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ENVIRONMENTAL SCIENCE

Khulna University Studies, 6(1&2): 13-19, 2005

ASSESSMENT OF SUPPLY WATER QUALITY OF KHULNA CITY CORPORATION, KHULNA, BANGLADESH

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KUS- 03/41-161003

Manuscript received: October 16, 2003; Accepted: July 03, 2005

Abstract: In order to determine the water quality of Khulna City Corporation, the ground (198-323 m depth; at Nirala, Sonadanga, Khalishpur, Mujgunni, Tutpara, Ferighat and Rupsa) and surface water (at Hadispark) from production well and from the tap of corresponding household (500 meter away from production well) were collected from different locations of Khulna City Corporation and their different physico-chemical properties viz., color, odor, temperature, turbidity, pH, Electrical Conductivity, Total Dissolved Solids, Dissolved Oxygen, Total hardness, Chloride and Iron content and coliform count (number/100 ml; both from faecal and nonfaecal origin) were measured. Most of the water samples were found alkaline (pH>7). In most cases from production well to households the pH, Turbidity and total hardness increases whereas EC value, TDS, chloride and iron content decreases. All the observed values are within the permissible limits of Bangladesh and WHO standards for potable purpose but two exceptional cases were found for turbidity 7 JTU at Sonadanga and chloride content 351 ppm at Ferighat. It was observed that production well water at Nirala, Sonadanga and Hadispark contaminated with coliform were 23, 23, and >4800 respectively both from faecal and nonfaecal origin, but at Khalishpur, Mujgunni and Rupsa were free from coliform. Water of corresponding households at Nirala, Rupsa and Hadispark had the coliform 09/100 ml, all from faecal origin and the total coliform at Nirala, Sonadanga, Rupsa and Hadispark were 23, 93, 23 and 460 respectively. So it is evident that the supply water at Nirala, Sonadanga, Rupsa and Hadispark does not meet the potable standard.

Key words: Assessment, risk, supply water, quality

Introduction

Khulna City Corporation (KCC) has been supplying ground water to the city dwellers by the supply water network system. This water is being used for domestic purposes. Although some private and community tube wells are found in the city, a large number of people directly depend on the KCC water supply systems, which hardly meet their demand both qualitatively and quantitatively (Islam, 1995). At present KCC is supplying water with 50% capacity of the total 30 million gallons/day demand of water to which only 30% dwellers get access (Anon, 2000). About 90% of the total population of the KCC area collects their drinking water from shallow /deep tube wells instead of KCC water supply system.

Water borne diseases are very common in KCC area like any other places in the country. So questions are easily being raised about the potability status of the supply water. The impact of water on health derives principally from the consumption of water containing pathogenic organisms or toxic chemicals and the use of inadequate volumes of water lead to poor hygiene. So water has a profound effect on human health as a means to reduce diseases and a media for their propagation. The principal risk to human health in our country is associated with the consumption of polluted water microbial in nature, although significant concerns are about chemical contamination. In chapter 18 of *Agenda 21* of UNCED stated 'An estimated so present of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water and on average as much as one tenth of each person's productive time is sacrificed to water related diseases' (1992; Sessions, 1993).

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DOI: <https://doi.org/10.53808/KUS.2005.6.1and2.0341-L>

People generally use water by observing the physical appearance and they hardly have any knowledge regarding the pollutants. Indiscriminate disposal of sewages, industrial effluents, solid waste etc. and along with agricultural runoff make the surface and ground water polluted. So qualitative measurement is essential for any kind of water before use. Like any other developing country, Bangladesh recognizes the 'Water supply and sanitation' as an important sector in the national development planning. Water is an essential part of life but purity of water is very much important from sanitary point of view. Realizing the situation, the present work was undertaken to analyze the quality based on the physico-chemical and microbial parameters of KCC supply water samples collected from different production wells and their adjacent household taps in the city.

Materials and Methods

To investigate the quality of KCC supply water, the water samples were collected from eight production wells (Seven ground water production well and one surface water treatment plant) and their respective household taps (some 500 meters away from the production well). The locations of the sampling points are Khalishpur-3, Mujgunni well field-1, Sonadanga, Ferighat, Hadispark, Rupsa-3 (DPHE), Tutpara well field-2 and KDA Nirala-3. The selected locations are shown in Fig. 1 and Table 1.

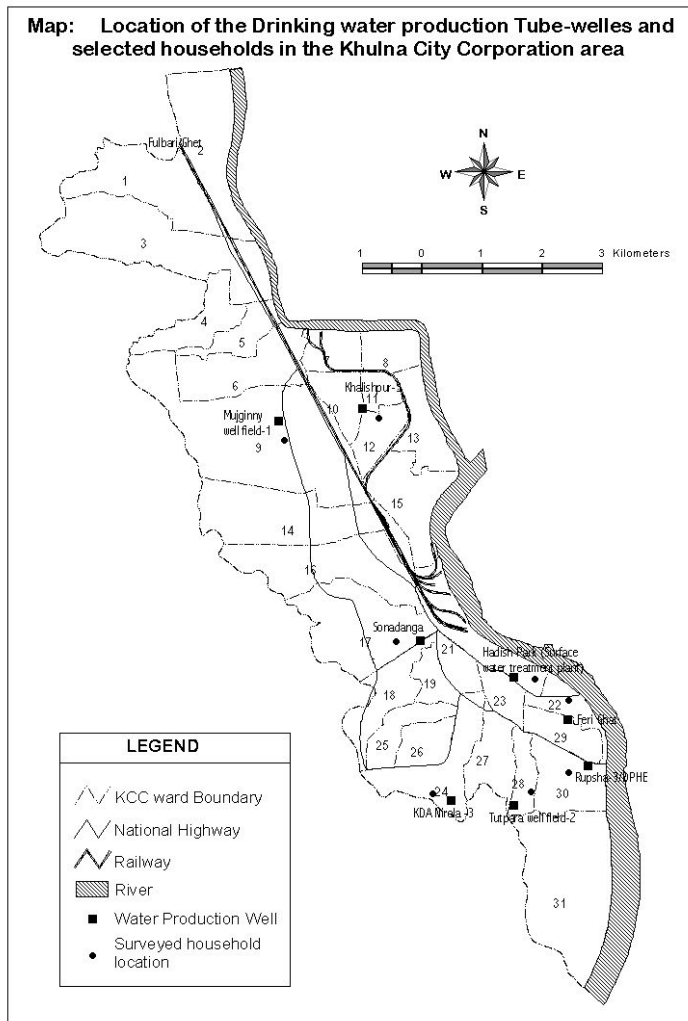


Fig. 1. Selected locations of the water sample collection points (after USAID, 1999).

At production well water was pumped out adequately (for nearly ten minutes). Representative samples of water 6 samples from each source (total 48) at different times were collected (500 ml each) into cleaned plastic bottles. After collection the samples were brought to the Water chemistry laboratory of Environmental science Discipline and FMRT Discipline, Khulna University immediately to determine coliform, pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO) and Total Hardness (TH). Then the samples were preserved by adding 1ml/litre of nitric acid to make the pH 4-5 for analysis of metallic cations. The samples were preserved in plastic bottles at 4°C for further analysis.

Glass electrode with LCD monitor was used for pH determination. Digital electronic devices were used for measuring temperature, EC and TDS. Titrimetric method was used for the determination of DO (Winkler's method), chloride and total hardness. Spectrophotometer and Nephelometric turbidity meter were used for measuring iron and turbidity respectively. Multiple tube method was followed for the determination of total coliform and faecal coliform (APHA, 1992; Kotaiah and Swamy, 1994). The obtained water quality and bacterial load data sets were compared with Bangladesh and WHO standard values.

Table 1. Drinking water production tube wells and respective household for this study in Khulna City Corporation area.

| Sl. No. | Location of well | Well no. | Year installed | Total depth (m) | Pump capacity m ³ /hr | Household/other Locations | Production well to household distance |
|---------|---|----------|----------------|-----------------|----------------------------------|--|---------------------------------------|
| 1 | Khalishpur-3 | 3 | 1973 | 238 | 68 | House No. -392, Rode No.-164, Khalishpur Housing Bazar | 500 m |
| 2 | Mujgunny well field-1 | 39 | 1986 | 290 | 70 | House No. -306 Road No.-20 Mujgunny | 500 m |
| 3 | Sonadanga | 43 | 1987 | 283 | 68 | Western motor office | 500 m |
| 4 | Feri Ghat | 54 | 1994 | 323 | 70 | Dr Delwer, Ferighat | 500 m |
| 5 | Hadish Park (surface water treatment plant) | – | – | Surface water | – | 57, Khan-E- Sabur Road | 500 m |
| 6 | Rupsha-3/DPHE | 49 | 1994 | 254 | 68 | House No-304, Road no 5 Rupsha. | 500 m |
| 7 | Tutpara well field-2 | 37 | 1988 | 198 | 102 | Maula Bari, Tutpara | 500 m |
| 8 | KDA Nirala 3 | 36 | 1988 | 253 | 68 | House No. 182 Road, No.1 Nirala Residential Area | 500 m |

Results

In this work in situ measurements were carried out for the determination of temperature, pH and electrical conductivity.

Temperature: The temperature of all water sample examined insitu in this study is in the range between 24-32 °C with an average temperature of the production well at 27.28 °C whereas, 26.35 °C for household. The value of temperature of production tube well and house hold is given in Table 2. In case of Production well the maximum temperature was 31.4 °C at Mujgunni-1 and the minimum 24.6 °C at Nirala.

Color and odor: It is observed that all water samples are colorless and odorless in normal human sense.

Turbidity: The results shown in Table 2 implies that the turbidity range between 1-3 JTU in all samples, except at Sonadanga where turbidity is higher than others. For production well the lowest value is 1 JTU at Ferighat and highest value is 7.5 JTU at Sonadanga. For household the lowest turbidity was 1 JTU at Ferighat and Rupsa and highest was 7 JTU at Sonadanga. The turbidity decreases from all Production wells to Households.

Water pH: The observed pH of water samples presented in Table 2 ranged between 7.2-8.5. The lowest pH for production tube well was 7.2 at Khalishpur and the highest was 8.5 at Hadispark. And for household the highest value was 8.5 at Nirala and the lowest is 7.4 at Khalishpur.

Conductivity: The Electric conductivity of all water samples ranged between 750-1400 µScm⁻¹. For production well the maximum and minimum EC were found 1373 µScm⁻¹ at Hadispark and 800 µScm⁻¹ at Nirala. For Household, the highest value was 1142 µScm⁻¹ at Hadispark and the lowest was 790 µScm⁻¹ at Rupsa.

Total dissolved solid: The obtained TDS contents are given in the Table 2. The TDS of water samples ranged between 150–1350 ppm. The highest value for production tube well was 1326 ppm at khalishpur and the

lowest value 155ppm at Mujgunni. For household the highest value was 1350 ppm at ferighat and the lowest 172 ppm at Mujgunni.

Dissolved oxygen: The dissolved oxygen both for production tube well and respective Household are given in the Table 2. It is estimated that dissolved oxygen of drinking water examined in this study lies between 5.8–10.5 ppm.

Chloride: Chloride content of the tested water samples ranged between 60-355 ppm. For production tube well the maximum value was 355 ppm at Ferighat and the minimum 76 ppm at Nirala. In case of household, the highest value was 250 ppm at Ferighat and lowest was 60 ppm at Nirala. The data implies that chloride content decreases from production well to household.

Total hardness: The hardness of the water samples was determined and expressed as ppm as CaCO₃, shown in Table 2. Total hardness of all samples ranges between 98-315 ppm as CaCO₃. For production tube well the highest value of total hardness as CaCO₃ is 286 ppm at Ferighat and the lowest is 120 ppm at Sonadanga. For Household the highest value is 351 ppm at Ferighat and the lowest is 98 ppm at Tutpara.

Table 2. Physico-chemical and microbial properties of water samples from KCC area, Bangladesh.

| Locations & depth (meter) | Sampling Points | Temperature °C | pH | Turbidity JTU | Electrical Conductivity $\mu\text{s cm}^{-1}$ | Total Dissolved Solids ppm | Dissolved Oxygen ppm | Total Hardness ppm as CaCO ₃ | Iron ppm | Chloride ppm | MPN Total Coliform in 100ml | MPN Faecal Coliform in 100ml |
|---------------------------|-----------------|----------------|-----|---------------|---|----------------------------|----------------------|---|----------|--------------|-----------------------------|------------------------------|
| Khalishpur-3; 238 | Production Well | 27.4 | 7.2 | 1.5 | 1125 | 1326 | 7.3 | 178 | 0.46 | 166 | 0 | 0 |
| | Household Tap | 25 | 7.4 | 1.5 | 1000 | 1120 | 7.7 | 160 | 0.38 | 115 | 0 | 0 |
| Mujgunni Wellfield-1 290 | Production Well | 31.4 | 8.1 | 3 | 1050 | 155 | 7.8 | 227 | 0.85 | 120 | 0 | 0 |
| | Household Tap | 25.9 | 8.2 | 2.5 | 950 | 172 | 7.9 | 276 | 0.65 | 76 | 0 | 0 |
| Sonadanga 283 | Production Well | 28 | 8.1 | 7.5 | 981 | 684 | 6.3 | 120 | 0.32 | 103 | 23 | 04 |
| | Household Tap | 25.9 | 8.1 | 7 | 980 | 686 | 7.3 | 125 | 0.27 | 92 | 93 | 0 |
| Ferighat 323 | Production Well | 29.9 | 7.6 | 1 | 1263 | 1267 | 10.1 | 286 | 0.54 | 351 | NA | NA |
| | Household Tap | 30.5 | 7.6 | 1 | 970 | 1350 | 8.2 | 315 | 0.46 | 250 | NA | NA |
| Hadispark (Surface water) | Production Well | 25.5 | 8.5 | 2.4 | 1373 | 1261 | 7.6 | 137 | 0.94 | 159 | >4800 | 93 |
| | Household Tap | 27.1 | 8.1 | 1.6 | 1142 | 796 | 8.1 | 172.5 | 0.50 | 112 | 460 | 09 |
| Rupsa-3 (DPHE) 254 | Production Well | 25.4 | 7.6 | 1.5 | 850 | 1210 | 8.1 | 155 | 0.76 | 92 | 0 | 0 |
| | Household Tap | 25.5 | 8.1 | 1 | 790 | 950 | 8.1 | 150 | 0.52 | 70 | 23 | 09 |
| Tutpara Wellfield-2 198 | Production Well | 26 | 8.1 | 3 | 897 | 1220 | 10.4 | 160 | 0.56 | 83 | NA | NA |
| | Household Tap | 26 | 8.2 | 2.6 | 886 | 696 | 8.6 | 98 | 0.43 | 77 | NA | NA |
| KDA Nirala-3 253 | Production Well | 24.6 | 8.1 | 2 | 800 | 560 | 6.1 | 131 | 0.84 | 76 | 23 | 09 |
| | Household Tap | 24.9 | 8.5 | 1.8 | 817 | 571 | 5.8 | 100 | 0.51 | 60 | 23 | 09 |

Iron (Fe): Iron content of the water samples ranges between 0.27–0.92 ppm. For production tube wells the highest value 0.94 ppm found at Hadispark and the lowest value 0.32 ppm at Sonadanga. And in the case of households the highest value 0.65 ppm found at Mujgunni and the lowest value 0.27 ppm at Sonadanga.

Estimation of total coliform: Biological aspect of the water samples has been determined by counting the number of coliform per 100 ml of water samples. The amount of coliform found in all water samples ranged 0-90 per 100 ml. Out of 12 water samples total coliform was not found in both productions well and household water of Mujgunni and Khalishpur. Coliform was also not found at Rupsa production well water. Total coliform count ranged from 23 to 93 per 100 ml, of water for samples of both production well water and household water at Nirala and Sonadanga including the household water at Rupsa. Production well and household water of Hadispark showed high coliform content, ranged 460 and >4800 per 100 ml respectively. However coliform bacteria was not determined with the samples both from production wells and respective households at Tutpara and Ferighat.

Estimation of fecal coliform: Out of 6 locations, water samples of 3 production wells at Nirala, Sonadanga and Hadispark showed fecal coliform content of 09, 04 and 93 per 100 ml respectively. Corresponding household water also showed fecal contamination except at Sonadanga. Production well water and household water of these three locations also contained higher total coliform (Table 2).

Discussion

The quality of the drinking water depends on major, minor and trace components. Other parameters, like pH, electrical conductivity etc. can provide some important information about the quality of water.

Temperature: The temperature value differed from location to location for production tube well may be due to the geothermal gradient about 25 °C/Km. The results show that the temperature of water of the most location (both production well and house hold) is within the standard (20-30 °C) value for Bangladesh.

Color and odor: As the water samples were colorless and odorless the water could be used by the city dwellers without any precautionary measure.

Turbidity: The results shown in Table 2 implies that the turbidity range between 1-3 JTU in all samples, which complies with the Bangladesh and WHO standards for drinking water except at Sonadanga where turbidity is higher than others. The turbidity decreases from all Production wells to Householdss may be due to the collection of colloidal particles onto the inner surface of the water supply system.

Water pH: Among all the properties, pH value is the most important as it gives the indication of the sample whether acidic or basic. The observed pH of water samples is presented in Table 2, which shows that all the samples are alkaline. The pH of all water samples ranged between 7.2-8.5, lying within the standard level (6.5-8.5) of drinking water for Bangladesh and WHO. The pH of ground water may be due to various components among which bicarbonate is one. Carbon dioxide in solution is derived from atmosphere and organic decomposition processes in soil, assists the solvent action of water as it moves underground and reacts with carbon containing rock and release bicarbonate (Motteleb, Mondal and Islam, 1999). The reaction can be written as: $\text{CaCO}_3 (\text{s}) + \text{CO}_2 + \text{H}_2\text{O} = \text{Ca}^{2+} (\text{HCO}_3)_2 (\text{soln})$. The highest pH for production tube well was 8.5 at Hadispark, may be due to chlorination with bleaching powder. The alkaline nature of the water can be correlated with bicarbonate contents. Table 2 shows that at most location pH slightly increases from production well to households. This may be due to faulty distribution network for drinking water supply.

Conductivity: The conductivity measures the concentration of soluble salts in water. It is found that EC decreases from production well to household at most of the locations except Nirala. The concentration of salts depends on the seasonal fluctuations of hydrolic movement and distribution-origin of ground water. The soluble salts in ground water originate primarily from solution of rock materials and are mostly higher concentrations than the surface water.

Total dissolved solid: Total dissolved solids (TDS) refer to the sum of all the dissolved components in water. Water containing too much dissolve solids (>1000 ppm) is not satisfactory for common uses. Some of the samples considerably exceed the standard TDS level of Bangladesh and WHO (1000 ppm) for potable purpose. The higher concentration may be due to seawater intrusion into the aquifer. Salinity varies with the specific surface area of aquifer materials, solubility of minerals and contact time; values tend to be highest where movement of ground water is least (Mottaleb *et al.*, 1999). Most of the households have TDS value within standard level. The obtained data shows that TDS decreases from production well to household at most of the locations. Higher concentration of the solids contributed by bicarbonate that can be minimized or removed by boiling. As a result concentration of dissolved solids may be reduced by precipitation of CaCO_3 and could be considered for drinking.

Dissolved oxygen: The dissolved oxygen both for production tube well and respective household complies with the standard level for Bangladesh (ECR, 1997) (6 ppm) and below the standard level of WHO (9 ppm). The variation in the DO values of the production tube well may be due to the variation in depth of the production tube well. This is because the contact with atmospheric oxygen decreases with increasing depth. For household the maximum and the minimum DO were 8.6 ppm at Tutpara and 5.8 ppm at Nirala respectively. In most locations DO level increases from production well to household. This may be due to the aeration with the pump used in water supply system.

Chloride: Chloride is an indication of Salinity in Water. It is one of the major constituents of natural water (Sawyer and McCarty, 1978). Most chloride in ground water comes from evaporation, salty connate water and seawater. Ground water containing significant amount of chloride also tend to have high amount of Na ions indicating the possibility of contacts with water of marine origin (Hem, 1970). Chloride content of the tested water samples ranged between 60-355 ppm lies within the standard level for Bangladesh (150-600 ppm) but sample collected from Ferighat had chloride content 351 ppm, exceeded WHO standard (250 ppm). The fluctuation of the chloride content in ground water may be related with local lithological distribution, seasonal hydraulic head fluctuation as well as by tidal effects of the study area. At concentrations above 250 ppm chloride rich water gives a salty test, causes various diseases such as high blood pressure etc. but it depends on individual adaptability (Sawyer and McCarty, 1978).

Total hardness: Hardness in water results from the presence of the bivalent metallic cations, mainly calcium and Magnesium (Todd, 1980). Hardness may be derived from the solution of Carbon dioxide, released by bacterial action in soil, which percolates into the subsurface through rainwater. Low pH conditions develop and lead to the solution of insoluble carbonates in the soil and in limestone formation, to convert them into soluble bicarbonates (Mottaleb *et al.*, 1999). In recent years, the health aspect is receiving increasing interest because of greater incident of coronary heart disease in area with soft water than with hard water (Crawford, 1972). According to hardness scale (Sawyer and McCarty, 1978), water of Production tube wells fall under *hard* class except at Nirala (131 ppm) and Sonadanga (120 ppm), which fall under moderately soft class. The hardness of the water samples was determined and expressed as ppm as CaCO₃, shown in Table 2. Total hardness of all samples ranges between 98-315 ppm as CaCO₃, which is within the standard level of Bangladesh (200-500 ppm as CaCO₃). Difference of total hardness from production well to household was observed but at two locations—Mujgunni and Tutpara were noticeable, where the differences were above 40 ppm as CaCO₃.

Iron (Fe): Iron occurs as either ferrous (bivalent) or ferric (trivalent) state. The ferrous iron is by far more common in ground water owing to its solubility in water, although it is unstable and in the presence of oxygen rapidly oxidized to insoluble ferric state. Iron content of the water samples complies with the standard range of Bangladesh (0.3-1 ppm) and WHO (0.3 ppm). Hence the iron concentration in both productions tubes well and household is not harmful for human consumption. Also the iron content decreases from production well to household at all station, it could be due to air oxidation within the supply system.

Estimation of total coliform: Biological aspect of the water samples has been determined by counting the number of coliform per 100 ml of water samples. The amount of coliform found in all water samples implies that most of the water samples contain coliform above the standard level of Bangladesh and WHO (0 per 100 ml). According to WHO guidelines coliform content per 100 ml of drinking water should not be more than 3. Water sample from 3 production wells (Nirala, Sonadanga, Hadispark) were found contaminated with coliform. So coliform contamination commenced from the respective production well and all the corresponding household water also showed coliform contamination of almost similar load. So it could be concluded that water supply system in Nirala, Sonadanga, and Hadispark are exposed to coliform and does not meet potable quality. The production well water of other three locations (Khalishpur, Mujgunni and Rupsa) was found containing no coliform organism and the corresponding household water samples were also found free from coliform except at Rupsa (23 per 100 ml). It implies that water distribution system of Rupsa is exposed to coliform contamination.

Estimation of fecal coliform: It is evident from the amount of fecal coliform of the water samples shown in Table 2 that source of coliform bacteria of these locations are of fecal origin. Fecal coliform was not found with production well water at rest of the 3 locations viz. Khalishpur, Mujgunni, and Rupsa. Corresponding household water of Khalishpur and Mujgunni were free on fecal contamination and total coliform content were also zero. So water supply systems of these two locations were free from coliform contamination. Although production well water of Rupsa was free from any coliform organism (count is zero for both total and fecal coliform), the corresponding household water was found substantial amount of coliform (23 and 09 per 100 ml for total coliform and faecal coliform respectively). So it could be assumed that water supply network of this area is exposed to coliform contamination of fecal origin.

Conclusion

In order to assess the risk of KCC supply water, samples were collected at production wells and their corresponding household taps from eight locations. The data implies that most of the physico-chemical parameters are within the stipulated standard of Bangladesh and WHO except turbidity 7.5 and 7 JTU in production well and Household tap water respectively and chloride 351 ppm for production well water and 250 ppm found at household tap water. For coliform content the data implies that water samples from Khalishpur-3 and Mujgunni Wellfield-1 have no coliform content both at production well and at household tap. But it is very high at the both two points for the remaining six samples (Table 2). So it could be recommended that the KCC supply water is at high risk for domestic uses defined by DFID 1998 (Rahman and Mahabub-Un-Nabi, 2002). To improve the situation, measures should be taken including proper monitoring, institutional surveillance (Samsuddin, 2002) etc. Moreover public awareness should be build up among the consumers not to use the without prior treatment like boiling and subsequent filtration to overcome the risk. For the development and management of water resources of the study area a detail climatological, hydrological and hydro-geological and hydro-chemical subsurface mapping should be considered.

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