Annexure

A. Sustainability of Arsenic Removal Technology

Based on the working principles, the Arsenic removal methods can be classified into three categories: (i) Chemical precipitation method, (ii) Adsorption method, and (iii) Membrane separation method. An appraisal of different treatment technologies and their effectiveness reported from laboratory testing conducted by researchers has been given through **pages 105-108 (Chapter-6).** Among these categories, Membrane separation method by Reserve osmosis has been reported the most promising one with removal efficiency of 99% followed by the Chemical precipitation method using Lime softening with removal efficiency of about 95%. The Chemical precipitation method by Oxidation/iron co-precipitation, has been reported to have removal efficiency ranges between 90 and 99 % under the controlled pH-Eh conditions and an optimized Fe dosage. The efficiency of adsorption methods by Activated alumina or by Ion exchange have been reported ranges above 45%. The Reverse osmosis technology although does not produce toxic solid waste but requires high tech operation and maintenance, and relatively costlier than other two methods. The oxidation/iron co-precipitation method is simple in operation and less costly, but produces toxic solid waste and requires daily dosing of chemicals; while the adsorption method, which is less efficient and relatively costlier than the oxidation/iron co-precipitation method, also produces toxic solid waste and requires periodic replacement/ regeneration of filtering media. Apparently, Lime softening and Iron co-precipitation techniques sound to be the most effective removal technologies, barring the Membrane separation method, however, the adsorption technique showed successful field performances and implications.

Performances of 10 arsenic removal devices developed by different agencies, and applied in West Bengal to treat for removing arsenic from arsenic contaminated groundwater with some degree of success have been given in Table 5.1 **(pages 76 -77) and Fig 5.1 (pages 101-102).** Very few plants could show satisfactory performance at the field level, both in terms of arsenic removal efficiency and in sustainable running. The devises which have shown relatively good performances at the field level are: Granular Ferric Hydroxide (GFH) of Pal Trockner (P) Ltd., Kolkata - a German Technology; Arsenic Removal Plant by Oxide India (Catalysts) Pvt. Ltd, Durgapur; and Apyron Arsenic Treatment Units by Apyron Technologies (P) Ltd. representing Apyron Technologies. The working principles of these technologies are based on adsorption technique. The major setbacks, with other devices remain with the operation, maintenance, replacement and removal of used filters. The systems in which O & M have been linked to the responsibility of suppliers have shown satisfactory performance. It was reported that majority of the operation and maintenance issues were related to tube wells, that have nothing to do with the ARP or its chemical media.

It indicates that sustainability of arsenic removal devices largely relies on the operation and maintenance of the devices, the consistency of the source water quality, and the acceptability of the devices by the users and beneficiaries. A technology having simple operation and cared maintenance as well as cost effective, users and eco-friendly has the potential of sustainability. There is, therefore, need arises for R & Ds to improve upon the existing devices and/or develop new technologies to satisfy the conditions of eco-friendliness (less sludge producing/sludge free), cost effectiveness and user friendliness. In areas where population density is relatively more and the area is under the grip of arsenic effect and there are limited scope for alternate freshwater supply; arsenic removal devices, by choosing the best working model among the existing devices under the public-private partnership with community participation in the O and M, would be a suitable proposition to meet the demand of potable water supply.

B. Sludge management

The arsenic removal devices, which have been implemented in the field particularly in West Bengal, are based on the working principles of Chemical precipitation and Adsorption. Both the arsenic treatment techniques produce several different types of waste, including sludges, brine streams, backwash slurries and spent media. Treatment of the slurry, obtained from arsenic removal process (from groundwater), is essential to make the slurry arsenic free so that it can be disposed without any hazard of the arsenic re-entering the aquifer system. Arsenic sludge management has been reported as one of the major concerns (pages 94-95, and 112-113). Even the treatment devices, which have shown relatively good performances at the field level, namely; Granular Ferric Hydroxide (GFH) of Pal Trockner (P) Ltd., Kolkata - a German Technology; Arsenic Removal Plant by Oxide India (Catalysts) Pvt. Ltd, Durgapur; and Apyron Arsenic Treatment Units by Apyron Technologies (P) Ltd., are also not devoid of sludge management problem. How the sludge produced and/ or being produced from different arsenic removal filters in the schemes implemented in West Bengal is disposed and managed, has not been clearly spelt out in any document, rather remained an unanswered question. The All India Institute of Hygiene and Public Health (AIIH&PH), Kolkata has suggested the following methods for arsenic rich sludge management:

- *Disposal in on-site sanitation pits,*
- *Mixing with concrete in a controlled ratio,*
- *Mixing with clay for burning for brick manufacturing.*

A number of studies (Rouf and Hossain, 2003; Mahzuz et al., 2009) showed that use of arsenic contaminated sludge in proportion in making bricks nearly at 1000oC neither reduces the compressive strength of bricks nor cause any negative effects. The studies clearly suggested that arsenic and iron sludge can be used as brick material. Banerjee and Chakraborty (2005) reported that stabilization process by briquette, cement-sand mortar and concrete mixing with other common ingredient do not produce toxicity Characteristic leachate beyond permissible limit. It was suggested that 25% (by volume) of cement can be replaced by the fly ash to stabilize arsenic-laden to the tune of 11% (by volume of cement-mortar. It indicates that arsenic sludge can also be used/managed effectively for our demand management.

C. Potentials of deeper aquifers and surface water as alternate source of drinking water

(i) Potential of surface water sources

Supply of surface water from ponds, rivers etc. for drinking purposes through pipe network system after suitable purification by conventional method of treatment viz. coagulation, flocculation, rapid sand filtration and disinfections, as an alternate option, have been put into practice in some places in West Bengal. Eight such surface water based schemes have been operationalized by the West Bengal Government in different places, covering population of 3.85 million in 1266 mouzas. All the surface water based schemes are successfully running to provide potable water supply to masses covered under the schemes. In Bihar also, a number of surface water based pipe water supply schemes with their intake from the Ganga River to meet demand of multi-village supply are under construction. Surface water based schemes are constrained by number of factors, namely; (i) technical feasibility, (ii) water availability, (iii) cost factors, etc

Surface water sources are not omnipresent, and, therefore, cannot be located and extended everywhere. Moreover, water in some of the flowing/ stationary bodies remains only for a specific period of a year and cannot form the regular source for public water supply system. In addition to that, due to changes in the river discharges and its flow course, it is difficult to keep a sustainable intake point of water for the whole year. Most of the arsenic affected areas in the Ganges are along linear track of the river Ganga in U.P., Bihar, and Jharkhand state and along the river Bhagirathi in West Bengal, supply of potable water from the surface water sources, wherever feasible, can be the most promising alternative. In areas, where surface water supplies are available or can be made available by any water conservation method, surface water based scheme after suitable purification could be the suitable proposition for potable water supply.

(ii) Potentials of Deeper Aquifers

The arsenic contaminated zones in the Ganga-Brahmaputra fluvial plains mostly lie within the shallow aquifer (<100m bgl). The deep aquifers (>100 m bgl) underneath the contaminated shallow aquifer, in many places of Bengal Delta Plains, are normally seen arsenic free. The deeper aquifer is separated by a thick clay layer of appropriate composition from the shallow aquifer. From the isotopic studies carried out in West Bengal, it was observed that there was no hydraulic connection between the shallow and deep aquifers as they belong to different age groups. Those deep arsenic free aquifers have the potential to yield nearly 5 to 20 lps of water, which is largely adequate to meet demand of water in the domestic sector. Field studies indicated that properly designed tube wells are capable to harness deeper arsenic free aquifer without posing any future threat of arsenic mobilization from the overlain contaminated zone (**pages 61-63)**. Similar is the experience from Bihar; deeper aquifers occur under semi-confined to confined conditions are arsenic free and hold groundwater of about ~3000 yrs, The deeper arsenic-safe aquifer has potential to yield about 150-200 m3 /hr, which can be taped through heavy duty deep tube wells.

A properly designed well with screen length tapping the desired aquifer, along with cement sealing of interface of shallow arseniferous aquifer and deep aquifer, is proficient in safe withdrawal of water from the deep aquifer having no risk of arsenic rich water. The areas where deeper aquifers can be tapped with no future risk of contamination from the overlain aquifer; supply of potable groundwater by exploration of deeper aquifers can provide an alternate option of dependability on groundwater resources.

References

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