Activity Based Training of WaterAid India Partners in Water Quality Monitoring & Management

- A Report -

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DEHRA DOON, UTTARANCHAL

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The EQM Group
PSI

EXECUTIVE SUMMARY

Effective monitoring of access to, quantity of and quality of water is a key consideration for India. Given the large investments and big programmes and schemes including the current thrust of Sector Reforms, absence of good quality monitoring on the ground is a big drawback. Monitoring the quality of water, linking it with parameters of health (focusing on waterborne diseases), social aspects of access for the marginalised and poor communities, different water focused programmes and schemes, subsidies and campaigns, interface between different agencies, etc., is either not being done or is being done piece meal by different agencies.

While only the government will have the means to undertake large sample surveys on a regular basis, the knowledge and information with the NGOs and the sector needs expansion. Civil society organisations should also pool their information and ideas together to monitor and assess the water status on a regular basis. This information should then be shared in the public domain.

The existing state level water and sanitation mission's role needs to be strengthened for civil society participation and citizens' forums should be engaged in planning and monitoring of progress in the rural (village, block and district level forums) settings. This calls for a community level monitoring system for water availability and water quality – which may also be required for supporting higher level planning and monitoring.

In the year 2006,Wateraid India (WAI), an international organization focusing on water, tied up with People's Science Institute, a research oriented organization, to train its regional partners on water quality management (WQM) in different parts of India. The program was carried out in two phases. In the first phase, there were a series of training workshops, following which the regional partners of WAI were asked to generate data on WQ from their respective project areas. This data was analysed and sent back to the partners. In the second phase, there were a series of refresher workshops on WQ and a field exercise to validate the WQ data generated by these partner organizations.

Key Objectives

- To train WAI regional partners in water quality management and assess their performance.
- To validate the water quality test results produced by the WAI regional partners
- To discuss different treatment options for specific WQ problems

- To provide safe drinking water in the project areas of WAI regional partners

Key Findings

- Bacteriological contamination (Faecal Coliform) remains the biggest WQ problem of India. The reason for this could be attributed to improper maintenance of sources, poor maintenance of hygiene, inadequacy of treatment facilities and administrative failures at all levels.
- There are a few region specific water contaminants in different parts of India, e.g. Fluoride and Iron in eastern parts of India, Nitrate (in a few discrete pockets) in Central and Northern parts of India, Hardness, Salinity and Fluoride in Southern parts of India;
- As far as the validation of water quality test results goes, Student's t-test showed that the difference between the WQ results produced by the WAI partners and that produced at the PSI laboratory was insignificant.
- A range of mitigation technologies is already available, but the acceptability, affordability and sustainability of a technical solution have to be considered from the users perspective, otherwise it risks failure.

This report on activity-based training of WAI partners on WQ serves two purposes-

1. It becomes a water quality status report of India's different regions, highlighting the major WQ problems.
2. It explains the capacity building process of WAI partners in WQM. It also explains the process of validating their results following a rigorous scientific approach.

Key Recommendations

Programme Recommendations

1. Water quality surveillance should be a community responsibility. Once trained, communities become equipped enough to carry out all general drinking WQ tests. Water Supply Agencies should do 100% source testing to identify safe and unsafe sources. They should also carry out chlorination of all drinking water sources on a regular basis. The information must be shared with the community. The community should play the role of a watchdog and ensure that the chlorination is carried out accordingly.

2. Water Quality Monitoring should be accorded a high priority and suitable institutional mechanisms at national, state, district, block and panchayat levels should be developed involving all related sectors.
3. To take care of pollution of drinking water sources arising from human waste and industrial and agricultural activities, appropriate linkages between Drinking Water Quality Control & Surveillance (DWQC&S) and hygiene education has to be established.
4. There should be emphasis on putting in place the requisite mechanism to monitor the quality of drinking water and devising effective IEC interventions to disseminate information and educate people on health and hygiene aspects of clean drinking water.

Policy Recommendations

1. State Water Supply Agencies should be aware of the problems of imposing a treatment technology on the community, and the importance of ensuring local involvement in decision-making.
2. An integrated WQ testing, monitoring and surveillance system to be operated with community participation by using Catchment Area Approach (involving district and taluka level) has to be developed. A pilot study on Catchment Area Approach has to be tested at the village level.
3. Water quality problems are a public health concern. The water supply agency should partner with the State's Health Department, local VOs and CBOs to mobilize capacity and resources to deal with the issue. This is in line with the aims and objectives of the National Rural Health Mission.

1.0 INTRODUCTION

Ensuring safe supply of water has been a major problem in developing countries. India is no exception. Centralized approaches of water supply and monitoring have not helped the cause either. This is illustrated by the fact that an estimated 480 million people[1] in India do not have access to safe drinking water. Centralized systems have not only proved to be futile, they are also prohibitively expensive. Hence a radical reorientation in monitoring the supply of safe water was urgently required. In accordance with the emerging need, Government of India pilot-tested a community based water quality monitoring approach[2] in four different districts of India. Following the success in these districts, it is now scaling up its activities in the entire country through a programme designed by the Rajiv Gandhi National Drinking Water Mission.

During 2005, in line with the initiatives taken by the Government of India, Wateraid India, an international water focused organization tied up with the EQM group of People's Science Institute, Dehra Doon and planned a training of its partners in nine different states (three different WAI regions) of India. The EQM group at PSI had been training communities across India on different aspects of water quality management since 2001. The programme was designed to build the capacities of WAI's partners in water quality monitoring and management (WQM) and to deal with the water quality problems at the local level.

1 Pangare G., Pangare V. & Das B. (2006): Springs of Life, Academic Foundation, New Delhi, p. 81
2 (2004): Nirmal Gram Patrika , MoRD (GOI), Issue 3:Oct-Dec 2004, New Delhi

2.0 BACKGROUND LITERATURE REVIEW

2.1 Community based water quality monitoring – The Interventions by Government and NGOs

Providing safe drinking water and sanitation facilities to all in rural areas is a major developmental challenge faced by India. Since water falls in the entry 17 of the State List in the Seventh Schedule to the constitution[3], supply and distribution of potable water is regulated by various local bodies/authorities and the State Governments are responsible for proper implementation of laws made by them. Department of Drinking Water Supply had taken many initiatives to meet this challenge of supply of potable safe drinking water. Since 1999, the government has initiated a reform process, which puts special emphasis on demand driven and community participatory approaches. The greater involvement of community level institutions like PRIs, CBOs, etc. in the whole process of planning, implementation, monitoring, operation & maintains, cost sharing has made these programmes self sustainable.

The emphasis of current UPA Government on Water and Sanitation Sector is reflected through increase in budgetary allocation for rural drinking water supply and sanitation from Rs. 3,300 crore in the year 2004-2005 to Rs. 4,750 crore in the year 2005-2006, a 43.93 per cent increase[4]. A community-based rural drinking water quality monitoring and surveillance programme was pilot-tested in four districts of the country. Now the scaled up programme envisages involvement of Panchayati Raj Institutions (PRI) and school and college laboratories in routine water quality monitoring linked to District, State and National level water quality laboratories under the technical supervision and guidance of the State Level Referral Institutions and the National Level Referral Institute. The National Institute of Communicable Diseases (NICD) under Ministry of Health & Family Welfare will act as the National Level Referral Institute. The modalities for launching the programme throughout the country are being worked out in consultation with the National Level Referral Institute.

To institutionalize the reform initiative in water and sanitation sector MOU process has been initiated with various states. The states are preparing the comprehensive documents on all aspects of sanitation and water supply in their respective states. For specific endemic problems in

[3] Constitution of India, Seventh Schedule
[4] Frontline, Vol.24 No.2, January 25-Febaruary 10 2007.

a particular state, different remedial measures have been initiated. The whole effort was to provide low cost but effective practical solutions to the identified problems thorough introduction of scientific and better water and sanitation management.

The voluntary sector had also contributed usefully to this WQM exercise (CAMPS, CLEAN-INDIA initiatives etc). But the efforts have been few and intermittent. So the benefits of the process have never trickled down to the lowest rung of societal hierarchy. Involving the community in the process of WQM has remained a distant dream in most of the cases. So it becomes imperative that WQM at the village level be institutionalized. And in this context local VOs can play an important role. Once they are trained on WQM, they can pass on the knowledge to the community, raise awareness in the community, monitor their performance and share their WQ testing results in wider public domain. Given the complexity of the situation and enormity of our country, community level monitoring systems for water quality are absolutely essential for supporting higher level planning and monitoring.

This program on WQM, run by Wateraid India with the technical support from People's Science Institute was a step in this direction. It was essentially a training of partners VOs of Wateraid India from different parts of the country. These organizations were trained on different aspects of WQM, which helped them to generate WQ data in a scientific manner. The program also looked at the sustainability of the WQM exercise and made sure that the data was validated in a state-of-the-art laboratory. Although the program looked at the region specific WQ problems in a detailed manner it also had a national perspective. Since it was carried out throughout the country it became easier to understand the region specific problems as well as the major pollutants threatening to impair the quality of drinking water.

The exercise was also useful to the several VOs across India. Along with learning the importance of safe water, they learnt how to monitor the quality of water and to deal with water quality problems subsequently. Once the VOs were capable of carrying out tests on their own, they also helped the village community to learn these WQ tests. The program should serve an eye-opener to both government and private agencies in India and it emphasize that monitoring of water quality and regular treatment of drinking water should become a key consideration of national and state level agencies.

2.2 Sustainability of Water Sources and Providing Safe Drinking Water through Effective Policy, Administrative and Legal Action

Given the increasing pollution of rural drinking water schemes, there is a need to identify water sources exclusively for drinking water needs of the rural community and incorporate this into the legal and administrative framework of rural governance so that these water sources are considered a common property resource and any threat to its sustainability is countered by administrative action. If this is not done, merely increasing funding will not solve the problem of increasing water distress.

Longer term planning for rural drinking water needs and for safe disposal of liquid and solid wastes, is required. Because our field observations clearly show that unsafe disposal of wastes, defecation (by human and animals) near the source, lack of hygiene education and improper maintenance of the source itself has aggravated the scarcity of safe drinking water. The current discourse on right to drinking water and priority for drinking water in the national and state level water policies, is not matched with the reality of budget allocation and projects on the ground. Water basin level approach to planning is being proposed in most state and national budgets planning. But increasing awareness about the importance of safe water and strengthening regulation for safe drinking water provision is also required to regulate the service providers for the sake of public health and safety.

Effective economic and management policies are also needed to prevent the crisis that threatens India in the coming years. Good management of the country's water resources will effectively reduce the amount of pollution that is currently plaguing the nation's surface, ground and coastal waters. The consequent improvement in water quality will also have repercussions in terms of increased access to safe drinking water, thereby ameliorating human and environmental health. Since the past few years, the government has recognized the importance of promoting the sustainable management of India's water resources due to decreasing number of good quality water resources and increasing water pollution, and has placed water development as one of its main priorities in the coming decades. Voluntary organizations and civil society organisations aren't lagging far behind. They are also testing the efficacy of several water quality improvement schemes at the micro level. So it becomes necessary that government agencies and the voluntary sector should share their experiences and extend further cooperation to provide safe drinking water to more and more people across the country.

2.3 Quality of Groundwater in India

Groundwater accounts for 80% of the rural domestic water supply in India. Hence it is imperative to examine the different issues that result in the deterioration of groundwater quality and measures that will improve the quality of groundwater in India.

Bacteriological Contamination (especially Faecal Coliform) accounts for the greatest pollution problem of groundwater sources. Ironically though, groundwater does not inherently contain high amounts of Faecal Coliform. Most of the coliform contamination reaches groundwater due to leaching of solid (human and animal excreta) and liquid wastes generated near the water sources. Faecal Coliform accounts for number of water borne diseases like Diarrhoea, Jaundice, Hepatitis, Cholera, Polio etc.

There are other groundwater quality problems as well, which are geogenic in nature. For instance, Fluoride and Arsenic, which are mainly contributed by the weathering of underground rocks. The Entire Gangetic Delta Plain, which consists of alluvial soil, contains arsenic in the deeper aquifers. Arsenic causes skin lesions and can lead to arsenicosis (skin cancer) at a later stage.

Similarly, Andhra Pradesh, Rajasthan, Gujarat, Assam, Uttar Pradesh and a number of other states in India (see fig.1 for details) contains underground fluoride bearing rocks such as Calclite, fluospar and fluoroapatite etc, which accounts for leaching of fluoride in water, leading to a deadly diseases called fluorosis.

Nitrate is another major groundwater quality concern. Use of fertilizers in Agriculture, disposal of raw sewage, absence of nitrogen fixing bacteria in the root-nodules leguminous plants (pulses) and industrial pollution are the main causative agents for nitrate in the groundwater. Nitrate has been found to be present in the following states of India, Madhya Pradesh, Uttar Pradesh, Punjab, Haryana, Delhi and Tamil Nadu. Nitrate causes " Blue Baby Syndrome" in infants (within the age group of 0-6 months), it may also lead to accumulation of N-nitroso amines in adults[5] leading to cancer.

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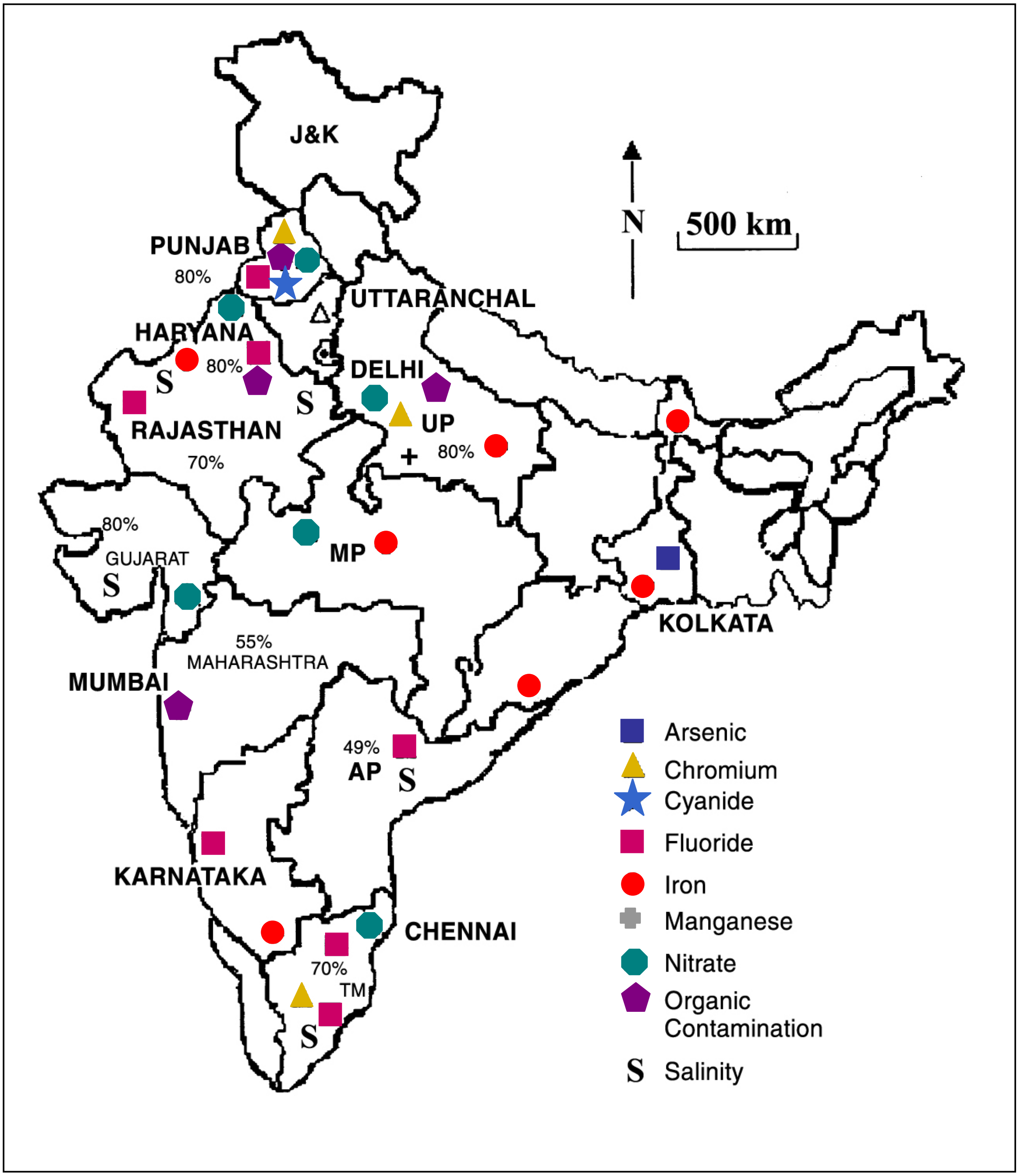
[5] Sawyer N, Mccarty P.L. and Parkin G.F., Chemistry For Environmental Engineering, Fourth International Edition, McGraw Hill Publications, 1994

Iron in groundwater is not a health concern. It more of an aesthetic problem. Different regions of India, parts of Madhya Pradesh and Uttar Pradesh, Coastal Orissa and Andhra Pradesh, Tamil Nadu are affected by Iron.

The issue of hardness and salinity in water are not health concerns. Rather they impart an unpalatable taste to water making it unfit for drinking. Most of the coastal regions in India suffer from excess salinity in groundwater. Whereas hardness is mainly caused by presence of carbonate, bicarbonate, chloride and sulphate salts of calcium and magnesium in water.

Fig. 1 Groundwater Quality Map of India



Source: Central Groundwater Board Of India, Groundwater Quality Map of India, 2002

2.4 Issues in Tackling Groundwater Contamination and Pollution

The first step towards evolving measures to prevent and cure groundwater quality deterioration is generating reliable and accurate information database through water quality monitoring (WQM) to understand the actual source/cause, type and level of contamination. However, there are a few observation stations in the country that cover all the essential parameters for water quality and hence the data obtained are not decisive on the water quality status. Moreover, WQM involve expensive and sophisticated equipments that are difficult to operate and maintain and require substantial expertise in collecting, analyzing and managing data. Since water technology is still not advanced in India, it is very unlikely that the available data is reliable. The existing methodology for WQM is inadequate to identify the various sources of pollution. Integration of data on water quality with data on water supplies, which is very important from the point of view of assessing water availability for meeting various social, economic and environmental objectives, is hardly done. And finally, in the absence of any stringent norms on water quality testing, results can change across agencies depending on sampling procedure, time of testing, and testing instruments and procedure.

Now let us examine technical issues in mitigating contamination. For seawater intrusion, artificial recharge techniques are available in India for different geo-hydrological settings. Artificial recharge could push seawater-freshwater interface seawards. These techniques can also be used to reduce the levels of fluoride, arsenic or salinity in aquifer waters on the principle of dilution. But, the issue is of availability of good water for recharging in arid and semi arid regions given the large aerial extent of contaminated aquifers. Finding enough freshwater for replenishment has always been a problem there. In Indian context, it is not economically viable to clean aquifers. In the case of arsenic, methods for *in situ* treatment have already been in use in developed countries. In the United States, zerovalent iron permeable reactive barriers (PRBs) are used *in situ* to remove chromium and several chlorinated solvents in groundwater and are tested successful for removing arsenic. India is too poor to afford some of the technologies that are successfully tried out in the West, especially United States because they are prohibitively expensive.

Once contamination starts, very little can be done to check it except a total ban on pumping. But this is very difficult, as millions of rural families in India depend on groundwater for sustaining irrigated agriculture and livelihoods. Any legal/regulatory interventions to ban pumping would mean depriving communities of their traditional rights. Though *de jure* rights in groundwater are not clear, land owners enjoy *de facto* right to extract groundwater under their land. While nitrate pollution can be properly controlled through following recommended dosage of fertilizers, crop rotation, proper timing of fertilizer application, and use of organic manure instead of chemical fertilizers, there are no institutional regimes governing fertilizer use and dumping of animal waste.

In India, groundwater quality monitoring is primarily the concern of the Central Ground Water Board and state groundwater agencies, where each of them set up their monitoring network. But there are issues concerning adequacy of scientific data available from them. The network of monitoring stations is not dense enough. Water quality analysis excludes critical parameters that help detect pollution by fertilizer and pesticide, heavy metals and other toxic effluents. The available scientific data, particularly that on pollution is of civil society institutions, and there is a paucity of such institutions that are capable of carrying out such professionally challenging, technologically sophisticated, and often politically sensitive tasks. There are problems associated with institutional design itself. The agency lacks legal teeth and administrative apparatus to penalize polluters. This reduces the effectiveness of the agency in enforcing pollution control norms.

3.0 ABOUT THE PROGRAMME

Wateraid India in collaboration with People's Science Institute (PSI), Dehra Doon started a programme on "**Activity-Based Training Of Rural Communities In Water Quality Monitoring And Management**" in January 2006.The programme was carried out in two phases.

Phase I

First phase of this programme involved training and capacity building of the regional partners of WAI (primarily VOs) in different aspects of water quality monitoring and management. It also involved establishing an association between the water quality and different waterborne diseases. Following which the partners were asked to collect and analyse samples from their respective project areas. The results of WQ testing were sent to PSI for a detailed analysis of WQ data.

Phase II

The second phase of the programme involved a refresher training on WQM, which involved sorting out technical difficulties and logistical problems while carrying out the WQ tests, filling the gaps in recording and reporting the WQ data and a session on different available WQ treatment options. Some major aspects dealt during the session on water treatment options are as follows:

1. Reduction at the source
2. Point-of-use chlorination
3. Other treatment options (SODIS, copper vessels, sand filters, earthen pots etc.)

During this phase PSI scientists also collected water samples from the project areas of different WAI partners. These samples were collected and analysed at the PSI laboratory in Dehra Doon to validate the test results of WAI partners.

Forty-nine partner VOs of Wateraid India from nine different states (in three different WAI regions) across India were trained under the aegis of this programme.

3.1 Methodology:

The methodology involved the following steps:

(1) Training on WQM

(2) Generation of WQ data

(3) Analysis of WQ data

(4) Filling up the gaps in the data

(5) Refresher training on WQ

(6) Collection of water samples and validation of data

3.2 Validation of water quality data using *Student's t –test for a population mean (Variance unknown)*

Object: To investigate the significance of the difference between an assumed population mean μ_0 and a sample mean $\overline{x}$.

Null Hypothesis: There exists a significant difference between the WQ results produced by WAI partner VOs and that produced in the PSI laboratory

Alternate Hypothesis: There is no significant difference the WQ results produced by WAI partner VOs and that produced in the PSI laboratory

Method:

From a population with assumed mean μ_0 and an unknown variance, a random sample of size n was taken and the sample mean $\overline{x}$ calculated as well as the sample standard deviation using the formula

$$S=[\Sigma^n_{i=1} (X_i-\overline{X})^2 /n - 1)]^{1/2}$$

The test statistic is

$$t = \frac{\overline{x} - \mu 0}{s / \sqrt{n}}$$

This was compared with student's t-distribution with (n –1) degrees of freedom. One tailed test was carried out with the level of significance being 50%.

4.0 RESULTS AND DISCUSSION

WQ trend across different WAI project areas

4.1 Eastern India (ROE)

The results clearly that a few health related water quality parameters like Faecal Coliform, Fluoride, Iron, Nitrate are a cause for concern in the eastern region of the country. In a few discrete cases parameters such as Total Hardness have been found to be above the permissible limit. According to the WQ results produced by the WAI partners from Eastern India, almost 100% of the samples collected from different parts of Bihar and Jharkhand had Fluoride more than the prescribed limit (see fig.1 for details). Whereas about 10-50% of water samples collected from different parts of Orissa had fluoride more than the prescribed limit. The concentration of fluoride varied from a low of 0.3 to a high of 1.5 mg/L in water samples collected from Bihar and Jharkhand. The concentration of fluoride was within the range of 0.1-2.6 mg/L in water samples collected from Orissa (see fig.4 for details). It was interesting to observe that the fluoride concentration in the western parts of Orissa was higher than the eastern parts.

Similarly, about 10-40% of water samples analysed from Bihar, Jharkhand and Orissa were found to have a Total Iron concentration more than the prescribed limit. The concentration range of Iron varied from 0.1-4 mg/L in case of water samples collected form Orissa. In case of Bihar and Jharkhand, some samples were found to have an Iron concentration below detectable limit. But certain samples in Bihar had Iron as high as 4.7 mg/L.

In one of the few discrete cases, Total Hardness was found to be as high as 416 mg/L in a sample collected from Patna, Bihar. About 10% of the samples analysed in Jharkhand had Iron above the permissible limit. Whereas in Bihar and Orissa 10-40% of the analysed samples had Iron more than the prescribed limit.

The WAI partners reported Faecal coliform in about 50% of all tha samples analysed. But during the process of validation PSI scientists found that almost all the water samples analysed from the eastern region had Faecal Coliform (see Annexure I for details).

4.2 Northern and Central India (ROW)

The water quality situation in Northern and Central India is a bit different from Eastern India. In these parts, fluoride is not a major WQ problem. Among all the water samples analysed, fluoride (more than the prescribed limit) was found only in five percent (5%) of samples. The highest fluoride concentration was recorded in Sehore (Madhya Pradesh), 1.5 mg/L (see table-II in Annexure II).

Similarly nitrate (above permissible limit) was only found in only 5% of the total samples analysed. The WAI partners reported Nitrate in a few water samples around Datiya (Uttar Pradesh). But the water samples collected by PSI scientists during their field visit to Datiya had nitrate in the range of 5-30 mg/L.

Iron (above permissible limit) was found in only 5% of the total samples analysed. Only a few discrete samples from Madhya Pradesh were found to have Iron above permissible limit. The highest iron concentration (1.8 mg/l) was reported near the urban slums in Bhopal, a few samples in Jhabua also had iron (1.0 mg/L) more than the prescribed limit.

Faecal Coliform is the major WQ problem of this region. About 90% samples from Madhya Pradesh and almost all the samples analysed from Uttar Pradesh showed the presence of Faecal Coliform.

4.3 Southern India

Fluoride is one of the major WQ problems of this region. Almost 55% of the total water samples analysed from the Warangal district (Andhra Pradesh) were found to contain fluoride more than the permissible limit. As high as 65 % of the samples from the Mehboobnagar district were also found to contain fluoride. In about 10% samples from the Sargur district (Karnataka) fluoride was found to be higher than the prescribed limit. The concentration in of Fluoride in Warangal district ranged from a low of 0.1 mg/L to a high of 2.2 mg/L., whereas in Mehboobnagar highest fluoride concentration was 1.5 mg/L. As mentioned earlier, some samples from Sargur district had a fluoride concentration of 1.0-1.2 mg/L.

Faecal Coliform is one of biggest WQ problem of this region. Almost sixty-five percent (65%) of samples from Nagercoil district, 45% samples from Tiruchirapally, all the samples from Mehboobnagar and 55% samples from Sargur were found to contain Faecal Coliform. The regional partner of WAI in Warangal district reported that only 10% of the samples analysed were found to contain Faecal Coliform. But during the field visit to Warangal, PSI scientists found that all the water samples from the district, collected and analysed on-site, had Faecal Coliform.

Along with Fluoride and Faecal Coliform, there are a few other WQ issues of this region also. In Sargur district, Iron (Highest concentration reported was 4.8 mg/L) was found to be present in 55% of the analysed samples; Nitrate (Highest concentration reported was 60 mg/L) was found to be present in 10 % of the samples analysed from Tiruchi. Similarly high values of total hardness were found in 30% of the total samples analysed from Mehboobnagar. According to the WQ test results, two samples from Mehboobnagar had total hardness values of 1240 mg/L and 1296 mg/L respectively. There were also a few cases of high salinity in water in the coastal region of Nagercoil. This could be attributed to the ingression of seawater in the coastal aquifers. Although the salinity values in water were not calculated directly but the field observations and high EC values gave a fair indication of high salinity.

Fig-1 WQ results produced by WAI partners from Eastern India

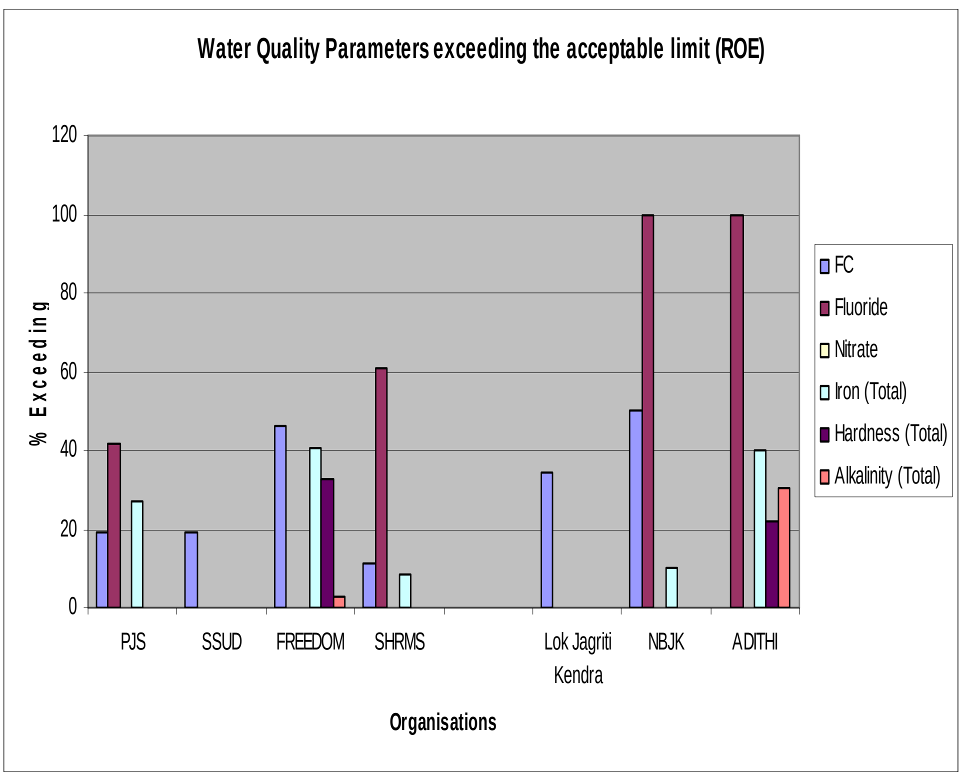


Fig.2- Analysis of WQ results produced by WAI partners from Northern and Central India

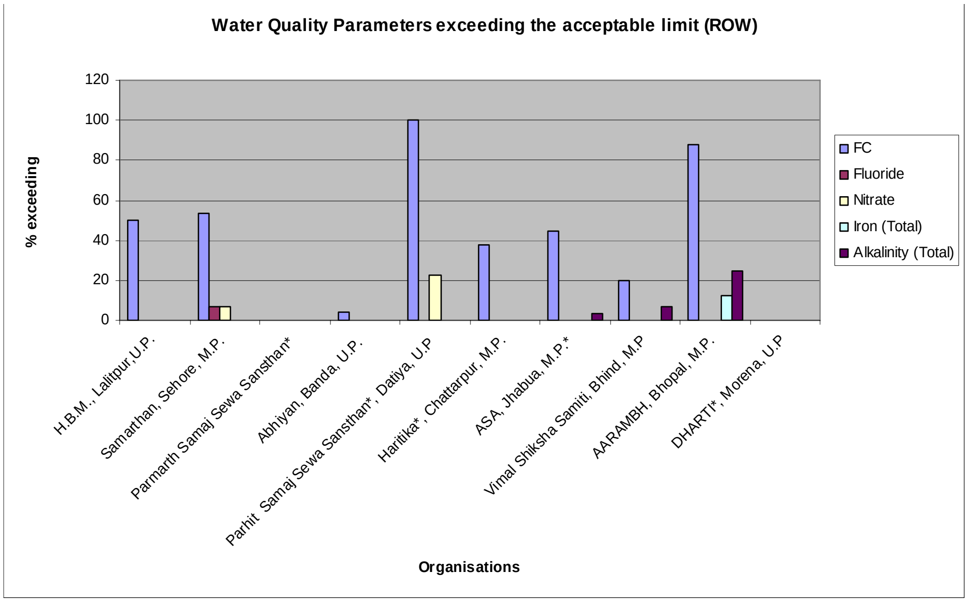
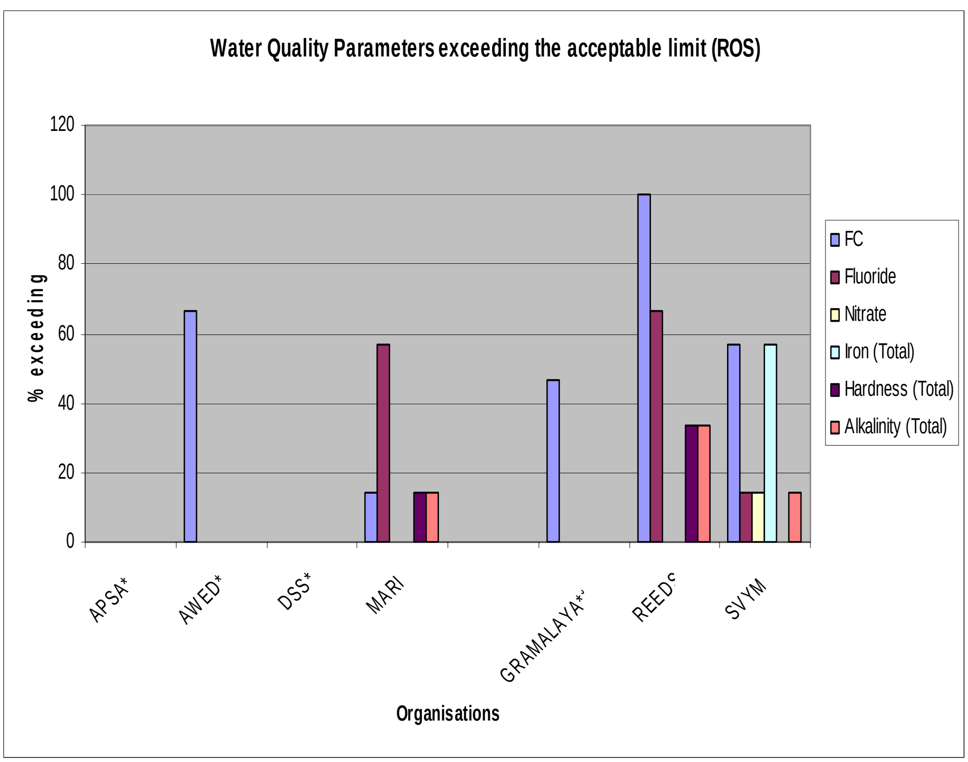
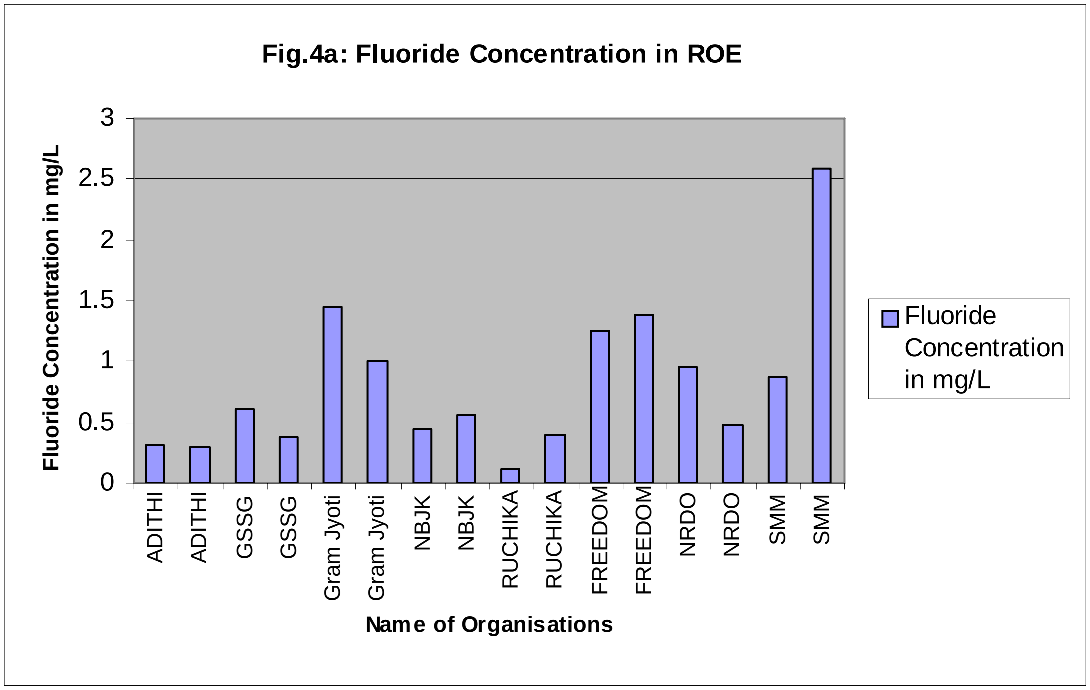
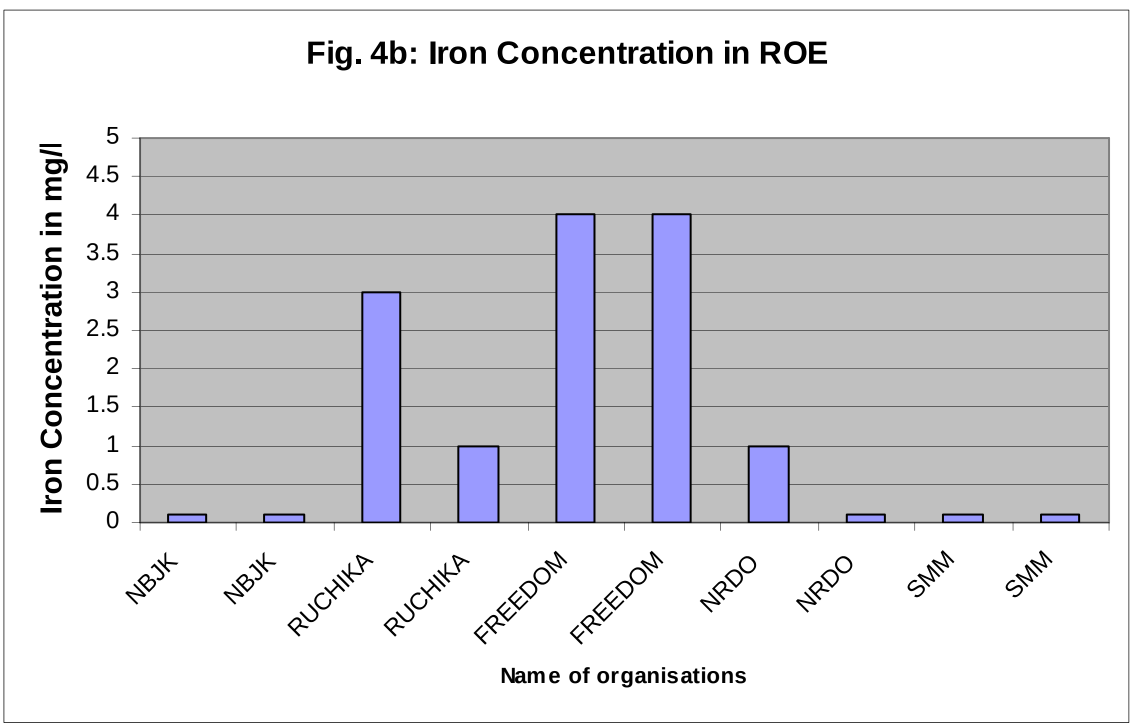


Fig.3- WQ results produced by WAI partners from Southern India



The results of different health related water quality parameters except Faecal Coliform such as, Iron, Nitrate and Fluoride (analysed at the PSI laboratory) are given in the following graphs. The results are presented according to the different regional offices WAI.





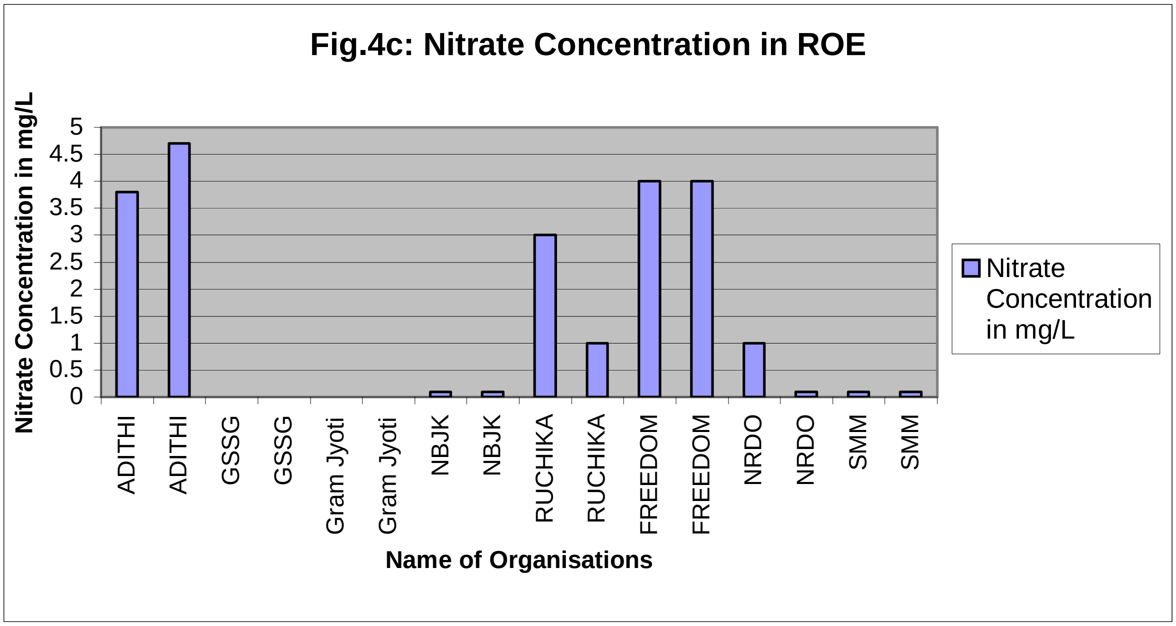


Fig.4c: Nitrate Concentration in ROE
Nitrate Concentration in mg/L
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
ADITHI
ADITHI
GSSG
GSSG
Gram Jyoti
Gram Jyoti
NBJK
NBJK
RUCHIKA
RUCHIKA
FREEDOM
FREEDOM
NRDO
NRDO
SMM
SMM
Name of Organisations
Nitrate Concentration in mg/L

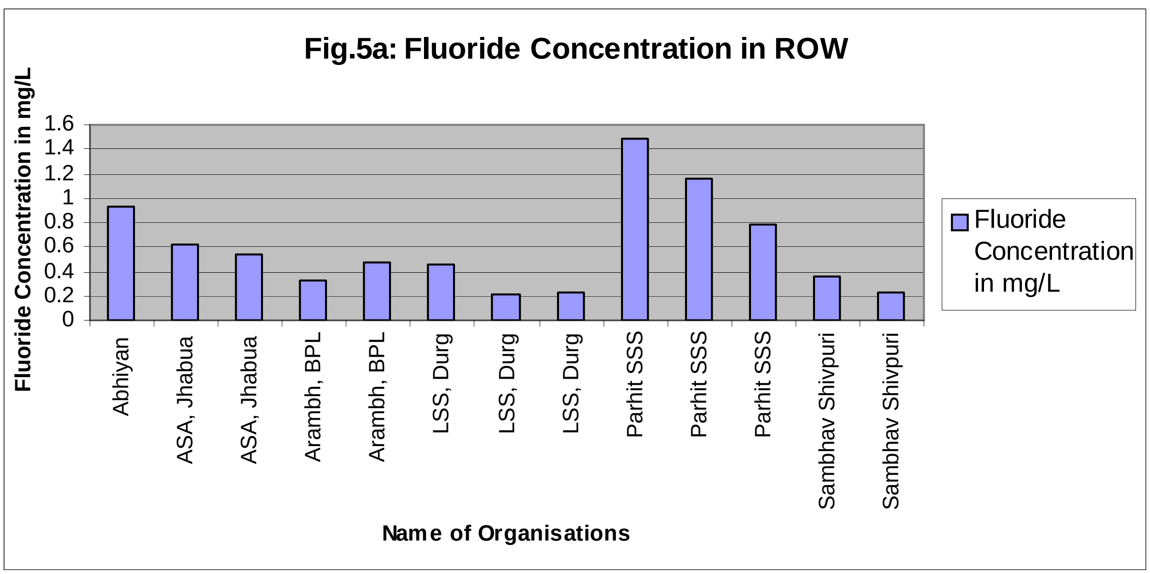


Fig.5a: Fluoride Concentration in ROW
Fluoride Concentration in mg/L
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Abhiyan
ASA, Jhabua
ASA, Jhabua
Arambh, BPL
Arambh, BPL
LSS, Durg
LSS, Durg
LSS, Durg
Parhit SSS
Parhit SSS
Parhit SSS
Sambhav Shivpuri
Sambhav Shivpuri
Name of Organisations
Fluoride Concentration in mg/L

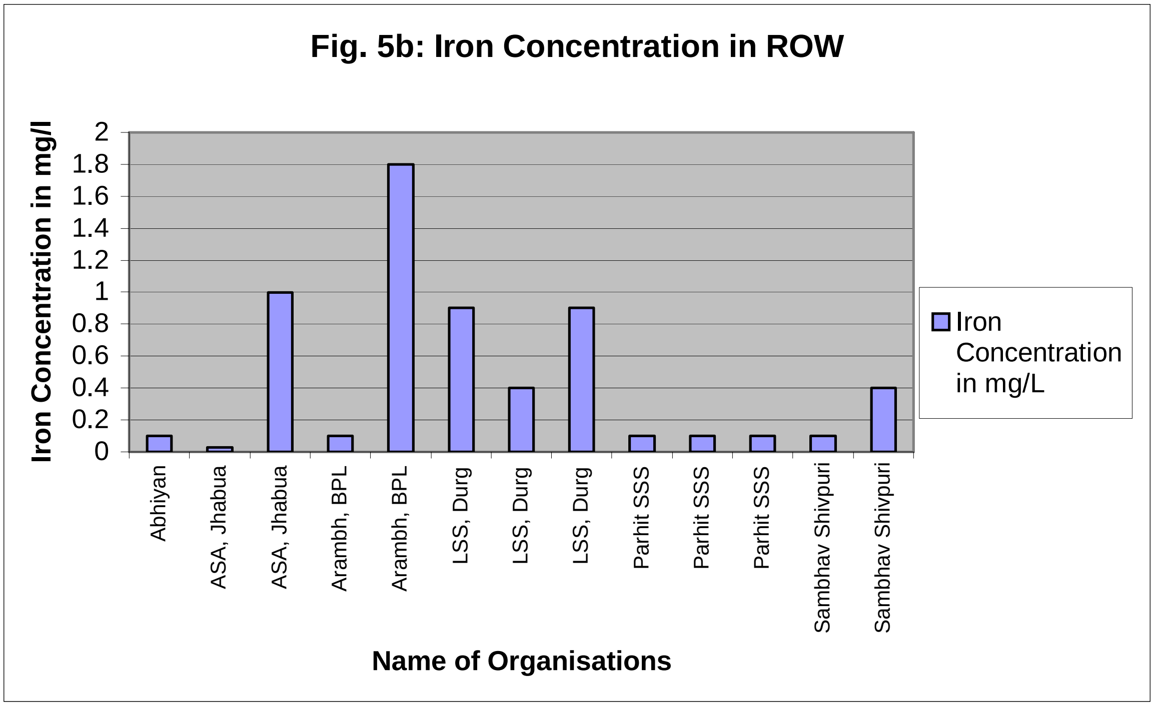


Fig. 5b: Iron Concentration in ROW
Iron Concentration in mg/l
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Abhiyan
ASA, Jhabua
ASA, Jhabua
Arambh, BPL
Arambh, BPL
LSS, Durg
LSS, Durg
LSS, Durg
Parhit SSS
Parhit SSS
Parhit SSS
Sambhav Shivpuri
Sambhav Shivpuri
Name of Organisations
Iron Concentration in mg/L

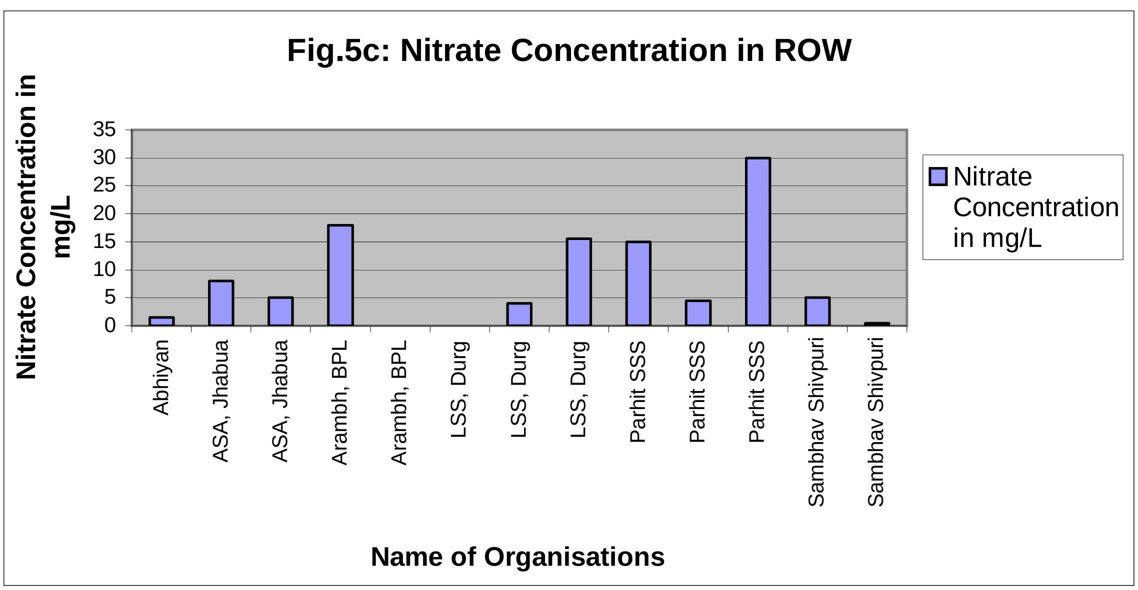


Fig.5c: Nitrate Concentration in ROW
Nitrate Concentration in mg/L
35
30
25
20
15
10
5
0
Abhiyan
ASA, Jhabua
ASA, Jhabua
Arambh, BPL
Arambh, BPL
LSS, Durg
LSS, Durg
LSS, Durg
Parhit SSS
Parhit SSS
Parhit SSS
Sambhav Shivpuri
Sambhav Shivpuri
Name of Organisations
Nitrate Concentration in mg/L

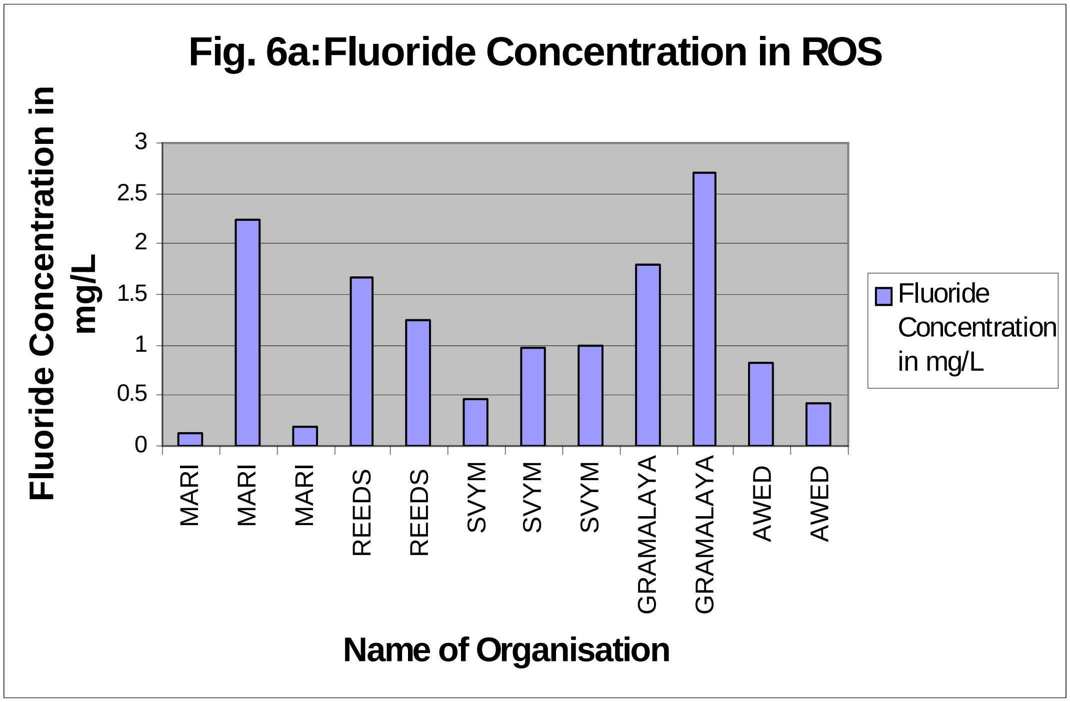


Fig. 6a:Fluoride Concentration in ROS
Fluoride Concentration in mg/L
3
2.5
2
1.5
1
0.5
0
MARI
MARI
MARI
REEDS
REEDS
SVYM
SVYM
SVYM
GRAMALAYA
GRAMALAYA
AWED
AWED
Name of Organisation
Fluoride Concentration in mg/L

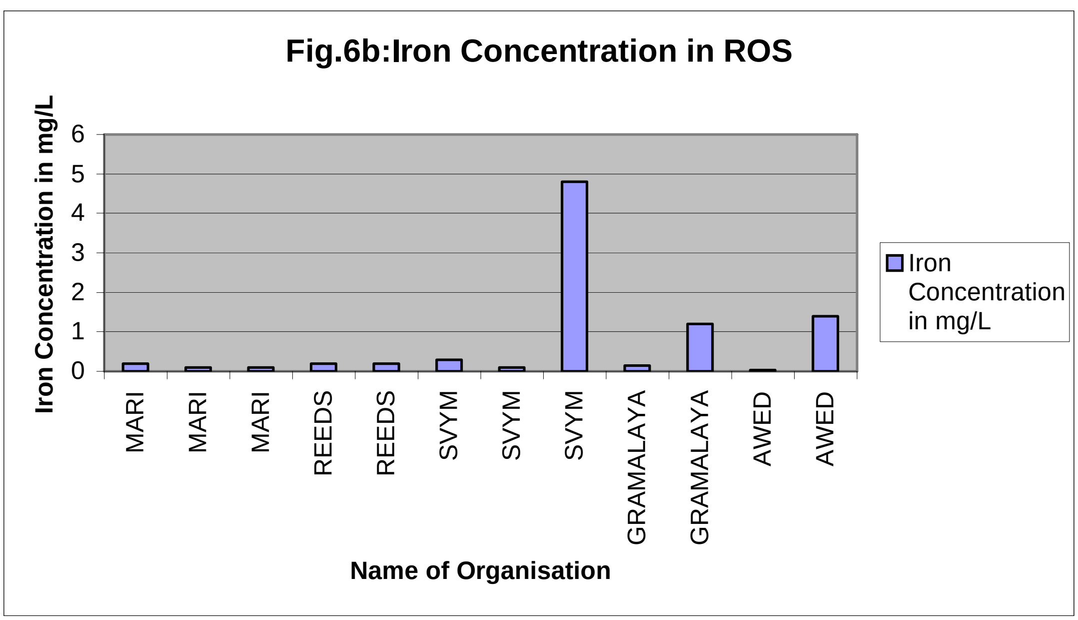


Fig.6b:Iron Concentration in ROS
Iron Concentration in mg/L
6
5
4
3
2
1
0
MARI
MARI
MARI
REEDS
REEDS
SVYM
SVYM
SVYM
GRAMALAYA
GRAMALAYA
AWED
AWED
Name of Organisation
Iron Concentration in mg/L

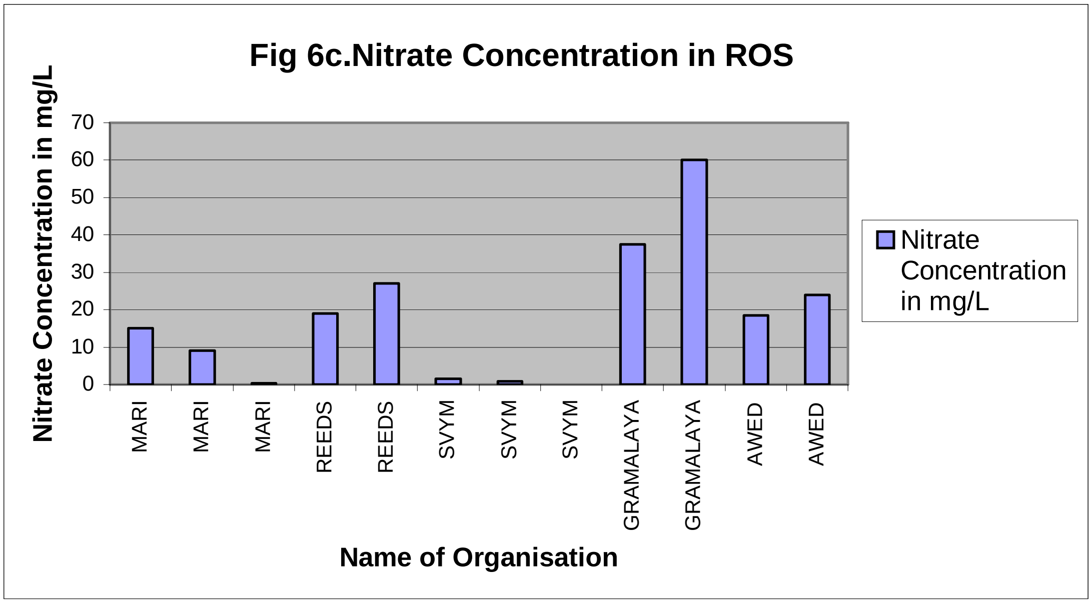


Fig 6c.Nitrate Concentration in ROS
Nitrate Concentration in mg/L
70
60
50
40
30
20
10
0
MARI
MARI
MARI
REEDS
REEDS
SVYM
SVYM
SVYM
GRAMALAYA
GRAMALAYA
AWED
AWED
Name of Organisation
Nitrate Concentration in mg/L

Table 1: Comparative statistical analysis of WQ results (PSI and WAI regional partners)

Results of t-Test for WQ analysis of ROE by PSI and WAI Partners

Name of Parameter	Estimated t value*	Critical t value** (At 50% level of significance)
PH	0.471255456	1.701
Chloride	0.383476641	1.706
Alkalinity	0.228627069	1.706
Total Hardness	0.274603419	1.706
Iron	0.380090933	1.703
Nitrate	0.23619051	1.703

Table 2:Results of t-Test for WQ analysis of ROS by PSI and WAI Partners

Name of Parameter	Estimated t value*	Critical t value** (At 50% level of significance)
Chloride	0.498622873	1.717
Total Hardness	0.495642285	1.717
Iron	0.490555354	1.721
Nitrate	0.009181605	1.721

Table 3: Results of t-Test for WQ analysis of ROW by PSI and WAI partners

Name of Parameter	Estimated t value*	Critical t value** (At 50% level of significance)
Chloride	0.486371	1.711
Total Hardness	0.482441	1.711
Iron	0.279816	1.711
Nitrate	0.057766	1.729

Note- * One tailed distribution for unknown and unequal Variances

** From Fisher's t- table

As far as the validation of water quality data was concerned, Student's t-test was applied (Please refer to Table 2) to find out any significant difference (this was used as the null hypothesis) between the WQ results produced by the community and that produced at the PSI laboratory. In all the cases the difference was insignificant proving the alternate hypothesis that there was no significant difference between PSI and the partner VOs of WAI across India.

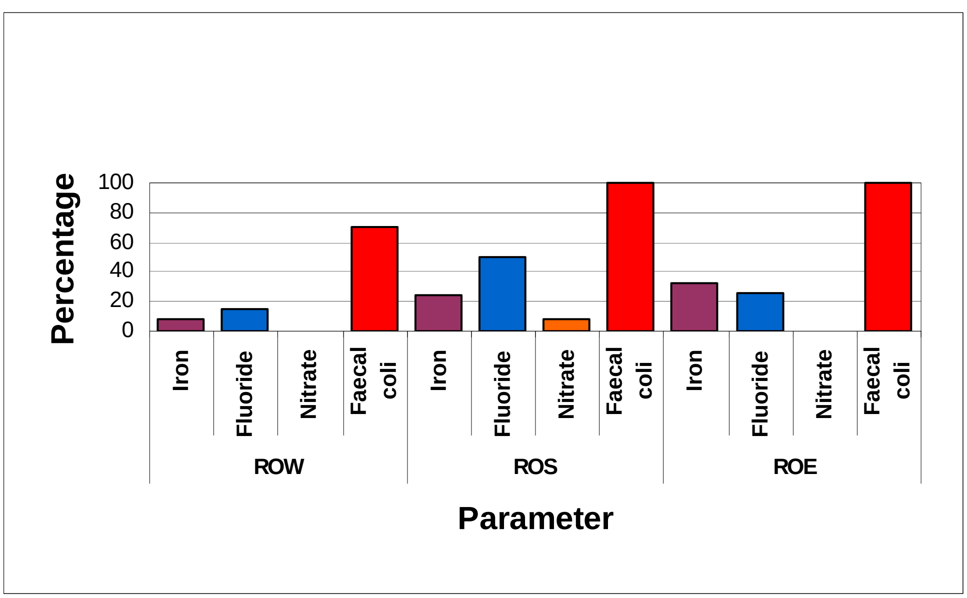
4.4 Results Summary

The results of the water quality monitoring by the different partners of WAI and in the laboratory of PSI are tabulated in Annexure II. The Tables I, II and III in Annexure II give a clear impression that although there are a few region specific water contaminants in different parts of India, e.g., Fluoride and Iron in eastern parts of India, Nitrate (in a few discrete pockets) in Central and Northern parts of India, Hardness, Salinity and Fluoride in Southern parts of India; bacteriological contamination (Faecal Coliform) remains by far the biggest WQ problem of India. This is evident from the graph given in Figure 7.

Samples collected from different parts of India clearly show the presence of Faecal Coliform. Although the sample size was small enough to reach any concrete conclusion but the results clearly indicate a trend of high bacteriological contamination in different parts of India. The reason for this could be attributed to improper maintenance of sources, poor maintenance of hygiene, inadequacy of treatment facilities and administrative failures at all levels.

The various concentrations of the health related water quality parameters (Iron, Nitrate, Fluoride and Faecal Coliform) are summarily presented in Fig.7 below:

Fig 7: Percentage Values of WQ Parameters Exceeding the Permissible Limits (BIS, IS: 10500-1991)



5.0 Water Treatment- Emerging Challenges and their solutions

The available treatment systems work on the principles of physics and chemistry. Hence, their efficiency depends heavily on maintaining certain specified operating conditions. This would call upon qualified technical manpower for system operations, and regular operation and maintenance, which are mostly absent. Most of the treatment systems for drinking water have to be tried out at the community level to be cost effective and affordable. As a result, new techno institutional models need to be evolved to manage the system in order to make them self-sustaining. Civil society/institutions need to be strengthened to respond to water quality problems quickly.

This Program on “Activity based Training of WAI partners on WQM” was designed to identify the WQ problems of different WAI project areas across the country. But once the identification of problems was over, PSI Scientists discussed several treatment options with the local partner VOs of WAI. But due to the constraints of time and logistics, on-site demonstrations could not be carried out in an extensive manner.

As an example, the biggest WQ problem in the different WAI project areas was definitely bacteriological contamination, e.g. Faecal Coliform. So PSI scientists discussed different techniques to remove the contamination from the drinking water at the source or at the point-of-use by using techniques such as, SODIS, Copper vessel, the point-of-use chlorination and other methods involving chlorinating the community sources etc (see Annexure III for details). For other major WQ problems like fluoride, different options such as Activated Alumna based Domestic and Community kits, community rainwater harvesting structures, reverse osmosis plants were discussed. PSI scientists also shared their experiences of working with the community in different regions across India. This discussion led to the fact that PSI should carry out an exhaustive session in water treatment in WAI project areas across India. It was also decided that based on the socio-economic viability of these treatment options, PSI would help the community to implement some of these options at the local level.

6.0 CONCLUSION

This report on community based water quality monitoring in WAI project areas serves two purposes -

1. It helped generate a baseline data on drinking water quality in different regions across the country,
2. It trained the WAI partners on different aspects on WQM and also validated their on-field performance following a rigorous scientific process.

The report establishes the fact that bacteriological contamination is still the biggest WQ problem in the country. But a few region specific water quality problems like Fluoride, Iron, Hardness and Salinity exist throughout the country.

The WQ field test results (carried out by the partner VOs of WAI) and that carried out in PSI laboratory had insignificant analytical differences. It was established through a statistical procedure. Hence field-testing of water quality at the community level becomes important to identify the safe and the unsafe sources. It also helps to decide on the treatment interventions as well.

7.0 Recommendations

It was encouraging to see the local VOs and the CBOs working together towards a common goal of safe drinking water supply. But it should be borne in mind that the once the problem is identified the village community will ask for solutions, be at the source or at the point-of-use. The recommendations based on this programme have been divided into two parts: programme recommendations and policy recommendations. They are summarized as under:

7.1 Programme Recommendations:-

1. Water quality surveillance should be a community responsibility. Once trained, communities become equipped enough to carry out all general drinking WQ tests. Therefore the communities must be trained with the technical knowhow and suitably equipped to carry out WQ tests.
2. Water Quality Monitoring should be accorded a high priority and suitable institutional mechanisms at national, state, district, block and panchayat levels should be developed involving all related sectors.
3. Water Supply Agencies should do 100% source testing to identify safe and unsafe sources. They should also carry out chlorination of all drinking water sources on a regular basis. The community should play the role of a watchdog and ensure that the chlorination is carried out accordingly.
4. A range of mitigation technologies is already available, but the availability must be complemented with the acceptability, affordability and sustainability of a technical solution from the users perspective, otherwise it risks failure. It was observed during the field trips that in some areas people were ready to accept point-of-use chlorination as one of the major treatment interventions but in some areas traditional purification systems such as copper vessel and Moringa seeds were found to be more acceptable. Suitable technologies should be identified and implemented with the participation of the community.
5. To take care of pollution of drinking water sources arising from human waste and industrial and agricultural activities, appropriate linkages between Drinking Water Quality Control & Surveillance (DWQC&S) and hygiene education has to be established. Local village level administration should be encouraged to conduct a programme with the

participation of health, education women & child welfare departments to develop and implement an appropriate strategy to supply safe water, based on the preceding lessons.

6. There should be emphasis on putting in place the requisite mechanism to monitor the quality of drinking water and devising effective IEC interventions to disseminate information and educate people on health and hygiene aspects of clean drinking water.

7.2 Policy Recommendations:-

1. Water quality problems are a public health concern. The water supply agency should partner with the State's Health Department, local VOs and CBOs to mobilize capacity and resources to deal with the issue. This is in line with the aims and objectives of the National Rural Health Mission.
2. State Water Supply Agencies should be aware of the problems of imposing a treatment technology on the community, and the importance of ensuring local involvement in decision-making.
3. Before contemplating making supply of water of poor quality punishable under the law, it is necessary to ensure that the agencies responsible for control and surveillance of water quality have adequate measures to ensure supply of safe water. It is recommended that there should be legislative measures for DWQC&S alongside the development of environmental management capacity and strengthening infrastructure of the agencies engaged in the field, including Panchayat Raj Institutions.
4. An integrated WQ testing, monitoring and surveillance system to be operated with community participation by using Catchment Area Approach (involving district and taluka level) has to be developed. A pilot study on Catchment Area Approach has to be tested at the village level.

Annexure I

Table-1 Analysis of WQ results produced by WAI partners from Eastern India

ROE

S.No.	Organisation	No.of villages covered	No. of sources analysed	Water Quality Parameters exceeding the acceptable limit (in percentage)					
				FC	Fluoride	Nitrate	Iron (Total)	Hardness (Total)	Alkalinity (Total)
1.	PJS	28	67	19.40	41.79	-	26.86	-	-
2.	SSUD	14	31	19.35	-	-	-	-	-
3.	FREEDOM	20	37	45.94	-	-	40.54	32.43	2.70
4.	SHRMS	9	36	11.11	61.11	-	8.33		
5.	Lok Jagriti Kendra	16	41	34.15	-	-	-	-	-
6.	NBJK	16	20	50	100	-	10	-	-
7.	ADITHI	14	27	-	100		40	22.14	30.57

Table-2 Analysis of WQ results produced by WAI partners from Central and Northern India

ROW

S.No.	Organisation	No.of villages covered	No. of sources analysed	Water Quality Parameters exceeding the acceptable limit (in percentage)					
				FC	Fluoride	Nitrate	Iron (Total)	Hardness (Total)	Alkalinity (Total)
1.	H.B.M., Lalitpur,U.P.	9	32	50	-	-	-	-	-
2.	Samarthan, Sehore, M.P.	6	15	53.33	6.67	6.67	-	-	-
3.	Parmarth Samaj Sewa Sansthan*	19	52	-	-	-	-	-	-
4.	Abhiyan, Banda, U.P.	11	25	4	-	-	-	-	-
5.	Parhit Samaj Sewa Sansthan*, Datiya, U.P.	12	40	100	-	22.5	-	-	-
6.	Haritika*, Chattarpur, M.P.	8	8	37.5	-	-	-	-	-
7.	ASA, Jhabua, M.P.*	14	27	44.45	-	-	-	-	3.70
8.	Vimal Shiksha Samiti, Bhind, M.P.	5	15	20	-	-	-	-	6.67
9.	AARAMBH, Bhopal, M.P.	6	8	87.5			12.5		25
10.	DHARTI*, Morena, U.P.	17	85	-	-	-	-	-	-

Table-3 Analysis of WQ results produced by WAI partners from Southern India

ROS

S.No.	Organisation	No.of villages covered	No. of sources analysed	Water Quality Parameters exceeding the acceptable limit (in percentage)					
				FC	Fluoride	Nitrate	Iron (Total)	Hardness (Total)	Alkalinity (Total)
1.	APSA*	NA	4	-	-	-	-	-	-
2.	AWED*	NA	3	66.67	-	-	-	-	-
3.	DSS*	NA	2	-	-	-	-	-	-
4.	MARI.	NA	7	14.28	57.14	-	-	14.28	14.28
5.	GRAMALAYA**	NA	15	46.67	-	-	-	-	-
6.	REEDS	8	3	100	66.67	-	-	33.33	33.33
7.	SVYM	14	27	57.14	14.28	14.28	57.14	-	14.28

Annexure II

Table-I: Water Quality Monitoring report by PSI (WAI ROE)

S. No.	Name of Organization	Name of State	Name of Village/Slums	Sources with Identity	pH	Chloride	Alkalinity	Total Hardness	Fluoride	Nitrate	Iron	Faecal Coliform
1	ADITHI	Bihar	Soti Bheriyahi	HP Swashakti Kuteer	7	20	440	400	0.31	9	3.8	ND
2	ADITHI		Soti Bheriyahi	HP Kailash Ram	7.5	76	520	416	0.30	0.9	4.7	+ +
3	GSSG		Pahad Pur	HP Primary School	7.5	28	280	224	0.608	5	BDL	+
4	GSSG		Pahad Pur	HP Gorakh Prasad	7.5	144	400	512	0.377	35	BDL	+
5	Gram Jyoti	Jharkhand	Thariyara	HP opposite Budhan Mirdha,s home	7	52	200	176	1.45	10	BDL	+ +
6	Gram Jyoti		Sareya	HP Ram Lal Hembran Home	7	28	120	120	1.00	10	BDL	+
7	NBJK		Tiril (Slum)	HP New garden Seromtoli	7	110	240	320	0.438	5	0.1	+
8	NBJK		Tiril (Slum)	Nagar nigam HP Near pond	7	40	112	112	0.560	15	0.1	+
9	RUCHIKA	Orrisa	Birju Nagar Joklandi (Slum)	HP near Mahila Samiti	6.5	84	80	80	0.110	45	3	+
10	RUCHIKA		Bharatpur	HP near Ruchika EGS center	6.5	144	80	120	0.398	20	1	+
11	FREEDOM		Dana pada tanki	HP gov. Near Brij Kishor Sahu home	7.5	32	360	360	1.26	BDL	4	+
12	FREEDOM		Kalyan pur	HP near gadadhar Maliks home	7.5	48	360	400	1.38	BDL	4	+
13	NRDO		Kopripota ranikhama	HP infrot of Community hall	7.5	16	100	64	0.954	1	1	+
14	NRDO		Kopripota ranikhama	HP of Primary School	7.5	16	100	80	0.474	2	0.1	+
15	SMM		Khamtarai Samserpur	HP near Jamal Khan,s Home	7	228	500	384	0.878	10	0.1	+
16	SMM		Khamtarai Samserpur	HP near Durga Prasad Niyali,s Home	7	164	510	400	2.580	45	0.1	+

Table- I (A): Water quality results by WAI partners (ROE)

S. No.	Name of Organization	Name of State	Name of Village/Slums	Sources with Identity	pH	Chloride	Alkalinity	Total hardness	Fluoride	Iron	Nitrate	Faecal Coliform
1	ADITHI	Bihar	Soti Bheriyahi	HP Swashakti Kuteer	7	20	400	48	>1	BDL	1	ND
2	ADITHI		Soti Bheriyahi	HP Kailash Ram	7	20	400	ND	<1	BDL	BDL	+ +
3	GSSG		Pahad Pur	HP Primary School	7.5	22	420	240	>1	0.01	1	+
4	GSSG		Pahad Pur	HP Gorakh Prasad	7.5	180	600	536	<1	0.01	35	+
5	Gram Jyoti	Jharkhand	Thariyara	HP opposite Budhan Mirdha,s home	7	60	280	224	>1	0.7	10	+ +
6	Gram Jyoti		Sareya	HP Ram Lal Hembran Home	7	42	440	144	<1	0.3	10	+
7	NBJK		Tiril (Slum)	HP New garden Seromtoli	7	160	280	296	<1	0.1	5	+
8	NBJK		Tiril (Slum)	Nagar nigam HP Near pond	ND	ND	ND	ND	ND	ND	ND	+
9	RUCHIKA	Orrisa	Birju Nagar Joklandi (Slum)	HP near Mahila Samiti	6.5	100	80	20	<1	>3	45	+
10	RUCHIKA		Bharatpur	HP near Ruchika EGS centre	6.5	140	96	40	1	3	1	+
11	FREEDOM		Dana pada tanki	HP gov. Near Brij Kishor Sahu home	7	36	440	320	<1	3	<1	+
12	FREEDOM		Kalyan pur	HP near gadadhar Maliks home	7	48	360	368	<1	0.01	<1	+
13	NRDO		Kopripota ranikhama	HP infrot of Community hall	9	10	80	40	<1	3	1	+
14	NRDO		Kopripota ranikhama	HP of Primary School	ND	ND	ND	ND	ND	BDL	1	+
15	SMM		Khamtarai Samserpur	HP near Jamal Khan,s Home	7	ND	ND	400	>1	ND	ND	+
16	SMM		Khamtarai Samserpur	HP near Durga Prasad Niyali,s Home	7	ND	ND	ND	>1	ND	ND	+

(ND- Not done BDL -Below detection limit)

Table II: Water Quality Monitoring report by PSI (WAI- ROW)

S. No.	Name of State	Name of Organization	Name of Village/Slums	Sources with Identity	Chloride	Total hardness	Fluoride	Iron	Nitrate	Faecal coliform
					Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	
1	Uttar Pradesh	Abhiyan	Tulsipurva	HP Chunnu Raidas home	55	176	0.933	0.1	1.5	+
2	Madhya Pradesh	ASA, Jhabua	Koya Dharia	HP near School	40	420	0.617	0.03	8	+
3		ASA, Jhabua	Koya Dharia	HP near Keggu Huldi	30	348	0.544	1.0	5	ND
4		Arambh, BPL	New Kabadkhana	Water supply, near masjid	300	752	0.326	0.1	18	+
5		Arambh, BPL	New Kabadkhana	HP Sahid miyan home	330	652	0.469	1.8	BDL	+ + +
6	Chattishgarh	LSS, Durg	Limau Tola	HP near School	20	252	0.460	0.9	BDL	+ +
7		LSS, Durg	Limau Tola	HP near Ghasia ram home	35	216	0.210	0.4	4	+ + +
8		LSS, Durg	Jabkasa	HP near Takat Ram home	55	232	0.221	0.9	15.5	ND
9	Madhya Pradesh	Parhit SSS	Durgapur	Hp near pachayat Bhawan	750	800	1.490	0.1	15	+
10		Parhit SSS	Durgapur	Well Kishan lal Srivastawa	140	476	1.160	0.1	4.5	+ +
11		Parhit SSS	Durgapur	HP near Shiv Mandir	255	780	0.783	0.1	30	ND
12		Sambhav Shivpuri	Patara	HP near School	75	320	0.354	0.1	5	+
13		Sambhav Shivpuri	Sankar pur Colony Bolukophatak	HP near Ram Singh Home	10	104	0.223	0.4	0.5	ND

Table II (A): Water Quality results by WAI partners (ROW)

S. No.	Name of State	Name of Organization	Name of Village/Slums	Sources with Identity	Chloride	Total hardness	Fluoride	Iron	Nitrate	Faecal coliform
					Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	
1	Uttar Pradesh	Abhiyan	Tulsipurva	HP Chunnu Raidas home	60	176	>1	0.1	1	+
2	Madhya Pradesh	ASA, Jhabua	Koya Dharia	HP near School	40	420	<1	0.03	>1	+
3		ASA, Jhabua	Koya Dharia	HP near Keggu Huldi	30	340	<1	1.0	>!	ND
4		Arambh, BPL	New Kabadkhana	Water supply, near masjid	300	768	<1	0.1	>10	+
5		Arambh, BPL	New Kabadkhana	HP Sahid miyan home	340	656	<1	>1	BDL	+ + +
6	Chattishgarh	LSS, Durg	Limau Tola	HP near School	20	264	<1	1.0	BDL	+ +
7		LSS, Durg	Limau Tola	HP near Ghasia ram home	38	224	<1	0.3	>1	+ + +
8		LSS, Durg	Jabkasa	HP near Takat Ram home	60	232	<1	1.0	<10	ND
9	Madhya Pradesh	Parhit SSS	Durgapur	Hp near pachayat Bhawan	760	800	>1	0.1	>10	+
10		Parhit SSS	Durgapur	Well Kishan lal Srivastawa	140	480	>1	0.1	>1	+ +
11		Parhit SSS	Durgapur	HP near Shiv Mandir	254	800	<1	0.1	>10	ND
12		Sambhav Shivpuri	Patara	HP near School	80	320	<1	0.1	>1	+
13		Sambhav Shivpuri	Sankar pur Colony Bolukophatak	HP near Ram Singh Home	10	104	<1	0.3	BDL	ND

Table-III Water Quality Monitoring report by PSI (WAI- ROS)

S. No.	Name of Organization	State(s)	Name of Village/Slums	Sources with Identity	Chloride	Total Hardness	Fluoride	Iron	Nitrate	Fecal Coliform
					Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	(MPN/100ml)
1	MARI	Andhra Pradesh	Project Nagar	Hp near Toliyam Rama Rao's house	365	936	0.127	0.2	15	+
2	MARI		Project nagar	Hp near the Panchayat building	15	416	2.23	0.1	9	++
3	MARI		Danampally	Hp at SC Colony	10	160	0.189	0.1	0.3	++
4	REEDS		Chennaredpally	Hp near the Shiva temple	155	1296	1.660	0.2	19	+
5	REEDS		Moiminapur	Hp Near Basapally Ellama's house	167	1240	1.250	0.2	27	++
6	SVYM	Karnataka	Basapura	Hp oppsite Aiyappa temple	97	712	0.470	0.3	1.5	+
7	SVYM		Holaihundi	Hp near the village entrance	25	280	0.975	0.1	0.8	+
8	SVYM		Chikkanandi	Bore well near Kuse Gautam's house	17	324	1.000	4.8	BDL	++
9	GRAMALAYA	Tamil Nadu	Kodiyam Padayam	Hp near Ramalingam's house	625	2616	1.790	0.14	37.5	++
10	GRAMALAYA		Aynu patty	Hp near OHT	290	1704	2.710	1.2	60	+
11	AWED		Midalam	Hp near Angan wadi	235	1456	0.822	0.04	18.5	++
12	AWED		Chinnavillai	Hp in the St.Josephs school	685	3280	0.432	1.4	24	+

Table-III (A) Water Quality results by WAI-ROS partners

S. No.	Name of Organization	State(s)	Name of Village/Slums	Sources with Identity	Chloride	Total Hardness	Fluoride	Iron	Nitrate	Fecal Coliform
					Mg/l	Mg/l	Mg/l	Mg/l	Mg/l	(MPN/100ml)
1	MARI	Andhra Pradesh	Project Nagar	Hp near Toliyam Rama Rao's house	325	960	<1	BDL	1	+
2	MARI		Project nagar	Hp near the Panchayat building	20	424	>1	0.1	10	++
3	MARI		Danampally	Hp at SC Colony	10	160	<1	0.01	>1	++
4	REEDS		Chennaredpally	Hp near the Shiva temple	240	1472	<1	BDL	BDL	+
5	REEDS		Moiminapur	Hp Near Basapally Ellama's house	700	3200	<1	0.7	BDL	++
6	SVYM	Karnataka	Basapura	Hp oppsite Aiyappa temple	100	720	<1	0.3	>10	+
7	SVYM		Holaihundi	Hp near the village entrance	25	280	>1	ND	1	+
8	SVYM		Chikkanandi	Bore well near Kuse Gautam's house	20	320	>1	0.7	>1	++
9	GRAMALAYA	Tamil Nadu	Kodiyam Padayam	Hp near Ramalingam's house	640	2640	>1	>3	BDL	++
10	GRAMALAYA		Aynu patty	Hp near OHT	300	1720	>1	BDL	1	+
11	AWED		Midalam	Hp near Angan wadi	150	1312	>1	3	10	++
12	AWED		Chinnavillai	Hp in the St.Josephs school	160	1264	>1	0.1	ND	+

Annexure-III

A SUMMARY OF DIFFERENT PROCEDURES FOR TREATMENT OF WATER

HOUSEHOLD LEVEL FILTERS

TYPE OF MATERIALS

There are various types of filter materials, which could be used for filtration:

Fine sand (0.3 mm) is generally used as a filter media. The layers of sand may be supported by gravel sand, which should have the following properties:

- It should be free from dirt and other impurities like clay, vegetable matter, organic impurities etc.
- It should be uniform in nature and size.
- It should be hard and resistant.
- It should be such that it should not lose more than 5% of its weight after being placed in hydrochloric acid for 24 hours.
- The gravel used below the sand should be hard, durable, and free from impurities, properly rounded and should have a density of about 1600 kg/m^3.
- Crushed coconut shell is also a good filter media and has been successfully used in our country in few filtration plants.

Procedure:

1. Collect the water in a container and allow the heavier particles to settle to the bottom.
2. Build a filter system using two pots.
3. Holes should be made on the bottom of first pot to let the water drain through.
4. Put together a mixture of one half sand and one half gravel. The mixture should be enough to fill the container three quarters full.
5. Place the mixture on the top container.
6. The container below should be empty and clean to store the filtered water.
7. Slowly pour the water to be filtered. Do not pour particles that have settled down to the bottom.
8. When the bottom container is filled cover the container until further treatment.

DISINFECTION OF WATER

Disinfection is done after sedimentation and filtration. It is usually the last step of purification of water. After this step, water is fit to be consumed. It is a treatment for destruction of harmful germs (bacteria, viruses, protozoa, etc.) by either killing them or making them inactive. Water can be disinfected by several means

- Application of heat or other physical agents
- Surface active chemicals
- Irradiation by ultraviolet light and radioactive ions.
- Alkalis and acids
- Metal ions like silver, copper, and mercury.
- Oxidants with halogen, ozone other chemical compounds like bromine, iodine and chlorine.

(Ozone at 0.5 ppm takes about 5 minutes to kill bacteria. Chlorine at 1ppm takes about 2 hours and silver takes about 4 to 10 hours.)

Municipalities commonly use chlorine, iodine and silver to kill bacteria. UV radiation and ozonation are also used for large water supplies in companies. These techniques have been made available in individual household level also. (These techniques have been dealt with in detail later on)

The best two methods for treating water are boiling and chlorinating. Both the methods will make water safe to drink if they are carried out properly.

Basic Disinfection Methods at Household Level

BOILING

Boiling is suitable for providing small quantities of drinking water for use around the home. It might not be economical for larger amounts of water. To properly boil the water, a strong heating source is required to bring the water to boil. Stove, wood fires or portable gas stoves can be used for heating. Clean containers made of metal or some other material that will not melt when placed into the heat, should be used.

Apart from killing germs, boiling also removes temporary hardness of water (carbon di-oxide is released and calcium carbonate is precipitated). Boiled water should be consumed immediately after cooling. This is because boiled water may get contaminated later on due to external agents.

Procedure

1. Let the water to be filtered stand long to let the heavier particles settle down.
2. Pour the clean water from top into a clean container that will be used for boiling.
3. Water must be boiled at least for two minutes i.e. at a rolling boil which means that the water is actively bubbling.
4. For mountainous regions or areas at higher elevations, water could be boiled for five minutes.
5. To remove flat taste, water can be left undisturbed for few hours or by pouring the water back and forth from one clean container to another for a couple of minutes.
6. Store the treated water in a covered container until ready to use.
7. To boil one litre of water 1kg of fuel wood is necessary.

Disadvantages: This is uneconomical where large quantities of water are involved.

3.1.3.b <u>CHLORINATION</u>

Chlorine is an effective oxidizing agent. Chlorinating water is the most common method used for treating water in the world. It is the best method for disinfecting not only large water supplies, wells but also water at household level due to its easy availability, economy and effectiveness. Chlorine is effective in killing bacteria by virtue of penetrating the bacterial cell wall and destroying the protoplasm. There are many chlorinating agents. Most common of them is bleaching powder.

Frequently used Chlorination Reagents:

- Bleaching powder
- Chlorine tablets
- Sodium Hypochlorite

For chlorination to be an effective disinfection process, dose of chlorine, optimum Contact period and Residual Chlorine are required to be found out. The residual chlorine is the amount of chlorine remaining after a specified contact period. On one hand, the residual chlorine assures complete and proper treatment- insurance against subsequent contamination during storage and transportation, on the other hand excessive RC (more than 0.2 ppm) can be harmful if consumed. Hence, chlorination requires use of correct amounts. Also storage and filtration should be performed before chlorinating (adding bleaching powder) to make the water free of organic impurities. If the water is turbid, or contains organic matter, not only is the chlorination process hindered but the free chlorine reacts with the organic matter to form harmful chloro organic compounds (Trihalomethanes THMs) which can cause cancer.

Bleach is a strong chemical that can be poisonous if swallowed. Eyes can be seriously injured. Household bleach contains 5% chlorine. The bleach used should be ordinary bleach and should be checked for not containing any other cleaning agent.

Advantages of chlorination:

- high potency for bacteria, high range of effectiveness
- Detectable in the form of Residual Chlorine which acts as an indicator of excessive dosage, - economical,
- Easy availability,
- Easy application/easily diluted.

Disadvantages:

- Chlorine on reacting with organic impurities forms disinfection by products (DBPs) called Tri halomethanes THMs which are carcinogenic. Hence the water to be treated should be free of organic contents.
- Objectionable taste and odour,
- Contact time of minimum 20 minutes needed.
- Water borne pathogens like cysts and protozoa (such as cryptosporidium and Giardia) are not removed by chlorine.
- Chlorinated water with high RC is not compatible with other membrane processes like RO, as RC is known to attack the membrane.

PROCEDURE FOR CHLORINATING AT HOUSEHOLD LEVEL:

a) With household liquid bleach

1. Add four drops of bleach to four litres or one gallon of clean water.
2. If the water looks dirty add eight drops of bleach to four litres of water.
3. Mix thoroughly and let the water stand for 15 minutes.

There should only be slight taste of the bleach after 15 minutes, and no taste after 30 minutes. If there is still taste of bleach after 30 minutes a drop less should be used during next chlorination.

b) <u>With Bleaching Powder</u>

1.3 to 5 mg of bleaching powder is necessary (depending upon the amount of contamination) to disinfect 1 litre of water. It takes minimum half an hour for disinfection. 26.0 to 100 mg or one pinch will disinfect 20 litres of water.

c) <u>With Sodium Hypochlorite</u>

Things Needed:

- Sodium Hypochlorite Solution app 4% W/V available chlorine
- 2 Jerry cans of 10 litres capacity
- Residual Chlorine testing kit

The Method:

Add 2 to 3 drops of Sodium Hypochlorite Solution in litres of water. Keep it for an hour to overnight as per convenience.

Test for the residual chlorine content in the water with the residual chlorine kit. Minimum Residual Chlorine available should be around 0.2mg/l. If the RC content is found high, then water can be exposed to sunlight for the chlorine to escape.

Care should be taken that the water to be chlorinated should preferably contain low organic impurities.

<u>PROCEDURE FOR CHLORINATING DUGWELLS</u>:

For disinfecting dug well which is used for drinking water, it has been observed that 4 mg of bleaching powder added to one litre of dug well water very effectively destroy the microorganism in the water and residual chlorine remains in water in the range of 0.2-0.5 mg/l. Bleaching powder with 25% available chlorine should be used.

$$\text{Volume of water} = \frac{3.14 \times (\text{Diameter})^2 \times \text{Height of water level}}{4} \times 1000 \text{ (in litres)}$$

$$\text{Amount of bleaching powder needed} = \frac{\text{Volume of water (in litres)} \times 4 \text{ mg}}{1000} \text{ (in grams)}$$

Procedure of adding Bleaching powder:

Materials Required:

- Bucket (2)
- Bleaching powder
- Glass rod
- **Procedure**
- Required quantity of bleaching powder is taken in bucket.
- Then with minimum water make a paste with the help of the glass rod.
- Pour water from dug well into the bucket.
- Mix and allow to settle.
- After the residue settled at the bottom take the supernatant (above portion of water) in another bucket.
- Mix the supernatant into the dug well.
- Stir the water of the well.
- After 30 minutes residual chlorine is assessed and then the water is used for drinking purpose

COMMUNITY LEVEL

CHLORINATING WELLS

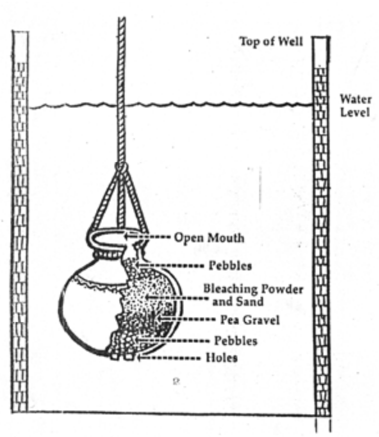
If wells are the main source of water, it is possible to chlorinate all the water rather than chlorinating small quantities.

POT CHLORINATION:

1) Single pot method

Procedure:

1. Choose a clay or earthen pot that can hold about seven to ten litres.
2. Three holes are to be made at the bottom of the pot about the size of little finger.
3. Half of the bottom of the pot should be filled with large pebbles so that they don't come out of the holes at the bottom of the pot.
4. A layer of sized gravel has to be put on top of the pebble layer.



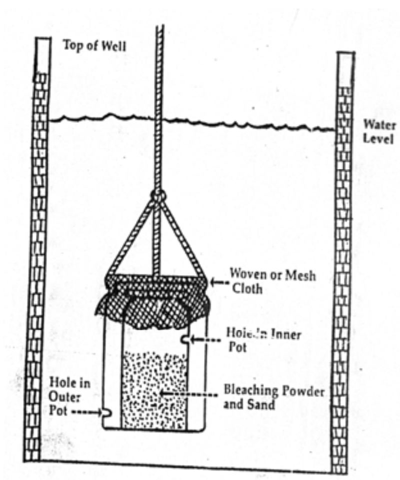
Chlorination Pot for Community and Dug Wells

5. Mix a combination of one part bleaching powder to two parts sand and put a layer over the top pea gravel. The layer should almost fill the top and leave enough space for more layer of pebbles.
6. Fill the rest of the pot up to the neck with pebbles.
7. Secure ropes or strings around the outside of the pot so that it can be lowered and raised in the well easily.
8. Lower the pot leaving its mouth open, into the well and into the water.

1.5 kg of bleaching powder in the pot will chlorinate the well for about a week if the rate of water abstraction is about 1,000 to 1,200 litres every day.

2) Double pot method

- Choose two pots, one smaller than the other. These pots should be made of plastic, ceramic, or clay.
- Mix approx. 1 kg of moistened bleaching powder and 2kg of coarse sand.
- Place the mixture in the small pot. This small pot needs a lid, which can stay on in the well.
- Make a hole, about a size of your finger, on one side of the small pot near the top.
- In the larger pot make a hole of the same size but near the bottom.
- Place the smaller pot inside the larger pot. Cover the mouth of the larger pot with a fine woven cloth. Lower this in the well.



- This type of chlorination will work for 2-3 weeks in well that supply up to 400-500 litres per day and has a capacity of 4500 litres.

<u>OTHER METHODS OF PURIFICATION AT THE HOUSEHOLD LEVEL</u>

<u>SODIS</u>

One/two litres of raw untreated clear water from a river, cannel or well filled in PET bottles, the mouth closed and exposed to bright sunlight (10am-4pm). A temperature of 37^0C to 45^0C is ideal. Three hours of exposure to sunlight kills 95% of harmful bacteria present in water, six hours of exposure kills 100% of bacteria.

USE OF COPPER VESSEL

Water kept in copper/brass vessel for 12 hours removes about 90% of the bacteria, while an earthen pot reduces bacteria by 50%. Ideally three copper vessels should be used in which water is filled over a period of three days

Administrative level

Final Chlorination: Another calculated dose of chlorine gas is added to the filtered water to destroy the traces of any remaining bacteria. Excessive chlorine residuals are needed at the municipal water treatment plant outlet in order to maintain adequate chlorine levels at the far end of the distribution system. The total dose of chlorine at the plant is thus a combination of the chlorine required to overcome initial demand (to kill bacteria) and the amount required to assure sufficient level at all points in the distribution system i.e. to keep the residual chlorine to protect the water from contamination during its transmission and storage

Clean water reservoirs/distribution networks: The water from the filter house is stored in the balancing tanks for further pumping. The filtered water collected in the balancing reservoirs is pumped with the help of suitable pumps to the service reservoirs located in the various parts of the city as per requirement.