Chapter - 7
Work Ahead: Critical Concerns and Key Challenges

7.1 Unfinished Agenda

Arsenic was first detected in India in the early 80s, in a village in West Bengal, where some of the villagers developed symptoms of Arsenicosis and skin pigmentations. At that time, the cause for sickness and symptoms were not known to the medical professionals. Neither the Public Health Engineers nor the community water supply sector professionals were aware of the danger posed by such a serious chemical contaminant as Arsenic. There was absence of even the rudimentary facilities of water quality monitoring and surveillance in the rural areas of the country at that time. The people continued drinking arsenic contaminated water for years, got sick and hospitalized and then only the cause and source of water contamination was identified. Since then, during the last three decades, substantial amount of work has been done to enrich our knowledge in respect of the following.

(i) *The source and cause of Arsenic contamination of ground water.*
(ii) *Extent and magnitude of the same.*
(iii) *Mechanism of dissolution of Arsenic from soil to ground water.*
(iv) *Impact on Community Health: Diagnosis of sickness and symptoms.*
(v) *Development of technologies for removal of arsenic from ground water.*
(vi) *Analytical techniques for detecting arsenic from ground water.*

It is needless to say that a comprehensive understanding of the above aspects would go a long way in developing immediate, interim and long term strategy, to address the problem. The first decade, that is, the 80s, when the arsenic problem was first detected, was conspicuous by slow response of the administration in identifying the problem and assessing the extent and magnitude of the same. The R&D studies, water quality monitoring and epidemiological assessment, were all too inadequate to measure up the situation. Till date, except the state of West Bengal, no other states in India, and a very few countries, have developed a comprehensive plan of action to deal with the situation. Even in West Bengal, where a master plan for an ambitious programme of supplying arsenic-free water to all the affected villages through a system of piped water supply after appropriate treatment is in place, implementation of the same is taking inordinately long time. As a result, a large portion of the affected population continues to be at risk. The basic agenda is of ensuring a sustainable and affordable supply of arsenic free water to all segments of community, in the geographical areas, where concentration of arsenic in ground water is high and above permissible limit. This agenda still remains largely unfinished in most of the countries. In the next few paragraphs in this chapter, we will discuss the current knowledge gaps, critical concerns and key challenges, facing the country and also the factors which are impeding the progress of mitigatory programmes.

7.2 Critical Concerns

The National Governments in many of the Asian countries, affected by high Arsenic in groundwater, are trying to meet the challenges with varying degrees of success. The primary task of providing Arsenic safe water to millions of people needs to address the following critical concerns.

- Water quality monitoring
  * *District & Block level Capacity Building.*
- Identification of Arsenic contaminated as well as safe sources: both public & private
- Provision of alternate sources of Arsenic free safe drinking water.
- Village specific GIS Database and Action Plan and sharing the same with all stakeholders.
- Establishing a transparent system of information sharing by all stakeholders
  * *Health Education.*
  * *Awareness Generation.*
- Health Risk Assessment and estimation of disease burden :
- Provision of Medical Relief for the critically affected people :
  * *Training of Medical Practioners in Govt, as well as outside the same.*
- Long-term change in agriculture and Irrigation practice:
  * *Restricting the use of Groundwater.*

7.2.1 National Standard for Arsenic in Drinking Water

In addressing the key-concerns and developing a National Plan of Action, for providing Arsenic safe water to the community, the 1st key-step is to establish a National Standard for Arsenic in Drinking Water.

The WHO is helping the countries in developing their own national standards. The present guideline value of Arsenic in groundwater of WHO is 10ppb, but as could be seen below in the table, many countries are still adhering to the standard of 50 ppb of Arsenic.

Country standard for Arsenic in Ground water

Countries	Standard Mg/L	Countries	Standards Mg/L
Australia	0.007	Bolivia (1997)	0.05
European Union (1998)	0.01	China	0.05
Japan (1993)	0.01	Egypt (1995)	0.05

Jordan (1991)	0.01	India	0.05
Laos (1999)	0.01	Indonesia (1990)	0.05
Mongolia (1998)	0.01	Oman	0.05
Namibia	0.01	Mexico	0.05
Syria (1994)	0.01	Philippines (1978)	0.05
USA (2001)	0.01	Saudi Arabia	0.05
Canada	0.025	Sri Lanka (1983)	0.05
Bahrain	0.05	Vietnam (1998)	0.05
Bangladesh (1997)	0.05	Zimbabwe	0.05

In setting national Standard for Water Quality parameter like Arsenic, Fluoride etc, the National Govts. need to consider various issues related to the social, cultural, health and other benefits related to the standard and the cost of compliance of the same. The table below depicts a case study for Bangladesh. The situation in Indian states, particularly, West Bengal is similar and the cost of implementing a higher standard is of the same order.

Estimated Health benefit and costs of compliance of present Bangladesh standard and WHO GV for arsenic in drinking water

Arsenic Level in Drinking Water	Present Level	<50 μg/L.	<10 μg/L.
Total Risk of Skin Cancer	377,000	55,000	15,000
Percent of population	0.290	0.042	0.012
No. of TWS to be abandoned	-	2.0 million	3.5 million
Cost of abandoned TWs (Taka)	-	9.1 billion	15.5 billion
Cost of alternative water supply (Taka)	-	12 billion	24 billion
Cost of monitoring remaining safe tube wells (Taka/year)		170 million	800 million

Note: Assumptions, No. of shallow tube well = 7.5 million; cost of a shallow tube well=4,500.
Source; Prof. F. Ahmed, BUET, Dacca

But the above case study is based on the EPA model, which as stated earlier, possibly over estimates the health risk associated with Arsenic. As a matter of fact, many Health Scientists in India, China and Bangladesh, believe that the additional health benefit of lowering the standard from 50 ppb to 10 ppb, would be marginal and does not justify the huge expenditure required. On the other hand, many health scientists strongly feel that standard should be strictly based on health risk and no compromise should be made on economic consideration.

It is, therefore, recommended that the standard for water purification units, the standard of Arsenic in treated water should be 10 ppb. But the threshold value for rejection of a water source could continue to be 50 ppb for sometime. BIS and the Dept. of Consumer Affairs should take an unequivocal stand in this matter.

7.2.2 Identification of Contaminated Sources and Creation of District, Block and Village Level Databases: Key Challenges

In West Bengal, all public tube wells have been tested through a net work of rural laboratories. Near about 150,000 water samples have been analyzed in the block level laboratories. And GIS Database has been created at the district, block and habitation level. However, the most challenging task, which is yet to be accomplished, is the testing of near about 500,000 private sources. Adding to the menace, the identification of contaminated public tube wells remains incomplete in other states like Bihar, UP, Jharkhand, Chhattisgarh, Assam etc. Though organizations, like SOES, Jadavpur University, Sriram Institute and quite a few others have done remarkable work, the basic task of identifying all arsenic contaminated sources, public as well as private, remains largely incomplete. If we consider the tube wells' use for irrigating and vegetable plants, in the arsenic affected districts, the task becomes more difficult and complex.

7.2.2.1 Field Testing Kit vis-à-vis Network of Laboratory

The magnitude of the tasks involved raises the question of use of field kits vis-à-vis creation of network of block/village level laboratories. In West Bengal, considering the risk of false positive and false negative data, by the use of field test kits, the Arsenic Task Force opted for creation of a network of rural laboratories, at the rate of one laboratory for every three blocks, through Public Private Partnership. As a matter of fact, the Arsenic crisis in West Bengal has been a blessing in disguise, in the sense that it has resulted in development of institution and capacity, at the block and village level Panchayatiraj organizations, for water quality monitoring and surveillance.

It must, however, be noted that though the above system has been successful in monitoring public sources, the big question remains on the monitoring of water quality of the private sources. In Bangladesh, a community based approach, using field kits, has created a very large database covering both public and private sources. However, the precision and dependability of the same is always open to question. The challenge is to produce field test kits, which are robust, reliable, cheap and simple enough to be used by relatively unskilled users in the villages of India and Bangladesh. It is also imperative to say tat these field kits and supplies should be readily available for the rural markets. Misclassification of arsenic contaminated drinking water sources is a real risk, considering the large number of wells, having arsenic concentrations close to the existing national drinking water standard. However, giving the private well owners full information, about the test result of his well, will alert them to a considerable degree, regarding the contamination of their water supply. This will also enable them to make their own decisions regarding the use of the tube wells, owned by them.

7.2.3 Provision of Arsenic Safe Water to the Community: The Key Challenge of Sustainability

In West Bengal, the Master Plan envisages supply of arsenic safe water, to all the affected habitations, through a system of piped water supply, which would be fed from treatment plants after appropriate treatments. 40% of the villages would be supplied from mega water treatment plants, drawing water from large perennial rivers like the Ganga. They would supply water through kilometers of water distribution system after appropriate treatment for bacteriological purification. 60% of the villages would be served by mini-piped water supply network, which would be fed from large diameter tube wells after removing arsenic by using appropriate technology. This is the most ambitious long term mitigatory programme undertaken by any State Govt. for the arsenic affected rural community. The implementation of the master plan is expected to be completed by 2011. But the progress of work indicates delay in project execution. The more vital question that remains to be answered is that, whether such a capital intensive approach could be sustainable in the long run. Effected operation and maintenance of the system, through people's participation in cost sharing and maintenance, could go a long way in ensuring sustainability. The success of West Bengal experience could set a model for nation wide replication. However, to make a community based scheme sustainable, the Govt. effort needs to be supplemented. These efforts can be community based approaches through the implementation of decentralized small scale community maintained rural water supply projects, based on traditional surface water sources, that are largely supported by rain water harvesting. There are millions of traditional surface water sources like ponds and dighis in states, like West Bengal, Bihar, UP, Jharkhand, Chhattisgarh, Assam etc, which could be rejuvenated, conserved and utilized.

7.3 Existing Knowledge Gaps

7.3.1 Health Impact: Scientific Health Risk Assessment and Rational Estimation of Disease Burden

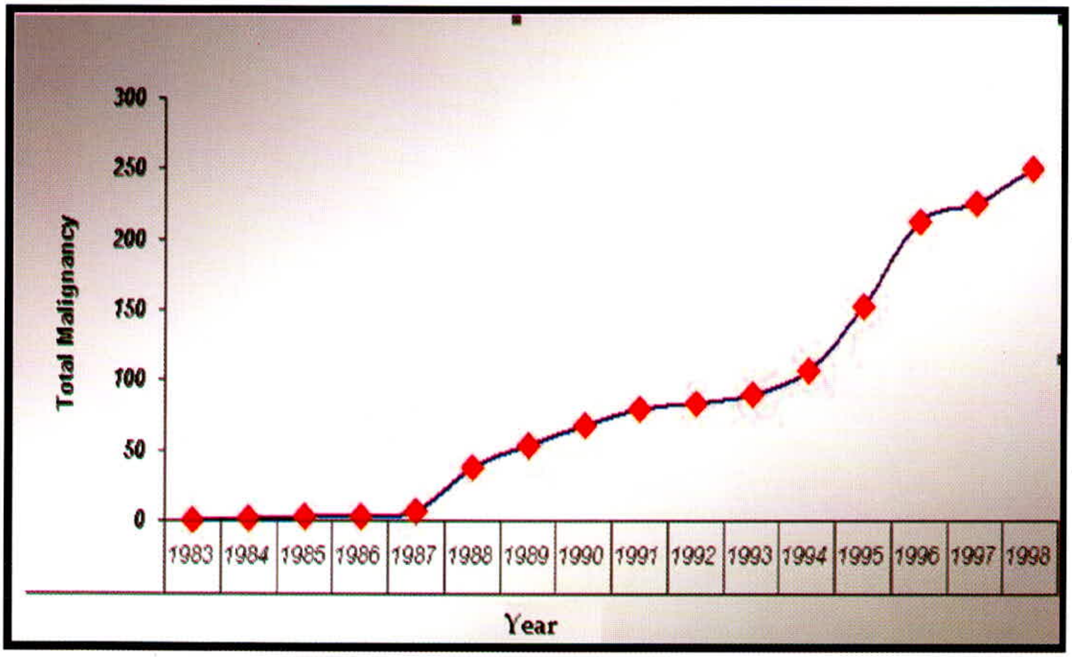
Though near about 30 million people are living in the hydrogeologically risk zones (79 affected rural blocks and 12 urban communities) in West Bengal and substantial population in Jharkhand, Bihar, Chhattisgarh, Uttar Pradesh and Assam, the exact number of people, drinking arsenic contaminated water and suffering from Arsenicosis, is yet to be established scientifically and epidemiologically. Considerable confusion and contradiction persists in this matter. While the official statistics of the Dept. of Health, Govt. of West Bengal, reports Arsenic related disease burden to be <15000, unofficial sources put the same between 200,000 to 300,000. The impact and symptoms of arsenic contamination differ in severity between individuals, population groups and geographical areas. The severity and manifestation of symptoms also depend upon the concentration of arsenic in water, the daily average intake, overall health and nutritional level of the person and many other factors. This makes assessment of the burden on an individual's health on account of arsenic consumption a complex exercise. A scientific epidemiological assessment of the extent and magnitude of the problem is yet to be made. High concentrations of arsenic in community water sources do not always co-relate with high levels of Arsenicosis symptoms in the community. According to a multistage model, applied by EPA to estimate life-time risk of skin cancer (based on an Epidemiological study in Taiwan), WHO guideline value of 10 ppb Arsenic in drinking water is associated with a life time excess skin cancer risk of 6 per 10,000 people. The same for the National Standards 50 ppb, followed in India, Bangladesh and many other Asian countries, is 29 per 10,000 people (0.29%).

Estimated incidence of excess lifetime skin cancer in Bangladesh

• Drinking Water Supply in Bangladesh	Estimated incidences of Excess Skin cancer (% of Present Population)
• At present Arsenic Contamination Level	375,000 (0.290%)
• Satisfying the Bangladesh Standard of 50 ppb.	55,000 (0.043%)
• Satisfying the WHO Guideline value of 10 ppb.	15,000 (0.012%)

Source; Prof. F. Ahmed, BUET, Dacca

It appears that the model over estimates the actual risk of skin cancer than it actually exists. This over estimation could be due to the conservative assumptions made in the model. Melanosis and Keratosis are considered as 1st & 2nd stages of Arsenicosis, which may turn into skin cancer if Arsenic ingestion continues. The primary identification of Arsenicosis is generally diagnosed by the visible symptoms of Arsenic related skin lesions. In Bangladesh, health surveys have been conducted in 58 upazilas covering about 12% of the population. The prevalence of Arsenical skin lesions has been found to be 0.086%, which is much lower than the estimated excess skin cancer risk at the present level of contamination in the country. The data of the health survey also presents a rather poor relationship between prevalence of Arsenical skin lesions and average Arsenic content in the tube well water. Limited information is available, regarding the disease burden due to arsenicosis in West Bengal. In an epidemiological survey carried out by Dr. Guha, Majumdar et al (1998), in one of the affected districts of West Bengal (South 24 Parganas), where 7683 people were examined in 57 arsenic affected villages, the prevalence of arsenical skin lesion was found to be 4.6%. Further, Saha (2003) reported the incidence of arsenic related cancer to be 5.1%, among 4865 cases of arsenicosis examination, during the period of 1983 to 2000. However, the data of the former study represents information in a highly exposed region of the state, while the later data were compiled from cases, examined in a tertiary referral centre and some scattered survey, carried out in the affected districts of the state.



(Source: Dr. K.C. Saha, Ex-Prof. of Dermatology, School of Tropical Medicine, Calcutta)

Figure 7.1: Increasing malignancy due to Arsenic contamination in West Bengal

Existing situations suggest that considerable knowledge gap exists, in respect of Health Impact of Arsenic contamination of groundwater in India. Dept. of Health & Indian Council of Medical Research should consider undertaking an Epidemiological Survey in all the affected states, with adequate sample size to find out the prevalence of Arsenicosis among the affected population and correlate the same, if possible with the Arsenic concentration in the well water. More effective collaboration and co-ordination is necessary between the Departments. of Health, Panchayat & Rural Development, Public Health Engineering to assess the health risk, associated with Arsenic in groundwater and plan mitigatory measures.

7.3.2 Arsenic Contamination in Agriculture: A Threat to Water - Soil- Crop - Animal - Human Continuum

Efforts are being aimed at ensuring safe drinking-water, either through mitigation techniques or through finding alternative sources of water. Even if supply of an arsenic-free drinking-water is ensured, arsenic-contaminated groundwater will continue to be used for irrigation purposes, posing a significant risk of this toxic element accumulating in the soil and, consequently, entering into the food-chain through plant uptake and consumption by animals and humans. Thirty to forty percent net cultivable land is under irrigation, and more than 60% of this irrigation is met from groundwater. Thus, the risk of arsenic-contaminated water, being used, is high.

During the past 10 years, researchers have mainly focused on ingestion of arsenic through contaminated drinking-water, but the incidence of Arsenicosis, in the population, is not consistent with the concentration of arsenic in drinking-water, obtained from groundwater. The figure below depicts the findings of a study in Bangladesh, which highlights the lack of correlation between the arsenic concentration in tube well water and arsenic related skin lesions, amongst the population using the same.

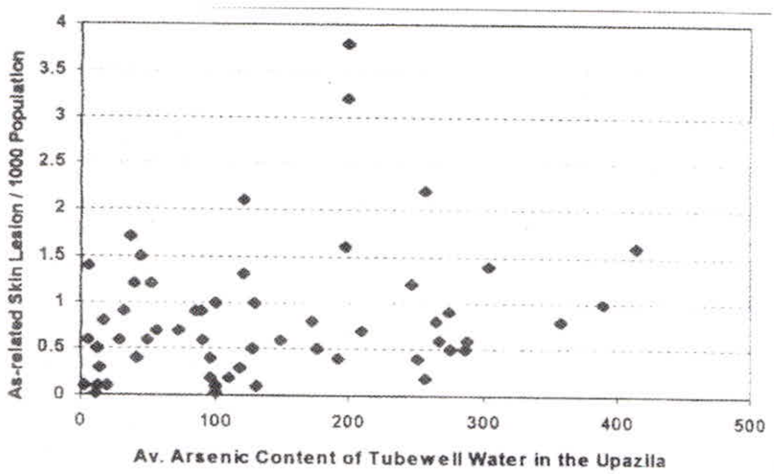


Figure 7.2: Relationship between arsenical skin lesion and average arsenic content in drinking water.

This inconsistency has raised questions on potential pathways of ingestion of arsenic. According to Dr. F. Ahmed of BUET, Bangladesh, while there is a very weak relationship between the number of patients and the average arsenic content in drinking-water at a local level, there is a stronger relationship at the regional level. These findings are consistent with observations of many researchers that people using water from the same source are not equally affected and that people from the same household ingesting water from a common tube well may not be equally affected.

The observed clinical symptoms of arsenic toxicity vary significantly, which poses a challenge in relating the potential pathways of transfer of arsenic from groundwater to human metabolic system through food-chain. Although there may be several other factors involved in the relationship between ingestion of arsenic and epidemiology of arsenicosis, the significance of groundwater-arsenic ingested through the food route is not adequately shown. Along with intake of food, it is also possible that incidental ingestion and inhalation of dust containing arsenic may be a significant pathway of exposure, particularly for the rural community and agricultural workers.

Present knowledge about the impact of use of arsenic contaminated water for agricultural practices is rather scanty. A WHO supported study by the Bidhan Chandra Agricultural University in West Bengal, on a limited scale, arrived at the following findings.

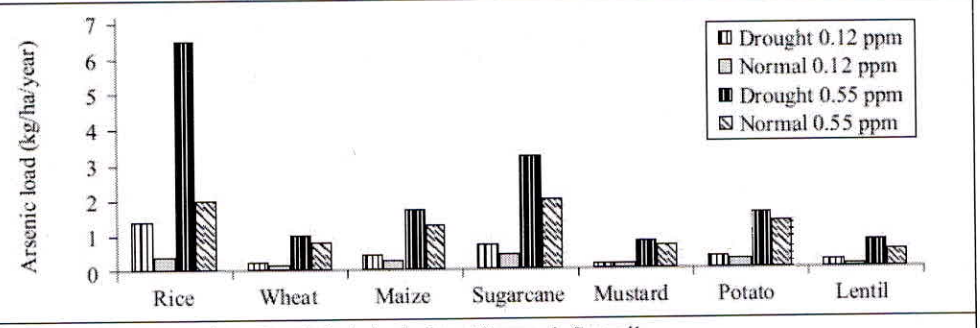
i. *The total arsenic loading of groundwater (used for irrigation) varied from 0.10 to 0.59 mg* L^{-1}.

ii. *The total and extractable arsenic content of soils varied from 2.56 to 16.87 and 1.08 to 9.30 mg* kg^{-1} *respectively.*

iii. *Average arsenic loading in grains and other edible parts of pre-kharif rice, pulses, oilseeds, vegetables and fruits under study were 2.66, 3.13, 2.01, 19.39 and 10.20 mg* kg^{-1}, *respectively.*

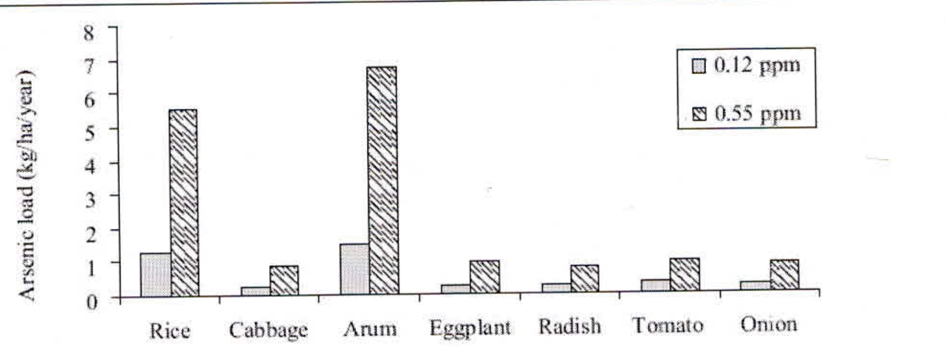
Another study, carried out by Bangladesh Agricultural Research Council, indicated that concentration of Arsenic in water, used for irrigation, varied from 0.136 to 0.55 mg/l and the total loading of Arsenic in irrigated soils for Boro rice that requires 1000 mm of irrigation water per season, ranged from 1.36 to 5.5 kg/hectare/year. Similarly, for winter wheat that requires 150mm irrigation water per season, loading of arsenic from irrigation ranged from 0.12 to 0.82 kg/hectare/year. The figures below depict arsenic load from irrigation water for rice and some other cash crops and also the dynamics for arsenic transfer through water soil crop root.

Arsenic load from irrigation-water for some cash crops



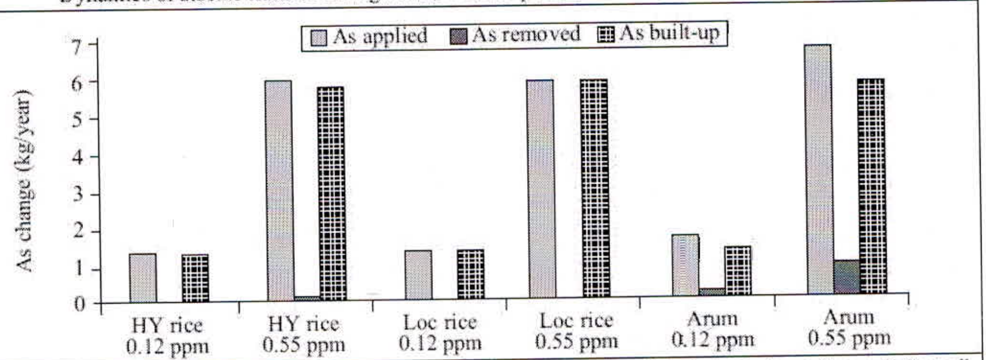
Irrigation data obtained from Bangladesh Agricultural Research Council
Arsenic in water from laboratory analysis

Arsenic load from irrigation water for some crops compared to that for rice



Irrigation data obtained from Bangladesh Agricultural Research Council
Arsenic in water from laboratory analysis

Dynamics of arsenic transfer through water-soil crop route



Estimation is based on laboratory values, and data were obtained from Bangladesh Agricultural Research Council
Irrigation water had 0.12 or 0.55 mg/L of arsenic
Plant arsenic-content data were based on moderate and extreme cases
Irrigation rates for rice and arum taken as 1 m and 1.2 m per crop respectively
As=Arsenic; HY=High-yielding; Loc=Local

From the findings of the above two studies, it is difficult to assess adequately the phototoxic impact of use of arsenic contaminated groundwater and the dietary impact of the same on human health. More elaborate studies are required to adequately assess the situation and formulate policies and practices for agricultural methods and selection of crops in arsenic affected areas.

7.4 Critical Needs for Research and Capacity Building

A careful analysis of the present situation, in respect of arsenic contamination in groundwater, in various states in India, would lead us to the inevitable conclusion that while lot of information and knowledge has been generated through large number of research studies, the findings of the same have not been consolidated in a replicable model to address the sufferings of the people. To sum up, the critical needs for further research and human resource development, the following areas need to be addressed on a priority basis.

i. A scientific and epidemiological assessment of the health impact and disease burden and identification of hot spots for prioritizing action plan.

ii. Consolidation of the knowledge regarding arsenic removal technologies, indigenous as well as imported, and development of designs for appropriately scaled up models for community supply systems and developing a national policy on technology options.

iii. Developing a robust, simple and user friendly, yet scientifically precise and sensitive device for field test kits, which could be used by the community for testing millions of private sources in the country

iv. Studies should be undertaken urgently to asses the impact of arsenic in agricultural and irrigation water and the transportation of the same in the plant and food chain.

v. Capacity building and skill development in the Panchayatiraj organizations in the district, block and habitation level and also in the NGOs and civil society organizations for quality monitoring and surveillance as well as mitigatory actions in support of the Govt. programmes.

vi. Long term change in agriculture and irrigation practice: Restricting the use of groundwater.

7.5 Technology Options: Critical Constraints and limiting factors

Based on the experiences in countries like India, China, Bangladesh etc, the following are the major technology options for providing Arsenic safe water in the affected areas.

- Tapping ground water from alternate arsenic-free aquifers at a higher depth and proper sealing-off of the arsenic bearing aquifer from the same. (>100m).

- Large scale piped water supply for the rural communities by drawing water from the rivers and treating them for removal of pathogenic microbes.

- Conservation and quality up gradation of traditional surface water sources like ponds, dug-wells etc. in the villages. These sources are generally free from Arsenic but grossly contaminated with fecal pollution.

- Removing arsenic from the ground water, by using technologies like, adsorption (activated alumina/Iron oxide), co-precipitation (oxidation, coagulation & filtration) or ion exchange. These technologies could be applied in community plants attached to hand pump tube-wells or large dia tube-wells. Otherwise domestic filters could also be developed on the basis of these technologies.

Of various options stated, Tapping of Arsenic free aquifers is restricted by the absence of clay barrier between the upper arseniferrous aquifer and the deeper Arsenic free aquifers, as has been found in parts of West Bengal, India. In some places, the water bearing aquifer is restricted to 80 to 90 m only, due to presence of hard rock beneath the same. The use of Arsenic Treatment Units fitted to hand pumps, are also facing the problem of sustainability because of the problem of operation & maintenance. A community based system of O&M, and active participation and cost sharing by the people, are essential for these to be successful. So far as domestic units are concerned, experience suggests low acceptability by the people. Considering that in the long run, use of ground water must be restricted in the Arsenic affected areas. The most appropriate technology option, for countries with high annual rainfall and large perennial surface water sources, appears to be the surface water based piped water supply systems. However, it is also the most capital intensive among all the options. Sustainability of such systems would be assured by people's participation in the operation and maintenance & cost sharing.

7.6 Key Factors Impeding the Progress of Mitigatory Programmes in the Arsenic Affected States.

Given the experience, in the developing countries of Asia, where Arsenic in groundwater is posing a great challenge to the health of a large number of people, the following could be mentioned as the major factors impeding the progress of the projects to address the problem.

- *Gap between the perceived need of the people and approach of the implementing agencies.*

- *Long period of completion for large capital-intensive government project / lack of interim relief.*
- *In general, rural populations are largely unaware of the technologies developed by various institutions and organizations due to poor promotional activities.*
- *Lack of knowledge among the people regarding the health impact of the arsenic problem.*
- *Lack of facilities at the grass root level for water quality monitoring.*
- *Lack of a transparent system of information sharing between all stakeholders.*

7.7 Establishing a Transparent System of Information sharing by all Stakeholders

There is an urgent need for awareness generation among the people regarding the problem and efforts undertaken by the Government and agencies in alleviating people's suffering. The people and Media must have easy access to scientific information. But under no circumstances scientific information should be used for creating unnecessary panic among the people. With a significant proportion of the population of India and Bangladesh, in extreme social and economic deprivation, competing environmental Health Risk exists in the society. Without diluting the gravity of the situation, it must be emphasized that we need to be objective and realistic in making political and economic decisions in relation to the current problem of Arsenic or Fluoride Contamination of Ground Water and people should have the opportunity of an in formed choice of options, through a transparent system of information sharing.