is not a practical solution. Taking 5-10% samples for validation at lab should be continued as a standard method to support the arsenic mitigation.

Causes of Arsenic Contamination

Though no scientific research has been done in Pakistan to investigate the causes of arsenic contamination, critical analysis of available data on prevalence of arsenic reveals that arsenic contamination is predominant in the Indus plain. For example, all those districts identified as high in arsenic contamination (i.e. Multan, Bahwalpur, Rahim Yar Khan in Punjab province, and Khairpur, and Dadu in Sindh province) are lying in alluvial deposits along the Indus River. Interestingly, within a given district, areas lying closer to the river

Indus system were found to have relatively higher arsenic concentration than those away from the river system. For example, in district Dadu, data available for three Talukas/ Tehsils (sub-district units) clearly provide justification for this theory. As can be seen from Table 4, Johi and Sehwan Talukas (which are located very near to Indus river) where over 27% of water sources have contamination over 50 ppb, while the third Taluka (i.e. Johi, which is located far away from the Indus river) has an average contamination of 3% which is 9 times less than that of other Talukas. The same pattern is prevalent in district Khairpur where Gambat Taluka is located very near to the Indus River, Khairpur Taluka in mid way while Kotdiji is farthest from the Indus River. The respective arsenic levels above 50 ppb for Gambat, Khairpur, and Kotdiji are 26.3%, 1.9%, and 0.7% (Table 4). In Tharparkar (one of the southern districts in Sindh bordering with the sea), areas closer to the sea were found to have a higher arsenic level than those away from it. All this field based evidence suggest that the process of arsenic release from alluvial deposits lying near to the Indus river system is faster than those lying away from the river zone. However, a detailed scientific investigation needs to be done to get more insight into this aspect .

Distribution of Arsenic in Groundwater

Data for 19,571 water sources from Sindh province and 3,965 water sources from Punjab are shown in Tables 7 and 8 respectively. For Sindh, arsenic distribution from water sources at depths of 10-150 feet more or less follows a similar pattern, showing both shallow and deep groundwater is contaminated. However, for depths over 150 ft no arsenic contamination was observed. 68 of 69 water sources in this depth range have no arsenic contamination at all while only one has contamination less than 10 ppb (Table 7). In Dadu, two water sources hardly 100 ft apart, one deep and the other shallow, when tested gave different results: the shallow one had contamination over 100 ppb while for the deep one it was less than 10 ppb.

Data from Punjab province, as given in Table 8, more or less showed results similar to those of Sindh. Both water sources from depths of less than 100 ft and above 100 ft have arsenic contamination. In addition, data gathered by UNICEF, for 6 wells (3 shallow and 3 deep) in Muzaffargarh (Punjab) located at lateral distance of 65 ft to 165 ft apart from each other revealed that arsenic in shallow well (20-35 ft deep) ranged from 2.2 ppb to 9 ppb while in deep wells (100 to 350 ft deep) it was from 61 to 170 ppb suggesting increase of arsenic with depth in this specific locality. *This seems to show a different pattern from that found at Sindh – where no contamination was found at depth above 150 ft. Detail hydrogeological investigation is required to explain such differences.* However, without testing one cannot generalize presence or absence of arsenic for given water sources and thus every source has to be tested for arsenic presence before establishing whether it is safe or not.

Table 7. Distribution of Arsenic with respect to Water Table-Sindh Province

Depth (ft)	Total Samples (No.)	Total Samples (%)	0-10 ppb (%)	10-50 ppb(%)	Over 50 ppb (%)
10-50	12,398	63.3	84.0	12.0	4.0
51-100	6,931	35.4	69.0	24.0	7.0
101-150	173	0.90	66.5	26.0	7.5
Above 150	69	0.40	100	0.0	0.0
Total	**19,571**				

Table 8. Distribution of Arsenic with respect to Water Table-Punjab Province

Depth (ft)	Total Samples (No.)	Total Samples (%)	0-50 ppb(%)	Over 50 ppb (%)
Less than 100	3,692	93	94.0	6.0
100 and above	273	7	96.0	4.0
Total	**3,965**			

What's still needs to be done in Pakistan?

As said earlier, arsenic mitigation in Pakistan is in its very early stage. So far what has been done is mainly due to UNICEF assistance, no project/programme has beeninitiated independently by government or any other agency including NGOs. Therefore, with formal recognition of the problem, it is expected that government and non-government agencies with support from the donor community will launch mitigation programmes. Following are the key areas to be considered under arsenic mitigation:

- Establishing institutional arrangement and developing capacity in arsenic mitigation. This is crucial for ownership of the programme, which is currently missing.
- Establishing coordination mechanisms and technical groups on various aspects of arsenic mitigation. Currently, there are no coordination mechanism among various government departments and civil societies.
- Legislation and policy development on arsenic mitigation such as to make arsenic testing compulsory, establishing a guideline value arsenic (i.e. whether 10 ppb or 50 ppb (proposed 10ppb)), short term and long term mitigation policy, compulsory screening for arsenicosis in government hospitals especially in arsenic affected areas etc.
- Establishing case diagnosis and management protocol system in the health department for suspected arsenicosis. This will also include registration of confirmed cases.
- Capacity building of health department on case diagnosis and treatment of patients.
- Sustainable water quality monitoring and surveillance system at various level including at community level. This is crucial area: arsenic mitigation programme shouldn't

be launched without having this in place. The reason is obvious: changing arsenic situation, treatment technologies, and new water sources/installation of drinking water systems etc. requires regular monitoring, not one time testing,

- Acquifer and water quality mapping of sources including database on arsenic situation in the country,
- Establishing effective and sustainable behavioural change communication programme on arsenic mitigation including development of communication support materials,
- Research work on key areas such as hydrogeological research, development of local and affordable treatment technologies. At the moment, only one such option has been developed. Linkages need to be established with universities and other research institutions, and with private sector for mass production and promotion of filters and other technologies.

Major lessons learnt

In Pakistan, while implementing arsenic mitigation programme, many lessons have been learnt at various levels. It is not possible here to give an account all of them. However, the major lessons learnt in the process are:

· Government ownership is key for the success and sustainability of the programme. Though obvious, government must lead all arsenic mitigation programmes because arsenic mitigation does not only involve identification of safe sources through blanket testing, case diagnosis, and creating awareness but also includes providing alternate safe water sources, treatment of patients, and long term monitoring and surveillance system which requires huge investment, that can not be done alone by communities and NGOs etc.,

- Water quality mapping and data management must be planned before carrying out blanket testing and surveys,
- Authentication of field data through highly accurate lab techniques, especially by laboratories owned by government, was found to be a very powerful advocacy tool for recognition of the problem,
- Though NGOs accomplish the assigned projects on arsenic mitigation well, in time and meeting the short-term objectives, the process is neither sustainable nor effective in the long term. Therefore, an arsenic mitigation programme should be launched jointly by the government, NGOs and of course communities such that the government assumes the role of direct implementation while NGOs support the government in capacity development, social mobilization, and awareness raising etc.
- Arsenic mitigation without any government policy lacks directions and vision, and
- Fast and effective sharing of vital data and information on arsenic with users/communities is important for building confidence and making the mitigation measures successful.

Conclusions

The following major conclusions can be drawn:

- Arsenic is an emerging serious issue at least in two provinces Punjab and Sindh where about 3% and 16% of water sources are contaminated with levels of arsenic over 50 ppb. The percentage of water sources with concentrations above the WHO level of 10 ppb is 20% and 36% respectively in Punjab and Sindh.
- Both shallow and deep water sources are contaminated and therefore testing of every water sources is necessary.
- Rigorous analysis of field and lab data has indicated the reliability of field testing kits. The accuracy level was almost 93%.

Recommendations

Institutional arrangement, capacity development at various levels, legislation and policy development, water quality monitoring and surveillance, case diagnosis and management, coordination mechanism, and resource mobilization needs to be addressed in Pakistan for ensuring sustainable and effective arsenic mitigation programme.

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