

REPORT OF

THE TASK FORCE ON FORMULATING

ACTION PLAN FOR REMOVAL OF

ARSENIC

CONTAMINATION IN WEST BENGAL

GOVERNMENT OF INDIA
PLANNING COMMISSION
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**REPORT OF THE TASK FORCE ON FORMULATING ACTION PLAN FOR
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1.0 Executive Summary

1.1 Planning Commission constituted a Task Force in August, 2005, under the Chairmanship of Member (E&F), Planning Commission for formulating an Action Plan for removal of Arsenic Contamination in West Bengal. It has been reported that about 79 Administrative Blocks in the State in 8 different districts (Malda, Murshidabad, Nadia, North 24 Praganas, South 24 Praganas, Howrah, Hooghly, and Bardhaman) are severely affected due to drinking of water contaminated with arsenic (>0.05 mg/L) which is much higher than the WHO permissible limit of 0.01 mg/L. The source of contamination is reported to be geological and major water demands of the affected districts are met from groundwater. Indiscriminate use of ground water, rampant use of pesticides, fertilizers and consumption of fish which have ingested Arsenic-contaminated water, malnutrition, poor socio-economic conditions, illiteracy, food habits and constant ingestion of contaminated water for prolonged periods have aggravated the problem.

1.2 The Report attempts to examine the magnitude of the problem, sources of Arsenic intake, available technologies, identify appropriate technologies, formulate an action plan and discuss operation and maintenance issues as well as monitoring and evaluating aspects. An attempt has been made to outline different technologies based on various scientific principles, assess these technologies, distinguish these technologies according to their scale of operation and also list new and potential technologies by incorporating Short Term / Medium Term / Long Term measures for tackling the problem of Arsenic contamination in drinking water supply.

1.3 The Report lists scientific principles behind technologies for removal of arsenic from groundwater as oxidation, co-precipitation, coagulation, adsorption, sedimentation, ion exchange, reverse osmosis, biological treatment, etc.

1.4 Short term measures for community level plants listed include about 9 technology models developed by various National and International agencies. A comparison of these technologies has been made with regard to their scale of operation, capital cost, process, media, capacity and cost.

1.5 In addition to Short Term measures, Medium and Long Term measures are also required to be adopted by promoting conjunctive use of ground and surface water and waste water recycling for use by communities for other purposes. It has to be judiciously ensured that Arsenic –free water is available on a sustainable basis from both ground and surface water sources for drinking purposes exclusively.

1.6 For domestic (individual level), Arsenic treatment plants, 3 technologies are available, namely, technology developed by School of Environmental Studies (SOES), Jadavpur University (Filter Tablet system), AIIH&PH and National Metallurgical Laboratory (NML), Jamshedpur. Relative merits and demerits of these 3 technologies have been discussed and it is concluded that NML's technology has some distinct advantages over the other 2 technologies.

1.7 Among new technologies for community level plants, Central Glass & Ceramic Research Institute (CGCRI) technology using Ceramic Filter and Agharkar Research Institute technology are mentioned. These 2 technologies are undergoing field trials.

1.8 Long-term measures suggested include tapping of surface water and shallow dug wells in West Bengal, which do not contain Arsenic. It is suggested that rainwater, surface water, flooded river basins, village ponds and dug wells which are available in plenty in the State may be harnessed for drawing Arsenic free drinking water. Central Ground Water Board, in its study, also observed that the Arsenic contaminated aquifers are within 20-80 m depth and, therefore, it is possible to tap Arsenic free aquifer at greater depths.

1.9 Awareness building measures suggested include conducting of Sensitization Workshops at State, district, Block and Gram Panchayat levels by the Public Health Engineering Department (PHED) of the State, imparting of training to local clubs, NGOs, etc. to enable them to develop skills to inculcate awareness on Arsenic contamination, holding of cluster meetings in affected villages, distribution of posters and pamphlets, regular home visits by health workers to affected homes, making people aware of importance of water quality monitoring, etc. It is also essential to conduct Arsenic detection tests on all [private drinking water sources tapping water from shallow aquifers (20-80 m) depth and seal such sources permanently if Arsenic is detected beyond 0.05 mg/litre.

1.10 **Summary of Recommendations –**

- Information Education and Communication (IEC) strategy needs to be changed in the light of problems being created by Arsenic contaminated ground water after its withdrawal from the Aquifers.
- It is strongly recommended that Arsenic contaminated water should not be used for drinking but for cooking, washing, bathing and irrigation/agricultural purposes, a proper scientific study has to be carried out. Also, the issue of permissible limits of Arsenic in vegetables / fruits / crops, etc. has also to be looked into.
- Treatment options for Arsenic removal have to be foolproof with zero environmental impact and inbuilt arrangement for sanitary disposal of Arsenic bearing sludge.
- Different types of in situ treatment and impact thereof with respect to effluent quality needs to be investigated/evaluated with perfect treatment of effluent. Cost effectiveness also needs to be examined with reference to sustainability of the system.
- To build in sustainability, water recharging component should be incorporated in the system.
- Best long term/medium term/techno-economically viable options need to be prescribed on absolute terms on the parameters such as capital cost, recurring cost, capability of decentralized management and utilization of technologies/options in the field and best technological options on least cost basis.
- In the Technology Park at Baruipur in West Bengal, excepting 2-3 plants based on Pal Trockner and BE College Technologies none of the others was found working. Reasons are-lack of awareness among affected people, lack of sense of belonging, lack of willingness to take responsibility, lack of safe methods for sanitary disposal of Arsenic-bearing sludge, no provision of salary for operating staff and irregular supply of chemicals needed to run the plants. **Based on the Report on the said Park, PHED of West Bengal had later installed more than 2000 plants in various affected areas of the State and other partner-NGOS of the project also installed some good Arsenic Removal Plants (ARP). The basic objective of the Park was to evaluate all the hand pump-attached technologies available in the country for removal of Arsenic in terms of their Arsenic removal efficiency, cost-effectiveness and user-friendliness to help the State Govt. and other agencies in selecting the technology. The Park was set up only for 2 years for the said**

evaluation and after this period was over, the purpose was deemed to have been achieved.

- Though Pal Trockner and BE College technologies emerge as two possible technologies, they are expensive and need rigorous maintenance procedures. In the Park, the toxic sludge formed was found going into nearby drains thereby indicating that people operating did not know how to dispose off the sludge so that it did not cause further pollution.
- Many technologies meant for removing Arsenic also removed iron from the water. Therefore, stringent monitoring mechanism is required. It was also observed that presence of Iron along with Arsenic in drinking water improved the Arsenic removal in co-precipitation process.
- Any Arsenic Removal package must comprise both the technology for sludge disposal as well as a package for technical education for the users and also should ensure a continuous supply of chemicals/media etc. Further, supply of chemicals and salary of operating staff has to be ensured with community participation/contribution.
- For domestic removal units, all the 3 technologies-SOES, AIIH&PH and NML processes are workable, but their success will depend on proper networking to make available the chemicals (for SOES and AII&PH processes) and mineral (for NML) to the villagers. Also, imparting proper education to the villagers will be critically important.
- Treatment of Arsenic – affected water appears to be feasible only in areas where piped water supply cannot reach. Arsenic removal using different technologies will work only if the methodology is backed by ways and means to educate all affected villagers in the working of the plant.
- Even though the affected water can be treated, whether it will be appropriate to draw the contaminated water has to be decided. In some blocks, Panchayats are drawing drinking water from the aquifer below 1000 ft level as upper layers are heavily contaminated either with Arsenic or iron. Whether continuous withdrawal of water from the aquifer will lead to leaching of Arsenic from the upper layers to the lower layers has to be examined. Leaching of Arsenic through contaminated aquifers to Arsenic-free aquifers can be prevented by putting a ‘sanitary seal’ across the dividing line between the two aquifers.
- The State has increasingly gone in for surface water and its efforts in this direction are commendable. It may be safe to completely stop using affected water. The State is enjoying an average rainfall of about 1600 mm every year and this water is precious. Rain Water Harvesting should be in place as a local solution wherever it is feasible. The State also has a number of water bodies/ tanks which should be put to good use for drawing drinking water. This should be done without affecting the water bodies which are being used heavily for pisciculture. In this connection, some apprehensions were expressed that the villagers who were weaned away from ponds / pools on the grounds that these may be contaminated (and thus depend on tube wells before the arsenic contamination was detected) may find it difficult to go back to the use of common ponds / pools. However, it is felt that this could be attempted with some proper planning and motivation. It may be necessary to treat water from ponds / pools (not used for pisciculture) to remove contamination and supply it as piped water wherever feasible.
- GOI may provide a list of technology suppliers to the State and a suitable service provider to be selected by the State to set up operate and maintain Arsenic removal plants in affected areas under a MOU with the State Govt. Service provider will mobilize funds for capital cost by approaching banks or venture capitalists, the State

to supply Arsenic-affected water free of cost to the service provider, provide him with free electricity/electricity at nominal rates, technology supplier to charge nominal fee for supplying technology to the service provider, O&M cost to be borne by the service provider, State Govt. to buy processed water from the service provider and supply it free of cost to villages, service provider to operate the Arsenic removal plant on a commercial basis.

- Standard methods need to be explained regarding safe disposal of sludge that comes out of arsenic treatment plant at the community as well as district level. Central Pollution Control Board standards need to be clearly indicated in this regard. It may also be noted that although the contract is given to Agency for installation, operation and maintenance and safe disposal of sludge but, in reality, once the arsenic contaminated sludge is taken away by the Agency from the treatment site, one does not know whether the sludge is disposed off in a safe manner. This means that adequate follow up action should be taken up by the PHED/Line Department regarding its safe disposal and it should not left to the Agency to dispose it as per its convenience.

2.0 Introduction

2.1 The Arsenic contamination of ground water and its epidemiological impact was detected in West Bengal in the early eighties. The 1st Steering Committee was constituted by the Govt. of West Bengal in 1988, which conducted the multicentric study to find out the cause of the problem. This study was supported by Rajiv Gandhi Drinking Water Mission. Thereafter a number of Task Forces were constituted by the State Govt. during the 90s and the present reconstituted Task Force is functioning since 2001. Almost all academic and research institutes working in Arsenic and ground water quality related problems are represented in the Task Force and the State Govt. has developed a master plan for long term mitigation for the problem in consultation with the Task Force, which is presently in the process of implementation with financial support from the Dept. of Drinking Water Supply, Govt. of India.

2.2 The problem of Arsenic pollution of ground water has been creating serious threat to a number of districts in West Bengal and some selected pockets of other parts of India. While WHO permissible limit of Arsenic in ground water is known to be 0.01 mg/L (10 parts per billion (ppb)), it has been reported that in 8 districts of West Bengal covering an area of about 34, 000 sq. km with a population of about 30 million, the Arsenic content is much more higher than the WHO limit. It may be noted here that Bureau of Indian Standards (BIS) has also revised the limit of Arsenic in drinking water from 0.05 to 0.01 mg/L (5 to 1 ppb) since 2003.

As per the latest Water Quality Survey conducted by the State Government under the Joint Action Plan with UNICEF, the extent of the problem is given below in the Table I:-

Table-I

Districts in West Bengal affected by Arsenic Toxicity

<u>District</u>	<u>Concentration in mg/l</u>
1. South 24 Parganas	0.06-3.20
2. North 24 Parganas	0.06-1.28
3. Malda	0.05-1.434
4. Nadia	0.05-1.00
5. Murshidabad	0.05-0.90
6. Bardhaman	0.10-0.50
7. Howrah	0.09
8. Hooghly	0.60

Note: As per the latest water quality monitoring and GIS database developed under the Joint Action Plan of the Govt. of West Bengal (Dept. of Public Health Engineering) and UNICEF, and overseen by the Task Force, 98% of affected public tube wells in the State are having maximum Arsenic concentration of 0.5 mg/l. Average level of concentration of Arsenic in public tube wells in the State is 0.135

2.3 It appears that 79 administrative blocks in West Bengal by the side of River Hooghly and adjoining areas are affected. It has been reported that more than 8 lakh people from 312 villages/wards are drinking Arsenic contaminated water. In these 8 districts, many samples of

water have been analyzed for Arsenic. These results provide substantial evidence of prolonged Arsenic ingestion by the people through food chain as well as drinking water sources. Hair, nails, scales, urine and liver tissue analyses of people living in affected areas show elevated levels of Arsenic. The source of Arsenic is geological. The contamination is mostly reported from aquifers at a depth of 20-80 meters below ground. The polluted water is known to have high iron, magnesium and bi-carbonates with low sulphate, fluoride and chloride levels. Various social problems are known to result from the Arsenic skin lesion in these districts. What is worrying is that malnutrition, poor economic/socio conditions, illiteracy, food habits and constant ingestion of Arsenic contaminated water for prolonged periods have aggravated Arsenic toxicity.

2.4 In all these districts, it has been found that major water demands are met from ground water. High withdrawal of water causes leaching of Arsenic from the aquifer to source. If proper remedial measures are not taken, it is possible that large percentage of 30 million people of these districts may become exposed to Arsenic toxicity in near future. **Annexure-II** gives details of studies done by Jadavpur University, Kolkata in the State.

2.5 Looking at the seriousness of the problem, the Twelfth Finance Commission awarded Rs. 600 crore to Govt. of West Bengal to combat the menace of Arsenic toxicity over a period of 5 years. The Hon'ble Chief Minister of West Bengal also raised this issue during his intervention at the 51st National Development Council's Meeting on 27-28 June, 2005 at Delhi.

2.6 Consequently, the Planning Commission constituted a Task Force to work out modalities of combating the menace of Arsenic pollution with identification of appropriate technologies. A copy of the Office Order with composition and Terms of Reference (TOR) is at **Annexure-I**.

3.0 Objectives and Scope

3.1 The objectives of the Task Force report are the following:

1. Examination of available technologies
2. Identification of appropriate technologies
3. Formulation of Action Plan
4. Time schedule
5. Operation & Maintenance
6. Monitoring & Evaluation

Note: Every technology in 2 above must be accompanied by eco-friendly sludge disposal means and analysis of Annual O & M cost. For Monitoring & Evaluation, a Third Party with a team of experts is suggested.

3.2 The scope of the present Report comprises the following:-

- It will make an attempt to outline different Arsenic removal technologies based on various scientific principles, which were employed in the context of West Bengal groundwater either at community scale or domestic scale to obtain Arsenic free safe

drinking water.

- It will try to provide an assessment of these technologies with regard to their success/failure in the field, probable reasons for success or failure, techno-economic considerations and infrastructure required to use them meaningfully.
- This Report will try to distinguish these technologies according to their scale of operation and classify them as short, medium or long term remedial measures and at community or domestic level.
- This Report will also try to list other new and potential technologies that can address the shortcomings of existing treatment processes.
- The Report makes an attempt to shortlist the potential processes that may be used for the treatment of Arsenic contaminated groundwater in West Bengal and make recommendation on how to make these technologies successful in the context of West Bengal.

4.0 Methodology

4.1 Methodology adopted for preparing this report was as follows:

- Existing literature and patent documents on different Arsenic removal processes developed all over the world were looked into
- Arsenic removal processes specific to West Bengal would be short listed from the available literature
- A number of scientists, innovators were interviewed to discuss several critical issues involved in successful implementation of the Arsenic mitigation programme and their views have been reflected at several points in this report.

5.0 Structure of the Report

5.1 Scientific principles involved in different technologies outlined in this report have been discussed primarily to serve as a guide for the technical discussion in the later part of this report. Since the area under consideration is West Bengal, the Report is confined to the technologies, which are relevant to the groundwaters of West Bengal only. Relevance was judged based on the employment of the said technology in the groundwaters of West Bengal or technically if it holds enough promises to be relevant. These technologies then have been classified as short, medium or long term remedial measures based on their nature. The short term measures have been further categorized as domestic or community scale.

6.0 Scientific principles followed in Arsenic removal technologies

6.1 Arsenic removal technologies from groundwater primarily evolve around following basic principles:

1. Coagulation/ Co-precipitation
2. Adsorption
3. Sedimentation
4. Ion exchange
5. Membrane/ Reverse osmosis
6. Biological Treatment (Oxidation)
7. Others

6.2 One or more of these principles are used sequentially to obtain Arsenic free water. For example, filtration is almost common in every water treatment. Arsenic in groundwater usually exists as inorganic Arsenic and both Trivalent (As(III)) and Pentavalent (As(V)) species are found. In West Bengal groundwater As(III):As(V) ratio widely varies. As(III) species are not only more toxic than As(V), they also respond differently to Arsenic removal treatment. For example, coagulation /coprecipitation using iron /aluminium salts work better with As (V) than As (III). In such cases, co-precipitation needs to be preceded by oxidation of As (III) to As (V) for enhancing quick removal of Arsenic complexes from drinking water resources. This is why in most of the coagulation/coprecipitation techniques; a preoxidation of As (III) to AS (V) is carried out to increase removal efficiency. In adsorption technique also, the media behaves differently for As (III) and As (V). Preoxidation of As (III) to As (V) requires addition of an additional oxidizing agent which may have an adverse impact on the resultant water quality. Sedimentation process is normally used in conjunction with coagulation/co precipitation or adsorption processes.

Ion exchange or membrane processes are expensive in nature and they appear to be not relevant in the context of West Bengal groundwater. Biological processes where microorganisms are used for treating the Arsenic contaminated water and or sludge hold a lot of promise and coupled with adsorption or coagulation technique they may produce a good alternative remediation technique. Further, biological processes hold lots of promise in sludge disposal protocol, which is very important, and is an integral component of any Arsenic treatment technology.

7.0 Short term Remediation measures

7.1 Community level Arsenic treatment plants

A number of community level Arsenic removal technologies were developed by various agencies, both national and international. These were based on different scientific principles mentioned earlier and Arsenic treatment plants were installed based on these technologies in various parts of West Bengal. Details are given below:

(i) Apyron technology

Apyron's Arsenic treatment units remove Arsenic by adsorption using enhanced activated alumina media called *Aqua-BindTM-Arsenic*. The adsorption media is a composite of manganese oxide and activated alumina.

(ii) Water Systems International (WSI) technology

WSI uses an ion exchange process for the removal of Arsenic. The unit called "bucket of resin" is attached to a tube well hand pump. WSI has designed the unit to a tolerance level of reducing Arsenic from 1500 µg/L to less than 50 µg/L. The targeted resin life at the level of 1000 µg/L of Arsenic is 300,000 liters before resin regeneration.

(iii) RPM technology

RPM technology is based on activated alumina (adsorption) enhanced by a proprietary additive engineered to accomplish excellent Arsenic removal. The system is easy to install and works with gravity force.

(iv) Pal Trockner – AdsorpAs[®] technology

Pal Trockner uses Granular Ferric Hydroxide (GFH) as adsorbent, which can eliminate Arsenic of any concentration from drinking water bringing down its level to below the permissible limit for potable use. The Arsenic removal capacity of GFH is 5 to 10 times higher than that of other similar adsorbent-based systems.

(v) Anir Engineering

Anir Engineering uses the proven technology of adsorption with slurry/granular ferric hydroxide. The technology offers high efficiency, cost-effective Arsenic removal, is simple to operate/maintain, with easy disposal of non-toxic sludge.

(vi) School of Fundamental Research (SFR) technology

SFR device is designed to be fitted to ‘force & lift’ pump which is connected to a vertical PVC cylinder filled with silicate matrix (ceramic material) coated with an additional oxidizing element for removal of the major portion of iron before the water enters into Arsenic removal system. The Arsenic removal system consists of PVC cylinders filled with goethite compound specially deposited on activated alumina.

(vii) PHED technology

The removal of Arsenic in this technology is accomplished in four chambers. Groundwater is abstracted and lifted by force and lift hand pump to spray into droplets over a bed containing packed hematite lumps before it is then led to sedimentation chamber at bottom. The settled water is conveyed through three chambers placed in series containing red hematite lumps, quartz and dual media (Sand-Activated Alumina), respectively.

(viii) All India Hygiene and Public Health (AIHH&PH) technology

This technology follows oxidation followed by coagulation/co-precipitation route for the removal of Arsenic from groundwater. Bleaching powder is used as the oxidizing agent and alum is used as the coagulant.

(ix) Oxide India (Catalysts) Pvt. Ltd. (BE college model)

This technology uses adsorption technique in which activated alumina is used as the adsorption medium. Activated alumina can adsorb As(V) better than As(III). Therefore, a preoxidation of As(III) to As(V) is done to increase the efficiency. Activated alumina plant is relatively more expensive. The adsorption medium is also expensive and requires regular backwash to remove deposition of iron onto it and thus making alumina site unavailable to Arsenic.

Annexure - III gives a comparison of different technologies with regard to their scale of operation, capital investment, and some other details.

8.0 Status of Arsenic treatment plants in the Technology Park, Baruipur, West Bengal

8.1 In the Technology Park at Baruipur in West Bengal, excepting 2-3 plants based on Pal Trockner and BE College Technologies none of the others was found working. Reasons reported at that time were- lack of awareness among affected people, lack of sense of belonging, lack of willingness to take responsibility, lack of safe methods for sanitary disposal of Arsenic-bearing sludge, no provision of salary for operating staff and irregular supply of chemicals needed to run the plants. **Based on the Report on the said Park, PHED of West Bengal had later installed more than 2000 plants in various affected areas of the State and other partner-NGOS of the project also installed some good Arsenic Removal Plants (ARP). The basic objective of the Park was to evaluate all the hand pump-attached technologies available in the country for removal of Arsenic in terms of their Arsenic removal efficiency, cost-effectiveness and user-friendliness to help the State Govt. and other agencies in selecting the technology. The Park was set up only for 2 years for the said evaluation and after this period was over, the purpose was deemed to have been achieved.**

8.2 To collect first hand information on the performance and present condition of the Arsenic treatment plants, the Task Force members made a visit on 11th of January, 2006. A total of 12 sites were visited where treatment plants were installed. Table 2 below gives the findings of this survey.

Table 2: Findings of the survey of 12 Arsenic removal plants installed in the technology park, Baruipur, West Bengal, on 11th January, 2006.

Sl.No.	Technology	Location	Status
1.	WSI-Hermonite	Kumorhat, Jamrultoal	Not functioning since more than 1 year (Fig. 1)
2.	Pal Trockner	Kumorhat	Apparently functioning, but not being used by many families. Caretaker is not getting salary for the last four months. Water quality has gone down substantially and water test has also deteriorated. (Fig. 2)
3.	AIHHPH	Kumorhat, Chadokhal	Not functioning for more than one year because of maintenance. Villagers say that the water was good when the plant was functioning. (Fig. 3)
4.	Apyron technology	Panchanantola	The treatment plant is missing. Only tubewell is existing. (Fig. 4)
5.	RPM technology	Chadokhal, Masjid	No plant could be seen (Fig. 5)
6.	School of Fundamental Research technology	Padmajola high school	Currently no plant exists. The water was never popular within the villagers even when the plant was present.
7.	BE College technology, Amal filter	Padmajala Naskarpara	Not working for more than one year. Media was changed only during installation about 4 years back (Fig. 6)
8.	PHED technology	Alipur	Not being used. In fact the villagers never used it. It takes long time for pumping to get the water. Villagers never used this water (Fig. 7)
9.	Pal Trockner	Dakshin Padmajala	Apparently working but not being used by any. Back flushing not being done for the last four months.(Fig. 8)
10.	Anir Engineering	Dhapdhapi, Khanpara More	Never worked well. Completely non functional for more than one and half years. (Fig. 9)

11.	Apyron Technology	Dhapdhapi	Worked for about a year but not functioning for more than one and half year. (Fig. 10)
12.	BE College Technology (Marketed by Oxide India)	Uttar Padmajala, Barotala	Appears to be working. No media recharging since the first installation. (Fig. 11)

9.0 Domestic Arsenic treatment technologies

9.1 School of Environmental Studies (SOES) filter tablet system

SOES developed a tablet and filter system for the removal of Arsenic at household level. The removal is based on the principle of oxidation-coagulation-precipitation-filtration route. The unit consists of two containers, the upper container is fitted with a filter candle and the lower container is collector for Arsenic free water. The tablet consists of an oxidizing agent, Fe (III) salt and activated carbon. The tablet is added to the contaminated water. The oxidizing agent converts entire Arsenic into As (V). Fe (III) salt gets hydrolyzed into hydroxide which attaches

As (V) with it and eventually gets adsorbed onto activated carbon. Water is then transferred into the top container containing the filter candle and the clean water is collected into the bottom container through filtration. 3 Indian patents have been filed for this filter tablet invention jointly with CSIR. SOES scientists have also proposed to dispose the generated sludge in a cow dung medium through bio-methylation route.

9.2 Scientists from SOES have reported field testing of their filter-tablet system during 1993-95 with Arsenic removal of 93-100%. These units were also evaluated by agencies like, ITRC, Lucknow, NTH, Kolkata, NEERI, Nagpur. The results showed Arsenic removal in the range 93-97.5%. 300 filter tablet units were also evaluated by PHED, West Bengal but the complete report is not available with SOES. However, on the basis 4 samples PHED reported a removal of only 50%. A one year field trial of this filter tablet system was to conducted through 150 families in 2 blocks of north 24-Parganas but the study report was available with SOES.

9.3 AIIH&PH domestic Arsenic removal system

AIIH&PH domestic Arsenic removal units use the same route as SOES, i.e., oxidation-coagulation-precipitation-filtration. However, they use bleaching powder solution as the oxidizing agent, and ferric alum as the coagulator. This technique also uses a two container system in which the upper container is fitted with a candle. They have tried with different types of candles and proposed that candle making may be used as way of self-sustenance for the villagers. For this, Self Help Groups may be considered. Tripura candles have been found to be very attractive as a low cost filter. AIIH&PH have distributed a number of their filtering units in various households of West Bengal through NGOs but a systematic evaluation of their system by a third party could not be obtained. For the evaluation, the services of Dr. Majumdar, former Professor (Sanitary Engineering), AIIH&PH, Kolkata may be considered.

9.4 Both SOES and AIIH&PH domestic Arsenic removal techniques adopt a robust principle for Arsenic removal, which perhaps, is also the oldest Arsenic removal technique. The final water quality, however, needs to be carefully monitored. Free residual Chlorine is essential to fight bacterial contamination that may occur during handling and storage of drinking water.

Also, the hardness and salinity of the resultant water need to be closely monitored because of the oxidizing agent, which also spoils the water test. Residual Chlorine if any, in water can be removed by de-Chlorinating agent for safeguarding against any interference during water test. It was observed by the scientists of SOES that sometimes overdosing of the oxidizing agent takes place causing bitterness in the filtered water. Shelf life of the oxidizing agent and its proper preservation is also of paramount importance in this type of systems. Non adherence to preservation norms often causes inefficient Arsenic removal.

9.5 NML's domestic Arsenic removal unit

National Metallurgical Laboratory, Jamshedpur's domestic Arsenic removal unit was designed keeping in mind the general shortcomings of oxidizing-coagulation-precipitation-filtration technique. NML technique uses adsorption route for Arsenic removal. It is essentially a three container system. A naturally occurring mineral is used as the adsorption medium. Finely divided powders of the mineral is mixed with the water in the top most containers and slowly agitated for about five minutes. The water is allowed to settle for about an hour. The mineral being heavy in nature has a natural tendency to settle. The settling may be expedited by adding a little flocculent, which is normally used in lowering the turbidity in surface water. The supernatant water is allowed to flow into the middle container attached with a common ceramic filter candle. Arsenic free water is slowly collected into lower container through filtration.

9.6 The basic research on this system has already been published (Reference: Removal of Arsenic from groundwater using low cost ferruginous manganese ore, S. Chakravarty, V. Dureja, G. Bhattacharyya, S. Maity, S. Bhattacharjee, Water Research, 36, 625-632, 2002). This system has been tested with a number of real Arsenic contaminated water samples of West Bengal. The unit has also been demonstrated in the field in collaboration with Rotary Club. Currently 50 units of NML's Arsenic removal system is being field tested in Sahebgunj district of Jharkhand over a period of eighteen months. In this connection, it is suggested that Bihar model of constructing sanitary wells and Rain Water Harvesting Structures may be replicated in Jharkhand also for Arsenic affected areas. Rajiv Gandhi National Drinking Water Mission, Ministry of Rural Development, Government of India is supporting this activity. It is suggested that the NML system may be evaluated over an elongated period of time for which a technical team comprising representatives from AIIH&PH, Kolkata, Department of Drinking Water Supply, New Delhi and PHED, West Bengal may be constituted.

9.7 NML's domestic Arsenic removal system has several advantages over the SOES or AIIH&PH system as shown below.

- The adsorbent which is being used for the removal of Arsenic in NML's system can take both As (III) and As (V) and hence it is not necessary to use any oxidizing agent. Thus the question of comprising water quality due to addition of oxidizing agent does not arise.
- The filter candle used in NML's process is only to separate any suspended particulate matter that might be present in the supernatant liquid. Any convenient filtering media may be adequate. In fact, if the settling is proper, slow sand filtration or even fine cloth may be sufficient.
- The naturally occurring mineral used in NML's system is very cheap and abundantly available. Only grinding cost is involved before using it as such. As no oxidizing

agent is used in this process, this drastically reduces the consumable cost.

- Since the mineral, being used in NML's system, is inert in nature, any inadvertent excess addition of the mineral by the villagers does not affect the resultant water quality. This is great advantage as excess addition of the chemical is a very commonly found phenomenon in domestic Arsenic removal systems.
- The Arsenic Removal System has an inbuilt sludge disposal mechanism also. This is its most significant advantage.

9.8 In addition to these, NML's system, like SOES or AIIH&PH, does not require any electricity, which makes it ideal under Indian rural conditions. Consumable cost for NML's process for a family of four consuming 20 litres of water per day for a month (30 days) will not be more than 10 rupees. NML's process also has an integrated sludge disposal protocol built in the system. Though NML's process may be up scaled to community level, no work has been done in that direction.

9.9 In addition to the above technologies, the UNICEF -GoWB model of domestic filter based on activated alumina technology is most widely used in West Bengal. Till now, almost 15,000 units have been distributed in the rural areas of the State. The model developed by Naval Material Research Laboratory, DRDO, Ministry of Defence, was also evaluated by the Task Force under West Bengal Govt. and found to be very effective. Presently the Department of Science & Technology, Govt. of India is supporting a project to promote this technology in the rural areas of Nadia district of West Bengal. There are also a few other emerging technologies developed by IIT, Mumbai, Tata Chemicals, Hindustan Lever etc.

10.0 New Technologies (Community level)

10.1 Central Glass and Ceramic Research Institute (CGCRI) technology using ceramic filter

CGCRI, a constituent laboratory of Council of Scientific and Industrial Research (CSIR) in Kolkata has developed a technology in which a fine iron based adsorbent is mixed with the contaminated water. The water along with the adsorbent is pushed through a series of ceramic filters. Clean Arsenic free water comes out through the sidewalls of the filter and the remaining water along with the adsorbent goes back to the reactor. This cycle is continued with fresh input of contaminated water. A demonstration plant using this technology was first installed by CGCRI in the year 2001 which had a capacity of 60 litres per hour. Subsequently, four Arsenic removal plants each with a capacity of 2500 litres per hour have been installed in the year 2003. These plants are being evaluated. CGCRI technology is cost intensive at smaller scale of operation. It also requires electricity, which may be an impediment in the rural sector. However, the cost may come down if the scale of operation is increased. No information could be obtained on the disposal of sludge.

10.2 Agharkar Research Institute (ARI), Pune technology

ARI technology comprises of three steps. In the first step Arsenic is oxidized using a bacterial culture (*Microbacterium lacticum*) immobilized on brick pieces in a polypropylene column. In the second stage, the oxidized Arsenic is adsorbed on activated alumina. In the third stage bacteria from the water are removed by charcoal filtration and ultraviolet treatment. The treatment method has worked with very high and consistent efficiency at the scale of 1000 liters per day in the laboratory conditions for two years. As in case of other adsorption technologies, the Arsenic adsorbed on activated alumina needs to be removed periodically

and disposed off safely. This technology has been field tested in 11 villages in Rajnandgaon district of Chhattisgarh state.

10.3 The granular Ferric Hydroxide technology promoted by M/s. Pal Trockner, has been largely used in a number of Swajaldhara schemes, promoted by GTZ. A 6,000 gallon per hour field demonstration plant of M/s Severn Trents, UK is functioning satisfactorily for the last 3 months. Basically, most technologies which were found to be technically viable in the technology park study could be scaled up to various levels.

11.0 Medium/Long Term measures

11.1 Arsenic removal technologies discussed so far, both community as well as domestic level were short term remediation measures. Long term remediation measures were not strictly part of this exercise. However, it was felt that long time measures also merit some discussion in this report. It is now well established that surface water and shallow dug wells in West Bengal do not contain Arsenic. There is a need to carry out techno-economic feasibility study for alternate drinking water supply at government, private and community levels from such water sources. There is also need to identify shallow dug wells, their mapping and estimating their life during which they will remain safe for drinking. Government of West Bengal has already taken some active measures to this effect. Water from River Hooghly is being treated and made available to the villagers through pipe distribution system. In some places deep tube wells in the range of 500-1000 ft. is being thought of as an alternative for Arsenic safe drinking water. However, this definitely is not a solution for every place. Proper care should be taken not to allow leaching of Arsenic contaminated water from the upper aquifer (not containing Arsenic) to lower aquifer by 'sanitary sealing' of the aquifers.

11.2 Rooftop Rain Water Harvesting Structures can also be included as local solutions for providing safe drinking water.

12.0 Awareness Building Measures

12.1 The general objective of awareness building measures is to provide Arsenic free water and spread awareness especially on Arsenic contamination of ground water and generate a sense of ownership on created assets under Arsenic Mitigation Programme and participation in operation and maintenance of such assets by community contribution.

12.2 Revival of Arsenic Removal Technology Park at Baruipur near Kolkata with capacity building and training centre for operation and maintenance of various technologies in the Park for their field application is recommended.

12.3 Implementation process will have the following steps – (i) Capacity building and awareness generation among the people regarding Arsenic contamination and the adverse health impact (ii) Community level Water Quality Monitoring and Surveillance (WQM&S), (iii) Operation and Maintenance of public water supply schemes and (iv) Networking.

12.4 Sensitization workshop at various levels such as State, District, Block and Gram Panchayat. The Public Health Engineering Department along with UNICEF has already conducted such sensitization programmes up to district level and in a few blocks. Such programmes shall have to be continued right from State level to Gram Panchayat on a regular basis. Further, UNICEF assistance may be availed by PHED for setting up Arsenic Mitigation Centre. It has been reported by the State Govt. that it has forwarded a proposal of Water Quality Survey with the help of existing network of laboratories of PHED and NGOs under the National Rural Drinking Water Quality Monitoring & Survey Programme of the Dept. of Drinking Water Supply of GOI.

12.5 Imparting training to the local clubs, user groups, NGOs to develop skills for imparting awareness on Arsenic contamination of drinking water. The same kind of training may

be given to the school children also so that they can propagate the same in their respective house holds.

12.6 Once the leaders of the groups are adequately trained on the subject they may hold cluster meetings in the villages to address the villagers. Tools like flash card etc. may be used during the meeting. Posters or pamphlets are to be developed. Wall writing may be done by the local youth. By that process, they internalize the essence of the message and can elaborate the same to their peers or other villagers wherever needed.

12.7 Regular home visits by the health workers for identifying Arsenicosis patients, referring them to the nearest health Centre and advise them to test their drinking water source. Specially, women groups may be trained for this purpose. Arsenic related activities should be integrated with National Rural Health Mission as well as State Health Departments activities for diseases surveillance programme.

12.8 People should be made aware of the importance of water quality monitoring. On this aspect, user groups may be created having basic knowledge who shall collect the water samples from households and get it tested through the nearest NGO-managed Water Testing Laboratories or PHED Laboratories.

12.9 A Master Plan prepared by the Public Health Engineering Department of West Bengal in May, 2006 to tackle Arsenic Contamination in Ground Water in the State may be seen as **Annexure - IV**.

13.0 Summary of Recommendations

13.1 Information Education and Communication (IEC) strategy needs to be changed in the light of problems being created by Arsenic contaminated ground water after its withdrawal from the Aquifers.

13.2 The issue of Arsenic contaminated water not to be used for any purpose including drinking, cooking, washing, bathing and irrigation/agricultural purposes was deliberated. However, as per the policy decision taken by State Govt. in accordance with the recommendation of the Arsenic Task Force, water from the tube wells having excess arsenic can be used for purposes other than drinking and cooking. It has been noted that there are no standards for permissible limits of Arsenic in vegetable /fruits / foodgrains. A decision whether to ban totally the use of Arsenic contaminated water for purposes other than drinking (cooking, washing, bathing, etc.) can be taken only after a scientific study is carried out.

13.3. Treatment options for Arsenic removal have to be foolproof with zero environmental impact and inbuilt arrangement for sanitary disposal of Arsenic bearing sludge.

13.4 Different types of in situ treatment and impact thereof with respect to effluent quality need to be investigated / evaluated with perfect treatment of effluent. Cost effectiveness also needs to be examined with reference to sustainability of the system.

13.5 To build in sustainability, water recharging component should be incorporated in the system. Best long term / medium term / techno-economically viable options need to be prescribed on absolute terms on the parameters - capital cost, recurring cost, capability of decentralized management and utilization of technologies/options in the field and best technological options on least cost basis.

13.6 Site specific standardization and evaluation of Arsenic Removal Technologies is essential.

13.7 Some common patterns emerge from on-site examination of 12 community level Arsenic treatment plants based on various technologies installed in the Technology Park in Baruipur, West Bengal. These are listed below.

13.8 In the Technology Park at Baruipur in West Bengal, excepting 2-3 plants based on Pal Trockner and BE College Technologies none of the others was found working. Reasons are-lack of awareness among affected people, lack of sense of belonging, lack of willingness to take responsibility, lack of safe methods for sanitary disposal of Arsenic-bearing sludge, no provision of salary for operating staff and irregular supply of chemicals needed to run the plants. **Based on the Report on the said Park, PHED of West Bengal had later installed more than 2000 plants in various affected areas of the State and other partner-NGOS of the project also installed some good Arsenic Removal Plants (ARP). The basic objective of the Park was to evaluate all the hand pump-attached technologies available in the country for removal of Arsenic in terms of their Arsenic removal efficiency, cost-effectiveness and user-friendliness to help the State Govt. and other agencies in selecting the technology. The Park was set up only for 2 years for the said evaluation and after this period was over, the purpose was deemed to have been achieved.**

13.9 From the present survey, it emerged out that **Pal Trockner model and the BE college technology** may be two possible Arsenic treatment technologies that could be used for Arsenic mitigation. However, it has to be again emphasized that both these technologies are expensive and require extensive maintenance protocols. A crucial prerequisite for successful implementation of these technologies is to make the villagers aware of the necessary conditions for successful operation of these plants and ensure their involvement in the maintenance of these plants. This requires a holistic approach and a team of professionals comprising of social scientists, psychologists, civil engineers and scientists.

13.10 Sludge Disposal Methods have to be foolproof, user-friendly and environment friendly.

13.11 O&M of the plants should be simple and cost effective in respect of consumables and re-generation of media.

13.12 Rain Water Harvesting Technologies have to be integrated with the Master Plan of the State Government.

13.13 There is no need to involve UNICEF for major programmes for Arsenic mitigation.

13.14 Capacity building for WQM&S as well as for plant operations should be in place.

13.15 It may be mentioned that SOES, Jadavpur University at Kolkata published an independent evaluation of AIIH&PH technology and BE college technology over a period of two years. A total of 7 units, 3 on AIIH&PH model and 3 on BE college model were considered. All these units were installed in Betai village in Nadia district. Installation cost for each AIIH&PH unit was Rs.40, 000 and Rs.60, 000 for BE college unit. According to SOES report, only one BE college unit consistently worked well throughout two years period and the performance of the rest were not satisfactory. They reported erratic performance for

the treated water quality. Arsenic content was found to be more than the desired level in many instances. No information was found on the sludge disposal in these units. The reasons attributed to the failure of these units, even though they were scientifically sound, were manifold in nature. Most important ones were lack of community participation, improper cleaning of the units, typical mindset of the villagers, lack of any programme to educate the villagers and make them aware of the community participation in making these units successfully operational etc. These reasons were exactly similar to the ones observed by us in the technology park in Baruipur.

13.16 It was strongly felt that whichever technology is being adopted there should be very strong monitoring mechanism to control the filtered water quality.

13.17 West Bengal waters are generally rich in iron. Most of these technologies that were employed in West Bengal also removed iron. Removal of iron is apparent from visual inspection of water, odour and also by the test. Unfortunately, removal of iron always does not ensure desired removal of Arsenic. Also, presence of Arsenic is not detectable by colour, odour or test. Only stringent monitoring of water quality on regular basis can ensure proper functionality of a treatment plant.

13.18 Any Arsenic removal technology and a treatment plant must also come with a complete package of sludge disposal (howsoever small it may be). Sludge amount being small does not mean that it will be less hazardous.

13.19 Any Arsenic removal technology must also come with a complete package of technical education for the users and must ensure a continuing supply line of chemicals/media etc.

(Domestic level plants)

13.20 All the three domestic Arsenic removal processes mentioned above (SOES process, AIIH&PH process and NML process) are workable solutions with their respective merits. However, a successful implementation of any of these processes will depend on appropriate networking to make available the chemicals (for SOES &AIIH&PH processes) and mineral (for NML's process) to the villagers. NML process has a special feature of foolproof sludge disposal facility integrated with the process. Other merits of NML process are low cost of consumables, no power requirement and no need for skilled operation. Imparting proper education to the villagers about the intricacies of the process being used is critically important for its success. However, since these are essentially domestic in nature, it is expected that a sense of belongingness will develop with the users, which may help in their successful implementation.

13.21 Intensive awareness-raising activities should be undertaken immediately with regard to the negative health effects of drinking arsenic-contaminated water in order to introduce preventive measures in cooperation with local bodies, NGOs and others.

13.22 All avenues for increasing the awareness in this matter should be utilized, including the mass media and communication facilities of Government/NGOs. Specific posters, leaflets and other communication materials should be developed for this purpose.

13.23 The extent of the problem may be documented by collecting all the requisite

information generated by the investigation projects relating to drinking water supply and health problems and evaluate the data.

13.24 Based on such an evaluation, the National Database on Arsenic in drinking water has to be strengthened. A comprehensive management information system (MIS) has to be established to facilitate monitoring, better planning and implementation of programmes. The data generated by the rapid case identification programme should also be stored and analysed centrally at an appropriate national institution having computer facilities and should form an integral part of the national database and MIS. The MIS under the NRDWQMSP can take care of this activity.

13.25 GIS or spatial thematic maps on the distribution of arsenic concentration in groundwater at various district/block scales which are reported to be available in 1: 4,000 scale should enable appropriate decision making in planning groundwater quality management, groundwater exploitation, alternate water supply and health care programmes in the arsenic affected areas.

13.26 Detailed site-specific project proposals have to be prepared taking into account the techno-economic feasibility for facilitating mobilization of resources and donor support. Efforts should also be made to mobilize support from the private sector and NGOs.

13.27 The report has examined the available technologies but these are largely on short term decentralized systems for treatment of water and avoiding drawing of contaminated water table. However, the feasibility of these options from the socio-economic viewpoint needs to be analysed. Considering the area of spread of the problem and the educational and socio economic background of the population facing this problem, decentralized mechanisms do not appear to be feasible. Under these circumstances, the exploitation of deep water table should be banned and use of shallow aquifers (free from Arsenic) for drawing water should be encouraged. In some areas, while the shallow aquifers are contaminated, deep aquifers are free from contamination. In either case, withdrawal of only Arsenic free water should be allowed. Leaching of Arsenic from contaminated to clean aquifers may be avoided by making this practice (of adopting 'sanitary (cement) sealing') statutory with sufficient punitive provisions for violation and strict enforcement.

13.28 The option of local rain water harvesting should also be examined. Also, village ponds that are promoted for multiple uses in West Bengal may be properly protected and used for drinking water supply after proper treatment.

13.29 The scale of problem of arsenic contamination in groundwater is huge, and becomes complicated in the lower part of the West Bengal delta because of hydraulic conditions, geological conditions, hydro-geochemical interactions and oxidation-reduction conditions arising from the groundwater exploitation and other hydro-geological conditions. Thus, water treatment technologies developed in laboratory for domestic and community level solutions as stand alone can not be effective and long term solution for safe drinking water supply is essential.

13.30 Treatment of Arsenic – affected water appears to be feasible only in areas where piped water supply cannot reach. Arsenic removal using different technologies will work only if

the methodology is backed by ways and means to educate all affected villagers in the working of the plant.

13.31 The State has increasingly gone in for surface water and its efforts in this direction are commendable. It may be safe to completely stop using affected water. The State is enjoying an average rainfall of about 1600 mm every year and this water is precious. Rain Water Harvesting should be in place as a local solution wherever it is feasible. The State also has a number of water bodies/ tanks which should be put to good use for drawing drinking water. This should be done without affecting the water bodies which are being used heavily for pisciculture. In this connection some apprehensions were expressed that the villagers who were weaned away from ponds / pools on the grounds that these may be contaminated (and thus depend on tube wells before the arsenic contamination was detected) may find it difficult to go back to the use of common ponds / pools. However, it is felt that this could be attempted with some proper planning and motivation. It may be necessary to treat water from ponds / pools (not used for pisciculture) to remove contamination and supply it as piped water wherever feasible.

13.32 GOI may provide a list of technology suppliers to the State and a suitable service provider to be selected by the State to set up operate and maintain Arsenic removal plants in affected areas under a MOU with the State Govt. Service provider will mobilize funds for capital cost by approaching banks or venture capitalists, the State to supply Arsenic-affected water free of cost to the service provider, provide him with free electricity/electricity at nominal rates, technology supplier to charge nominal fee for supplying technology to the service provider, O&M cost to be borne by the service provider, State Govt. to buy processed water from the service provider and supply it free of cost to villages, service provider to operate the Arsenic removal plant on a commercial basis.

13.33 Standard methods need to be explained regarding safe disposal of sludge that comes out of arsenic treatment plant at the community as well as district level. Central Pollution Control Board standards need to be clearly indicated in this regard. This issue comes under safe handling and disposal of toxic elements/waste, as such clarification from State and/or Central Pollution Control Board may be required before an arsenic treatment technology is sanctioned or approved. It may also be noted that although the contract is given to Agency for installation, operation and maintenance and safe disposal of sludge but in reality once the arsenic contaminated sludge is taken away by the Agency from the treatment site one does not know whether the sludge is disposed off in a safe manner. This means that adequate follow up action should be taken up by the PHED/Line Department regarding its safe disposal and it should not left to the Agency to dispose it as per its convenience. As such, while extending contract, the ultimate disposal of arsenic effluent and sludge also needs to be clearly incorporated in the contract.

13.34 For choosing appropriate technology, it is suggested that the technology with least life cycle cost along with performance guarantee may be chosen.

13.35 Rainwater harvesting in pond, impounding reservoirs may initiated in rural habitation. Such reservoirs need to be earmarked as dedicated water source for domestic use. The quality of water need to be upgraded by using horizontal roughing filter/slow sand filter. However, community participation for managing the system must be ensured.

13.36 State Govt. is already in action to implement the master plan on Arsenic mitigation and is poised to cover all the Arsenic affected habitations identified so far under the Bharat Nirman Programme. However, these efforts have to be supplemented with other measures as outlined in previous paras.

No. 12074/1-2(4)/2005-E&F
Government of India
Planning Commission
(Environment & Forests Division)

Yojana Bhavan, Sansad Marg, New
Delhi, the 22nd August, 2005.

ORDER

Subject: - Constitution of a Task Force for formulating Action Plan for removal of Arsenic contamination in West Bengal.

Life and sustenance of about 87 lakh people in West Bengal are severely affected by Arsenic contamination in ground water. In order to address the problem, it has been decided to constitute a Task Force under the Chairmanship of **Dr. V.L. Chopra, Member, Planning Commission.**

The Composition of the Task Force is as under:

- | | |
|---|----------|
| 1. Dr. V.L. Chopra, Member (E&F)
Planning Commission
Sansad Marg, New Delhi-110 001. | Chairman |
| 2. Dr. Prodipto Ghosh, Secretary, Ministry of
Environment and Forests, Paryavaran
Bhawan, CGO Complex, New Delhi-110
003. | Member |
| 3. Dr. V. Rajagopalan, Chairman, Central Pollution
Control Board (CPCB), Parivesh Bhavan,
East Arjun Nagar, Shahdara, Delhi-110 032. | Member |
| 4. Principal Secretary (Public Health & Engg.),
Government of West Bengal,
Writer's Building, Kolkata-700 001. | Member |
| 5. Chairman, West Bengal Pollution Control Board,
10-A, Block LA, Sector-III, Salt Lake City
Kolkata - 700 098. | Member |
| 6. Dr. S.N. Prasad, Associate Professor,
Department of Civil Engineering,
Indian Institute of Technology (IIT),
Hauz Khas, New Delhi-110016. | Member |

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|-----|---|------------------|
| 7. | Prof. Dipankar Chakraborty,
Head, Department of Environmental Sciences,
Jadavpur University, Kolkata - 700 012. | Member |
| 8. | Dr. (Prof.) Varshney, Director, 88,
Vaishali, Pitampura, New Delhi-
110 034. | Member |
| 9. | Dr. P.H. Ananthanarayanan, All India
Institute of Hygiene & Public Health,
Chittaranjan Avenue, Kolkata-700072. | Member |
| 10. | Mrs. Adarsh Misra
Pr.Adviser, Planning
Commission, New
Delhi-110001. | Member |
| 11. | Shri Chandra Pal,
Adviser (State Plans - East)
Planning Commission, New Delhi-110001. | Member |
| 12. | Dr. Dilip Biswas, (Former Chairman, CPCB)
40/14, Chittaranjan Park, New Delhi-110019. | Member |
| 13. | Dr. K.M. Paknikar
Agharkar Research Institute
Gopal Ganesh Agarkar Road,
Pune-411004 (Maharashtra) | Member |
| 14. | Dr. R. Mandal, Adviser (E & F),
Room No. 215, Planning Commission,
New Delhi-110 001. | Member-Secretary |
3. **Terms of Reference of the Task Force are:**
- i) Formulation of an Action Plan for removing Arsenic contamination from the ground water of West Bengal,
 - ii) Examine available technologies and recommend right methodology,
 - iii) Recommend the time schedule and Road Map for implementation
 - iv) Recommend measures for O & M of the assets,
 - v) Recommend mechanism to monitor and evaluate the programme.

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4. The Task Force may co-opt other Members and constitute Sub-Groups on specific themes.

5. The Task Force would submit its report **within six months from the date of this Order**. Payment of TA/DA for the non-official members of the Task Force would be borne by the Planning Commission as per rules.

(K.K. CHHABRA)

Under Secretary to the Govt, of India

To

Chairman, Members and Member-Secretary of the Task Force.

Copy to:

1. PS to Deputy Chairman, Planning Commission.
2. PS to MOS (Planning)
3. PSs to Members, Planning Commission
4. PS to Member Secretary, Planning Commission
5. PS to Pr. Adviser (E & F), Planning Commission
6. PS to Adviser (E & F), Planning Commission

(K.K. CHHABRA)

Under Secretary to the Govt, of India

Note: 2 Members (Dr. A.K. Keshari, Associate Professor, Deptt. Of Civil Engineering, IIT Delhi and Dr. Atanu Sarkar , Scientist, Centre for Science & Environment, New Delhi) were co-opted later. Dr. S. Natesh, Sr. Adviser, Dept. of Biotechnology, GOI, New Delhi and Dr. Santanu Bhattacharjee, Scientist, National Metallurgical Laboratories, Jamshedpur were Special Invitees for the 1st Meeting of the Task Force held on 13.9.2005.

Annexure I (A)

No. 12074/1-2(4)/2005-E&F
Government of India
Planning Commission
(Environment & Forests Division)

Yojana Bhavan, Sansad Marg,
New Delhi, 30th March 2007.

ORDER

Subject: - Revival of the Task Force for formulating Action Plan for removal of Arsenic contamination in West Bengal.

With reference to Planning Commission Order of even No. dated 22nd August 2005, it has been decided to revive the said Task Force with tenure of **2 months**. While the Terms of Reference will remain unchanged, the composition will be as under:

2. The Composition of the Task Force is as under:

- | | |
|--|----------|
| 1. Dr. V.L. Chopra, Member (E&F)
Planning Commission
Sansad Marg, New Delhi-110 001. | Chairman |
| 2. Dr. Prodipto Ghosh, Secretary, Ministry of
Environment and Forests, Paryavaran
Bhawan, CGO Complex, New Delhi-3. | Member |
| 3. Chairman, Central Pollution Control Board
(CPCB), Parivesh Bhavan,
East Arjun Nagar, Shahdara, Delhi-110 032. | Member |
| 4. Principal Secretary (Public Health & Engg.),
Government of West Bengal,
Writer's Building, Kolkata-700 001. | Member |
| 5. Chairman, West Bengal Pollution Control Board,
10-A, Block LA, Sector-III, Salt Lake City
Kolkata - 700 098. | Member |
| 6. Dr. A.K. Keshari, Associate Professor,
Department of Civil Engineering,
Indian Institute of Technology (IIT),
Hauz Khas, New Delhi-110016. | Member |

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- | | | |
|-----|---|------------------|
| 7. | Prof. Dipankar Chakraborty,
Head, Department of Environmental Sciences,
Jadavpur University, Kolkata - 700 012. | Member |
| 8. | Director,
All India Institute of Hygiene and Public
Health
Chittaranjan Avenue
Kolkata – 700 072 | Member |
| 9. | Dr. Santanu Bhattacharjee, Scientist,
National Metallurgical Laboratories,
Jamshedpur | |
| 10. | Shri Ajay Shankar.
Pr.Adviser (E & F),
Planning Commission,
New Delhi-110001. | |
| 11. | Dr. Dilip Biswas, (Former Chairman, CPCB)
40/14, Chittaranjan Park, New Delhi-110019. | Member |
| 12. | Dr. K.M. Paknikar
Agharkar Research Institute
Gopal Ganesh Agarkar Road,
Pune-411004 (Maharashtra) | Member |
| 13. | Shri P.N. Asari, Adviser (E & F),
Room No. 223, Planning Commission,
New Delhi-110 001. | Member-Secretary |

3. **Terms of Reference of the Task Force are:**

- i) Formulation of an Action Plan for removing Arsenic contamination from groundwater of West Bengal,
- vi) Examine available technologies and recommend right methodology,
- vii) Recommend the time schedule and Road Map for implementation
- viii) Recommend measures for O & M of the assets,
- ix) Recommend mechanism to monitor and evaluate the programme.

.3/-,

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6. The Task Force would submit its report **within 2 months from the date of issue of this Order.** Payment of TA/DA for the non-official members of the Task Force would be borne by the Planning Commission as per rules.

(Anil Malhotra)
Deputy Secretary to the Govt, of India

To

Chairman, Members and Member-Secretary of the Task Force.

Copy to:

7. PS to Deputy Chairman, Planning Commission.
8. PS to MOS (Planning)
9. PSs to Members, Planning Commission
10. PS to Member Secretary, Planning Commission
11. PS to Pr. Adviser (E & F), Planning Commission
12. PPS to Adviser (E & F), Planning Commission

(Anil Malhotra)
Deputy Secretary to the Govt, of India

Co-opted Members

1. Smt. Shanta Sheela Nair, Secretary, Shri R. M. Deshpande, Additional Adviser, and Shri Kamal Mazumdar, Deputy Adviser, Department of Drinking Water Supply, Ministry of Rural Development had kindly consented in September 2006 to join the Task Force as Special Invitees and had attended meetings of the Task Force and also visited Kolkata in March, 2007 with Planning Commission Officers for discussions with State Govt. Officials and field visits to affected areas.
2. Planning Commission Officers wish to place on record their gratitude to Smt. Nair and her colleagues for the valuable guidance, encouragement and support to the Commission without which the report could not have been finalised so expeditiously.

Annexure II

Summary of 5 studies on Arsenic Contamination in West Bengal Carried out by the School of Environmental Studies (SOES), Jadavpur University, Kolkata

S.No.	Block/Village	Size of Sample	Arsenic Level		Symptoms
			>10 $\mu\text{g/l}$	>50 $\mu\text{g/l}$	
					Skin Lesions
1.	Rajapur Village , Domkal Dt.	336 Nos. handpumps	307 Nos. (91%)	213 Nos. (63%)	
		3500 residents	--	--	149
		420 biologic (hair, urine & Nail) samples	389 Nos. (92.6%)		
2.	Jalangi Block	1916 water Samples (31% of total tubewells)	77.8%	51% 17% (>300 $\mu\text{g/l}$)	
		7221 people in 44 villages	--	--	1488
		1600 Biologic samples	88%		
3.	Murshidabad	29612 handpump samples	53.8%	26%	
		25 lakh villagers	All	--	
		12 lakh villagers	--	All	
		3800 Biologic samples	95% of Nail Samples 94% of Urine samples	75% of Hair samples	
4.	Sagarpura village	565 tubewell samples	86.2%	58.8%	
		21 villages (ground Water)	--	All samples	
		3302 villagers	--	--	679 (20.6%)
		850 Biologic samples	85%	--	
5.	Murshidabad	25274 villagers	--	--	4813 (19%)
		2595 children	--	--	122 (4%)

Note: Other problems due to Arsenic included susceptibility of pregnant women to spontaneous abortions, still births, pre-mature births, low birth weights, etc. Adults had other problems such as weakness/lethargy, chronic respiratory problems, anemia, etc.

Annexure-III

TECHNOLOGIES AVAILABLE IN INDIA FOR TREATING ARSENIC CONTAMINATED WATER

S. No	Technology Supplier	Whether field-tested (6-12 Months)?	Where field-tested and results?	Max. As Conc. Treated	As level after treated	Domestic or Community-level size?	If Domestic, can it be upgraded to Community-level?	Capital Cost, Capacity etc.	Whether tech. generates sludge?	Training requirements?	Remarks
1	2	3	4	5	6	7	8	9	10	11	12
1.	Agharkar Res. Instt. Pune.	10 months at 5 sites in Chattisgarh . Continuing .	Tests done at 2 villages – Kaurikas a and Murethit ola Dt. Rajnandg aon.	Upto 5 ppm.	10 ppb.	For Community-level	Can be downgraded to Domestic level	Rs. 65, 000 for 1000-2000 litres/day cap. Running cost – Rs. 20/per Cu. M. of raw water.	Yes. Arsenic precipitate generated to be disposed off in a concrete pit.	Minor training reqd. Even unskilled person after trg. can operate the plant.	
2.	Central Glass & Ceramic Res. Instt., Kolkata.	Tested in pilot plant of 500 LPD at Akrapur, Barasat. North-24 Paraganas under DWS, MORD	4 X 2500 LPD plants set up under PHED, State Govt. since March, 2003. In Sept.	Arsenic upto 1.5 ppm, Iron upto 15 ppm. Akrapur plant treating 0.9-1.5 ppm Arsenic.	Less than 10 ppb of arsenic and less than 0.3 ppm Iron as per	Only Community-level.	No.	Rs. 3 lakh for 2500 LPD and Rs. 4 lakh for 5000 LPD. Running cost at Rs. 10-15 paise per litre only.	Yes, but very low. In 3-6 months, only about 5 litres sludge generated. R&D in progress to recover &	No. Even Housewives can operate the plant. Persons with 10 th Std. education can operate	Uses Ceramic membranes. Not able to get the membranes on large scale. Instt. finding it difficult to get finances

		sponsorship since Jan. 2002. Plant still operational .	2006, another 2500 LPD plant set up as SSI on self-finance		WHO Standards.				use Arsenic from sludge.	after some training.	for this. Tech. patented in India (NF /234/2001 for process to make porous ceramics for pressure filtration and NF /235/2001 for getting Arsenic-free (< 10 ppb) water and equipment therefore), USA, Bangladesh, Taiwan,
3.	All India Instt. of Hygiene & Public Health (AIH&PH), Kolkata	Tested for more than 3 yrs.	Tech. Park near Kolkata set up under Indo-Canada Envi. Facility (ICEF) at Baruipur, South 24 Paragana	Upto 0.3 to 1 mg/l	0.01 to 0.04 mg/l	Oxide India, BE College and AIH&PH tech. suitable for both levels.	Except Pal Trockner and Apyron, the other 3 tech. suitable for both levels.	<u>Community-level</u> Cost incl. installation - Rs. 45 K to Rs. 50 K, Cap. 8K to 12 K litres/day, Operating cost – Rs. 1.40 to 2.00per	Pal Trockner, BE & Apyron tech. plants use 'adsorption tech., no sludge is produced. But, media, after exhaustion,		

			<p>s. Also tested in 8 Dts.. Used tech. of Pal Trockner, Oxide India, Apyron, BE College & AIH& PH</p>					<p>1000 lt. <u>Domestic Level</u> Capital cost incl. installation – Rs. 100 to 500, Cap. 50 to 200 lt. per day, Operating cost – Rs. 3.30 to 9 per 1000 lt.</p>	<p>has to be disposed off as hazardous waste. AIH&PH tech being ‘co-ppt’ tech generates sludge to be disposed off in toilet pits or used for making bricks by kilns.</p>		
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Annexure-IV**Patent documents**

S. No.	Title	Patent Number
1.	Process for removing Arsenic from aqueous streams	US Patent No.: 6,863,825
2.	Zirconium-modified materials for selective adsorption and removal of aqueous Arsenic	US Patent No.: 6,824,690
3.	System for removal of Arsenic from water	US Patent No.: 6,821,434
4.	Composition and process for removing Arsenic and selenium from aqueous solution	US Patent No.: 6,800,204
5.	High efficiency ion-exchange system for removing Arsenic from water	US Patent No.: 6,706,195
6.	Method for simultaneous removal of Arsenic and fluoride from aqueous solutions	US Patent No.: 6,613,230
7.	Composition for Arsenic removal from ground water	US Patent No.: 6,461,535
8.	Method and apparatus of the removal of Arsenic from water	US Patent No.: 6,368,510
9.	Process for removal and stabilization of Arsenic and selenium from aqueous streams and slurries	US Patent No.: 6,197,201
10.	Zero brine, zero rinse water process for treatment of contaminated drinking water for removal of Arsenic	Pub No. US 2004/0178148
11.	Process for removing Arsenic from aqueous streams	Pub No. US 2004/0144729
12.	Treatment of Arsenic-contaminated water using Akaganeite adsorption	Pub No. US 2004/0262225
13.	Manganese/oxygen compound with Arsenic adsorption, Arsenic adsorbent, and method of adsorptively removing from aqueous solution	Pub No. US 2004/0109821
14.	Process for the preparation of Arsenic free water, apparatus therefor, method for the manufacture of porous ceramics for use in pressure filtration to produce Arsenic free water	Pub No. US 2003/0183579
15.	Composition and process for removing Arsenic and selenium from aqueous solution	Pub No. US 2003/0155303
16.	Arsenic removal from aqueous media using chemically treated zeolite Materials	Pub No. US 2003/0132155
17.	High efficiency ion-exchange system for removing Arsenic from water	Pub No. US 2002/0125195
18.	System and method for simultaneous removal of Arsenic and fluoride from aqueous solutions	Pub No. US 2002/0113023
19.	Process and apparatus for the removal of heavy metals, particularly Arsenic, from water	Pub No. US 2002/0036172
20.	System and method for removal of Arsenic from aqueous solutions	Pub No. US 2002/0003116
21.	Method and apparatus for the removal of Arsenic from water	Pub No. US 2001/0052495
22.	Method of Arsenic immobilization in crystalline form from water	Pub No. US 2004/0222162
23.	Process for removing Arsenic from acidic aqueous solution	Pub No. US 2004/0007536
24.	Method and system for the determination of Arsenic in aqueous media	Pub No. US 2003/0030800

Summary of Master Plan Prepared by PHED Directorate of West BENGAL to tackle Arsenic contamination of ground water in May 2006

1. Problem of excess arsenic > 0.05 ppm prevailing in West Bengal since 80's.
2. Health implications due to consumption of excess arsenic bearing water:-
 - (a) Hyper pigmentation
 - (b) Kuralosis
 - (c) Weaknesses
 - (d) Anacmia
 - (e) Burning sensation of eyes
 - (f) Swelling of legs
 - (g) Lever fibrosis
 - (h) Chronic lung diseases
 - (i) Gangrene of toes
 - (j) Neuropathy
 - (k) Skin cancer.

Ground water being inexpensive in abstraction, bacteriologically safe and available at the place and time of requirement is used as main source of drinking water in West Bengal.

3. Earlier detection/ diagnosis:

CGWB's report: Occurrence of arsenic in ground water above 0.05 mg/l in parts of West Bengal was in report since 1978. From clinical sources ST medicine Kolkata and AIIH&OPH the first case of chronical dermatosis was diagnosed in STM in July, 1983.

- Working Group was constituted by Government of West Bengal in December, 1983 and working group observed that ground water showed presence of arsenic beyond 0.05 mg/l in South 24 pgs. District, North 24 pgs district Nadia, Murshidabad , Malda Burdwan.

4. Strategy:

- (a) State Government prepared project costing at Rs.10.82 lakh which was sanctioned by GOI under TM in May 1988 to study nature, extent and causes of arsenic pollution.
- (b) Steering Committee with leading professionals in related fields was constituted and the Committee's report was submitted in June 1991.
- (c) State Government constituted another Committee in April, 1992 and its final report was submitted in October, 1994.

Recommendations of Steering Committees were as under:-

- (a) Arsenic contamination of ground water of West Bengal is due to geomorphological reasons. Arsenic contamination in geological formation is mobilized in ground water due to various environmental reasons.
- (b) Arsenic is occurring usually in near surface succession of quaternary sediments of various thicknesses mainly confined to intermediate aquifer (20 m – 80 m bgl).
- (c) Deeper aquifer (third aquifer) is expected to yield arsenic free water which may be tapped for drinking purpose. The water is invariably required to be tested for Arsenic before use.
- (d) The district wise specific suggestions for using water for drinking purposes were as follows:-
 - i) For Pubasthali / Burdwan district), the deep aquifers below 100 m depth may be tapped. The deeper aquifers in general are separated from shallow ones containing arsenic rich ground water by thick impermeable clay layers.
 - ii) In Nadia, Murshidabad district aquifers below 100 m have not been found to be rich in Arsenic. But in different locations, upper aquifer is separated from lower ones by thin semi permeable sandy/ silty clay. So utilization of nearby surface water to be thought of
 - iii) Hydrology of Murshidabad, Nadia, North 24 pgs and South 24 pgs district suggests that deeper aquifer tubewells will not be suitable due to absence of thick clay barrier separating “Arsenic” affected aquifer from the deeper aquifer. Besides, (R.O. Ion Exchange) there is problem of salinity in South 24 pgs. And North 24 Pgs.
 - iv) In Malda district, aquifer is limited in 80-90m depth, so only surface water is recommend. For piped water supply system, arsenic removal plants already introduced in district are recommended (with tool proof sludge disposal facilities).
 - v) Development and use of treatment units to be fitted with HP and big dia tubewells supporting PWSS is to be taken up side by side. (Sludge disposal facilities to be integrated with the system).
 - vi) Setting up of laboratories for monitoring and surveillance of ground water on regular basis should be ensured.

Arsenic contamination being dynamic in nature spreads both horizontally and vertically and, therefore, monitoring of water quality and identification of affected areas on continuous basis is considered to be of high priority.

It is pertinent to mention that Arsenic Sub-Mission set up by GOI had already recommended to plan for covering affected areas with surface water source depending upon quality of supply and availability of water.

5. Constitution of Task Force

State Government constituted Task Force in April, 1995 with experts from various authorities and key institutions namely, CGWB, GSI, Department of Drinking Water Supply, GOI, SWID, Directorate of Health and Family Welfare Department, WBPCB, AIIH&PH, University of Kolkata, Jadavpur University, Kalyani University, B.E. College (Deemed University), UNICEF etc. Task Force is working in advisory capacity and as state level Consultancy Body for carrying out activities in this regard.

All the current activities on water quality monitoring and surveillance and mitigation of arsenic contamination are being carried out as per recommendations of committee Task Force.

6. WQ M & S

Based on testing of water sources for arsenic, it reveals that “AS” contamination is gradually spreading and the affected areas are increasing. Extent of spread of such areas with passage of time is as under:

Sl. NO.	Date	No. of affected districts	No. of affected blocks	No. of affected villages	NO. of affected habitations	NO. of affected municipalities.
1.	May 93	7	34	78	149	3
2.	Sept. 95	7	56	388	757	9
3.	Dec.97	8	61	1302	3049	9
4.	Dec.98	8	65	1312	3067	9
5.	Dec.99	8	67	1550	3365	11
6.	Dec.2001	8	75	2065	4244	11
7.	Dec.2002	8	75	2579	4973	11
8.	Dec.2006	8	79	3235	6623	11

7. Magnitude of problems (Para 5 & 6)

- Presently, the risk population in rural areas is around 166.77 lakh out of state's rural population of 577.35 lakhs.
- In urban areas, risk population is 120.00 lakh out of total states urban population of 224.86 lakh.
- According to 2001 census, total risk population is 286.77 lakh out of total population of 802.22 lakh which is 35.70%.

7. Achievement

Programme for testing of all public tubewells in Arsenic- affected 79 blocks of 8 districts has been concluded under Joint venture of PHED and UNICEF. For this purpose, 20 laboratories run by NGOs have been set up in Arsenic-affected blocks of the State.

District-wise summary is as under:-

Sl. No.	Districts	Total no. of public tubewells	% of tubewells with Arsenic 0.05 mg/l	No.of affected mouzas	No. of affected habitations
1.	Burdwan	6518	6.46	76	102
2.	Hooghly	2087	12.22	41	91
3.	Howrah	879	0.34	3	3
4.	Maldah	19279	28.72	311	871
5.	Murzhidabad	40593	30.66	791	1218
6.	Nadia	29640	25.28%	937	1945
7.	24 Pgs (N)	25987	25.76%	927	2124
8.	24 pgs. (S)	7284	6.59	143	269
	Total districts. 8	1,32,267	25.20%	3229	6623

MITIGATION MEASURES (ROAD MAP)

1. New HP fitted tubewells in deeper aquifer.
2. Ring wells at upper aquifers.
3. Arsenic Treatment plant with existing HPs fitted tubewells (sludge disposal strategy to be spelt out).
4. New Big dia tubewells for deeper aquifer for exiting ground water based PWSS.
5. Arsenic removal plants in existing ground water based PWSS (sludge treatment component to be integrated)
6. New ground water based PWSS (alternate safe source).
7. Surface water based PWSS with river water as source.
8. PWSS with pond water as source.

9. Master Plan :

- Permanent solutions are to be found out.
- **Observations on Short-term/ intermediate measures are :**
 - (a) Ringwells are not accepted by people and are prone to bacteriological contamination.
 - (b) Arsenic Treatment plant attached to HPs tubewells have been found effective as intermediate intervention. Sludge disposal methods are not integrated with treatment plant. In long run these units have failed to serve the purpose due to O & M and sludge disposal problem.
 - (c) Deeper aquifers replacement tubewells in some cases, turned out to be ineffective due to leaching of Arsenic deeper layers from top.
 - (d) Tube wells of some ground water based PWSS though sunk in deeper "AS" free aquifer showed present of "AS" in due course of time due to leaching action.

10. **Master Plan is being prepared with following recommendations of Arsenic Task Force**

- a) All Arsenic affected villages to be covered by PWSS.
 - b)** Areas covered under existing short-term and mid-term measures such as ATU attached HP tube wells. Replacement of tube wells etc. should be integrated within future plan of Action.
 - c) Attempts to be made to cover affected areas with surface water schemes wherever possible/ available.
 - d) Affected areas, which can not be covered under existing / proposed surface water based PWSS to be served from ground water based PWSS.
 - e) All proposed ground water based new PWSS should be provided with ARP unless safe water aquifer well separate from contaminated aquifer by thick impermeable barrier of clay is available.
 - f) All existing ground water based PWSS in affected are to be provided with ARP except where safe aquifer well separated from contaminated layer by thick impermeable barrier is available.
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Fig. 1 WSI-Hermonite technology Kumorhat, Jamrultoal



Fig. 2 Pal Trockner technology, Kumorhat



Fig. 3 AllHPH technology, Kumorhat, Chadokhal



Fig. 4 Apyron technology, Panchanantola



Fig. 5 RPM technology, Chadokhal, Masjid



Fig. 6 BE College technology, Amal filter, Padmajala Naskarpara



Fig. 7 PHED technology, Alipur



Fig. 8 Pal Trockner technology, Dakshin Padmajala



Fig. 9 Anir Engineering technology Dhapdhapi, Khanpara More



Fig. 10 Apyron Technology, Dhapdhapi



Fig. 11 BE College Technology (Marketed by Oxide India) Uttar Padmajala, Barotala

