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**Original Research Paper**

# Heavy Metal Content in Drinking Water of Lakhimpur District of Assam with Reference to Health Hazard

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## ABSTRACT

Heavy metals in water have severe toxicity towards aquatic life and human beings. In north-eastern region of India, increasing rate of heavy metal content in drinking water has become a matter of serious concern as it has adverse health affects at high concentration. Many researchers have already studied high concentration of arsenic and heavy metals in different districts in this region. In Lakhimpur district of Assam in India, no detailed study about arsenic and heavy metals in drinking water has been done till now. In order to assess the concentration of heavy metals in drinking water of Lakhimpur district of Assam, twenty locations were selected for the study. The analysis was carried out for three years from June 2005 to May 2008 covering four seasons in a year. Metals studied in the present investigation were Zn, Pb, Ni, Cu and As. From the analytical data, it was found that Cu and Zn concentration was within ISI permissible limit. The all season average values of Ni in all the sampling points were found within 0.1mg/L. Pb concentration was found to be at a higher level in almost all the sources. In 5% samples As content exceeded ISI limit of 0.05mg/L. Seasonal variations were also observed and high values were detected in monsoon season. Health survey in the district were also done with the help of a pre-prepared questionnaire and the over all health status was found to be not satisfactory. Most of the people in the district suffered from mild to severe gastrointestinal diseases. Though, arsenic concentration was high in a few locations, no case of arsenocosis has been reported till date.

## INTRODUCTION

Metals constitute a very important group of parameters in monitoring water quality. Metals enter into water bodies through dissolution from soil of various geological strata and discharges of domestic, industrial and agricultural wastes. Although it is well known that metals such as Cr, Co, Cu, Fe, Mn and Zn among others are essential for biological systems including humans, others such as As, Cd, Pb, Hg do not possess any beneficial biological effect and are toxic at certain levels. However, all trace metals including micronutrient elements can exert toxic effect at high concentration. Heavy metals are harmful and insidious pollutants because of their non-biodegradable nature and potential to cause adverse effects in human beings beyond certain level of exposure and absorption. Heavy metals can cause biochemical effects such as inhibition of enzymes, genetic damage and hypertension. Some of the heavy metals like Zn, Cr, Cd and Pb are carcinogenic (Luckey & Venugopal 1977). In many parts of the world arsenic concentration in water has been increased to about 14.2 mg/L or 284 times, which is much more than the permissible value of 0.05 mg/L (Sikdar 2005). Arsenic contamination of groundwater has become a major issue of concern worldwide. The Bengal Delta Plain (BDP) has become the world's largest arsenic contaminated area. High concentration of arsenic in groundwater has been reported from the Bengal Delta Plains in West Bengal (India) and Bangladesh. It is also reported in many parts of Argentina, Mexico, Romania, Taiwan and many parts of USA, particularly the south west. Mining related arsenic problems in water has been identified in many parts of the world, including Austria, Ghana, Greece, India (Madhya Pradesh), South Africa, Thailand and USA. In Australia, arsenic contamination by mining activities and agriculture causes substantial environmental concern (Nguyen et al. 2005). High arsenic levels in the drinking water of western and southwestern United States was reported by Davis et al. (1994). Pandey et al. (1999) first reported arsenic contamination and human affliction at a single village named Kourikasa in Chhattisgarh state (India). Pandey et al. (2005) reported Rajnandgaon district in Chhattisgarh state as the most arsenic contaminated area in Central India. Recently ground water of Assam has been reported to have high arsenic concentration. According to the findings of a survey conducted by a team of scientists of North Eastern Regional Institute of Water and Land Management (NERIWALM), an alarmingly large number of places in 20 out of 23 old districts of Assam have their groundwater contaminated with high concentration of arsenic making groundwater in these places totally unsafe for consumption. NERIWALM scientists found during their survey that the groundwater of Ikrani near Titabor in Jorhat district has the

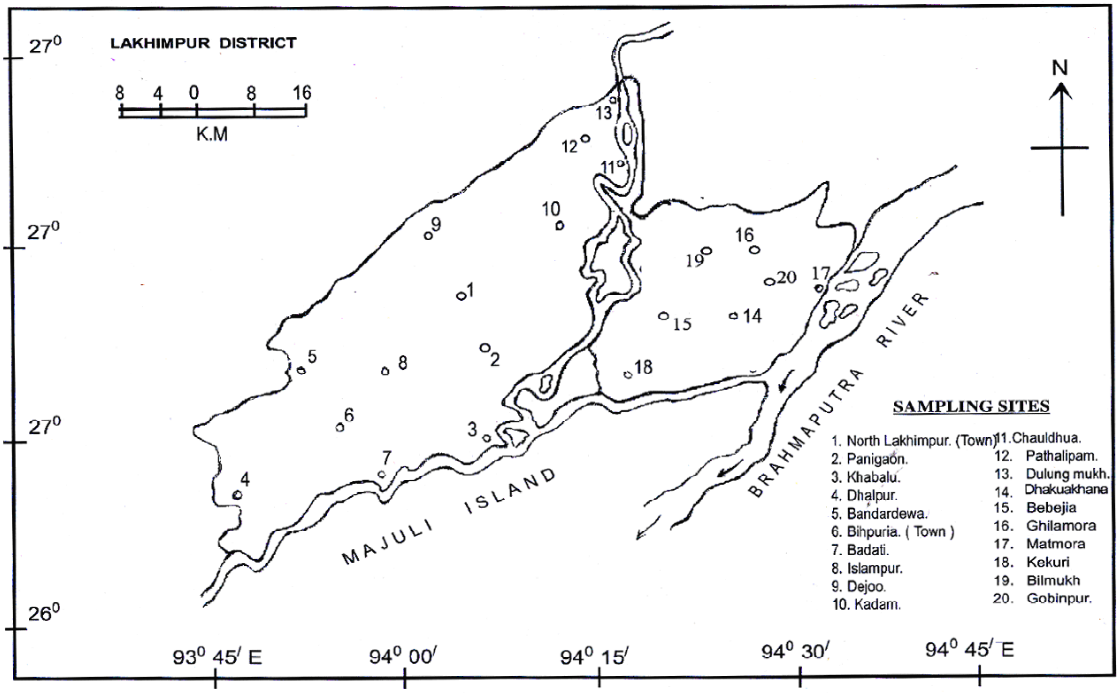


Fig. 1: Locations of study area.

highest amount of 657 micrograms of arsenic per litre of water. It was followed by the groundwater of Kathiatali Na-Dewri Goan in Nagaon district with 601 micrograms of arsenic per litre of groundwater and Kadam Kachari Goan in Boginadi area of Lakhimpur district with 550 micrograms of arsenic per litre of water (Singh 2004). Similar survey was also carried out by State Public Health Engineering Department (PHED) with financial and technical assistance from UNICEF's Kolkata office. This survey reported to have arsenic contamination beyond permissible limit in the groundwater of places spread over in 15 districts. Besides places in Assam, scientists of NERIWALM also found arsenic contamination in groundwater in a number of places of Arunachal Pradesh, Manipur, Tripura and Nagaland. The highest amount of 986 parts per billion in a litre of water was found at Khunyani in Thoubal district of Manipur (Singh 2004). If arsenic is taken for long time, it may cause many diseases like anaemia, abdominal pain, hepatic malfunction, renal tissue damage, pigmentation of skin, black foot disease, lung disease, loss of appetite, cancer, constipation, keratosis (skin thickness and scales), melanosis (blackening of the palms) and carcinoma (Guha Mazumder et al. 1998, Prabhu et al. 2003, Kumar et al. 2004, Saha et al. 2005). As per WHO report of 1984, zinc when present in drinking water above permissible limit causes some toxic effects. Symptoms of zinc toxicity include irritability, loss of appetite, nausea, etc. (Bhattacharya et al. 2004). Lead intoxication may cause a wide variety of symptoms involving multiple organ system. The most common symptoms are gastrointestinal disturbances, less frequently nausea, vomiting and liver disfunction. Human exposure to lead adversely affects the cognitive and behavioural deficits (Needleman & Gatsoni 1990, Goyer 1993). Nickel is also toxic to human health if present in drinking water beyond a certain level. Toxic effects of mercury and other heavy metals result in memory loss, vision disturbance, cardiovascular problems, anaemia, irritability, thyroid gland, liver disease, skin infection, mental retardation, kidney disease, vomiting, neurological disorders, etc. (Hu 2001). The metals studied in this investigation are Cu, Zn, Ni, Pb and As.

## STUDY AREA

Lakhimpur district is situated in the north-east corner of the Indian state of Assam and lies on north bank of the mighty River Brahmaputra. It is located between the latitudes of 26°48′ N-27°53′ N and longitude of 93°42′ E-94°20′ E. The district is industrially backward and no large scale or heavy industry has so far been established in this district. The total geographical area of the district is 2277.00 sq.km out of which 2261.26 sq.km is rural and 15.74 sq.km is urban as per 1991 census. The district falls in the sub-tropical climate region and enjoys monsoon type of climate. It experiences a dry and hot summer season when compared to the other parts of Assam. Summers are typically hot and humid,

Table 1: Location of sampling stations.

| Location number | | Name of location | Sampling Point |
|---|---|---|---|
| 1. | (a) | North Lakhimpur ( TW) | 1 |
| | (b) | North Lakhimpur (RW) | 2 |
| | (c) | North Lakhimpur (PWS) | 3 |
| 2. | (a) | Panigaon ( TW) | 4 |
| | (b) | Panigaon (RW) | 5 |
| | (c) | Panigaon ( PWS) | 6 |
| 3. | | Khabalu (TW) | 7 |
| 4. | (a) | Dhalpur ( TW) | 8 |
| | (b) | Dhalpur (RW) | 9 |
| | (c) | Dhalpur (PWS) | 10 |
| 5. | (a) | Banderdewa (TW) | 11 |
| | (b) | Banderdewa (RW) | 12 |
| 6. | (a) | Bihpuria (TW) | 13 |
| | (b) | Bihpuria (RW) | 14 |
| 7. | (a) | Badati (TW) | 15 |
| | (b) | Badati (RW) | 16 |
| | (c) | Badati( PWS) | 17 |
| 8. | (a) | Islampur (TW) | 18 |
| | (b) | Islampur (RW) | 19 |
| 9. | (a) | Dejoo (TW) | 20 |
| | (b) | Dejoo (RW) | 21 |
| 10. | (a) | Kadam (TW) | 22 |
| | (b) | Kadam(RW) | 23 |
| 11. | (a) | Chauldhuwa (TW) | 24 |
| | (b) | Chauldhuwa (RW) | 25 |
| | (c) | Chauldhuwa (River Subansiri) | 26 |
| 12. | (a) | Pathalipam (TW) | 27 |
| | (b) | Pathalipam (RW) | 28 |
| 13. | | Dulungmukh (TW) | 29 |
| 14. | (a) | Dhakuakhana (TW) | 30 |
| | (b) | Dhakuakhana (RW) | 31 |
| 15. | (a) | Bebejia (TW) | 32 |
| | (b) | Bebejia (RW) | 33 |
| 16. | (a) | Ghilamara (TW) | 34 |
| | (b) | Ghilamara (RW) | 35 |
| 17. | | Matmora (TW) | 36 |
| 18. | | Kekuri (TW) | 37 |
| 19. | | Bilmukh (TW) | 38 |
| 20. | (a) | Gobinpur (TW) | 39 |
| | (b) | Gobinpur (RW) | 40 |

with an average temperature of 29°C. Winters are cold and generally dry with an average temperature of 16°C. There is a heavy rainfall in summer and continuous drought in winter. The district is a flood prone area. The supply of pure and safe drinking water is inadequate in the town areas and almost nonexistent in the rural areas of the district. Only a small segment of the total population is benefited by the public water supply scheme. Tube wells and ring wells are the most common source of drinking water. In some remote areas river is also used as a source of drinking water. The medical facilities, even in modern times, have not shown any major progress.

## MATERIALS AND METHODS

After a careful study of the topography and other aspects of the Lakhimpur district, water samples were collected from forty sampling stations distributed over twenty locations in the Lakhimpur district as shown in Fig. 1. Of these forty sampling stations, twenty nine sampling stations were from North Lakhimpur sub-division and eleven from Dhakuakhana sub-division. The names of these forty sampling stations are given in Table 1. Out of these forty samples, twenty samples are taken from tube wells, fifteen samples from ring wells and four samples from public water supply point and one sample from the river in each season. All the tube wells are shallow in depth (6m-10m) as the water level is very high in the whole district. Water samples were collected in pre-cleaned plastic containers and the containers in all cases were filled as much as possible and tightly stoppered to avoid contact with air, or to prevent agitation during transport. The analysis of water samples was carried out for three years from June 2005 to May 2008. Storage and preservation of samples were done following standard procedures (APHA 1995).

For estimating metals, samples after collection were filtered through a 0.45mm membrane filter and then acidified with nitric acid to pH 2.0. Water samples were stored at ~ 4°C in a refrigerator until analyses. The analysis was carried out within three months. For digestion and pre-concentration of the water samples, standard methods (APHA 1995) were followed. The total concentration of the metals (Cu, Ni, Pb, Zn, As) was determined by atomic absorption spectroscopy (AAS-VARIAN Spectra, AA 220). The details of technical parameters used for measuring the heavy metals are given in Table 2.

## RESULTS AND DISCUSSION

The results of all seasons average values of the heavy metals are given in Tables 3 and 4 and Fig. 2(a, b). The values show wide variation from point to point and from season to season.

**Lead:** The highest value of lead (0.40 mg/L) was observed in sampling point 39 (Tube well, Gobinpur) followed by 0.38 mg/L in sampling point 24 (Tube well, Chauldhuwa) in monsoon season. Generally, higher value of lead was detected during monsoon season. Again, in a number of sampling sources the amount of lead was found to be at below detection level. Lead is one of the hazardous and potentially harmful polluting agents. It inhibits the formation of haemoglobin by reacting with-SH group and interfering with many enzyme functions (Sharma 1997). Lead is generally present in very low concentrations ranging from 0.0006 to 1.12 ppm in natural waters (Rani & Reddy 2003). It is a serious cumulative body poison and the concentration from 0.10 to 10.0 ppm has been found to inhibit the growth of algae (Drusilla et al. 2006). Wasserman et al. (1997) established statistically significant adverse associations between environmental lead exposure and intelligence in school-aged children. Such an environmental significant trace metallic element was observed to be present at higher concentration levels compared to the WHO guideline value of 0.01 mg/L and ISI permissible limit of 0.05mg/L (WHO 1996, BIS 10500: 1991). The presence of lead at higher concentrations in almost all the sources in the present investigation may be attributed to the domestic and municipal waste discharge (including mainly batteries, chemicals from photograph processing and other lead based paint) at the open dumping site and surface runoff.

**Copper:** The highest value of copper (0.178 mg/L) was observed in sampling point 33 (Ring well, Bebejia) and second highest value (0.170 mg/L) in sampling point 28 (Ring well, Pathalipam). Copper was not present in a number of drinking water sources. The sampling points where copper was found to be at below detection level were 1, 4, 15, 22, 24 and 30 among the tube wells. Again, among the ring wells copper was found to be at below detection level in sampling points 2, 35 and 40. Comparatively higher values of copper were recorded in ring wells during monsoon season. Copper is an essential element in human metabolism. It is an integral part of a number of enzymes and proteins (WHO 1984). At concentration levels of above 1.0 mg/L, copper causes staining of laundry and sanitaryware (WHO 1996). Copper in water has an unpleasant astringent taste; the taste threshold being > 5.0 mg/L. Copper has been shown to cause gastrointestinal discomfort and nausea at concentrations above about 3 mg/L (WHO 2004). Based on acute gastrointestinal effect, WHO has recommended a guideline value of 2 mg/L for copper in drinking water. However, in the present investigation all the samples were found to have copper concentrations below 2 mg/L. In sampling points 33 (Ring well, Bebejia), 28 (Ring well, Pathalipam) and 31 (Ring well, Dhakuakhana), the copper concentrations were higher than the ISI desirable limit of 0.05 mg/L (BIS 10500: 1991). But all the values were within or much below the ISI permissible limit of 1.5 mg/L (BIS 10500: 1991).

**Zinc:** The highest value of zinc (3.91mg/L) was observed in sampling point 22 (Tube well, Kadam) and the second highest value (3.53 mg/L) in sampling point 29 (Tube well, Dulunghmukh) in monsoon season. Among the ring wells, the highest concentration (2.20mg/L) was observed in sampling point 28 (Ring well, Pathalipam). The zinc concentration of the tube wells and supply waters was found comparatively higher than the other sources (Ring well & River). This may be due to the pipes and pumps used in the tube wells and supply water systems or may be due to the soil type of this area. Zinc is an essential element for the effective functioning of various enzyme systems. A child requires 0.3 mg/L of zinc per every kilogram of body weight, a deficiency of which may cause retardation of growth. Besides the growth retardation, zinc deficiency may also lead to immaturity and anaemia. The sampling point 14 (Ring well, Bihpuria), 16 (Ring well, Badati) and 19 (Ring well, Islampur) were found to have very low zinc concentration (0.12mg/L, 0.10mg/L, 0.09mg/L respectively) and therefore, the drinking water in these locations is seriously deficient in zinc nutrition. Zinc at concentration above 5.0 mg/L can cause undesirable astringent taste and opalescence in alkaline water. However, none of the samples had zinc concentration above 5 mg/L. According to WHO (2004) zinc at concentration levels of 3 mg/L is likely to give rise to consumer complaints regarding appearance and taste. In the present study only 7.5% of the investigated samples have zinc concentrations above 3mg/L. However, all the values were within the ISI limit of 5 mg/L (BIS 10500:1991).

**Nickel:** The highest value of nickel (0.084 mg/L) was observed in sampling point 36 (Tube well, Matmora) followed by 0.076mg/L in sampling point 8 (Tube well, Dhalpur) in

Table 2: AAS parameter for the analysis of different heavy metals.

| Instrument | Metal | Wave length (HCL) in nm | Flame composition |
|---|---|---|---|
| AAS-VARIAN Spectra AA 220 | Arsenic | 193.7 | HG-ASS |
| | Copper | 324.8 | Air-$C_2H_2$ AAS |
| | Lead | 217.0 | Air-$C_2H_2$ AAS |
| | Nickel | 232.0 | Air-$C_2H_2$ AAS |
| | Zinc | 213.0 | Air-$C_2H_2$ AAS |

Table 3: Average values of heavy metal content in tube well water.

| Sampling No. | Zn | Cu | Ni | Pb | As |
|---|---|---|---|---|---|
| 1 | 2.36 | BDL | 0.052 | 0.07 | 0.006 |
| 4 | 0.55 | BDL | 0.039 | 0.04 | 0.008 |
| 7 | 1.81 | 0.013 | 0.039 | BDL | BDL |
| 8 | 3.49 | 0.044 | 0.076 | 0.10 | BDL |
| 11 | 2.30 | 0.035 | 0.067 | 0.11 | 0.006 |
| 13 | 2.90 | 0.018 | BDL | 0.03 | 0.053 |
| 15 | 0.86 | BDL | .038 | 0.24 | 0.118 |
| 18 | 1.37 | 0.014 | BDL | 0.04 | BDL |
| 20 | 2.95 | 0.028 | 0.051 | BDL | 0.021 |
| 22 | 3.91 | BDL | 0.040 | 0.10 | 0.075 |
| 24 | 0.76 | BDL | 0.019 | 0.38 | 0.034 |
| 27 | 3.44 | 0.019 | 0.034 | 0.06 | 0.022 |
| 29 | 3.53 | 0.041 | BDL | BDL | 0.010 |
| 30 | 2.12 | BDL | 0.067 | 0.04 | 0.013 |
| 32 | 0.83 | 0.027 | 0.054 | BDL | 0.015 |
| 34 | 0.98 | 0.016 | BDL | 0.03 | BDL |
| 36 | 2.10 | 0.019 | 0.084 | 0.10 | 0.082 |
| 37 | 1.68 | 0.033 | 0.050 | BDL | 0.009 |
| 38 | 0.76 | 0.049 | 0.033 | 0.07 | 0.043 |
| 39 | 1.17 | 0.0.30 | 0.024 | 0.40 | 0.022 |

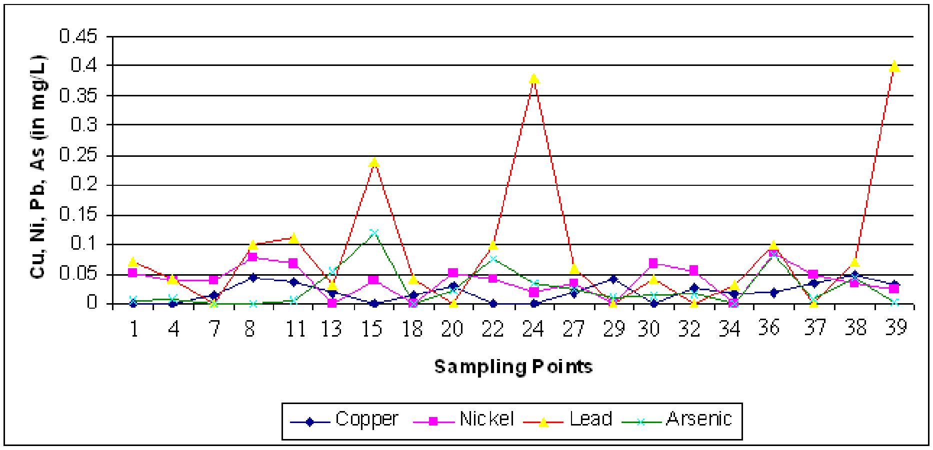


Fig. 2(a): Average content of Cu, Ni, Pb and as for tube well water.

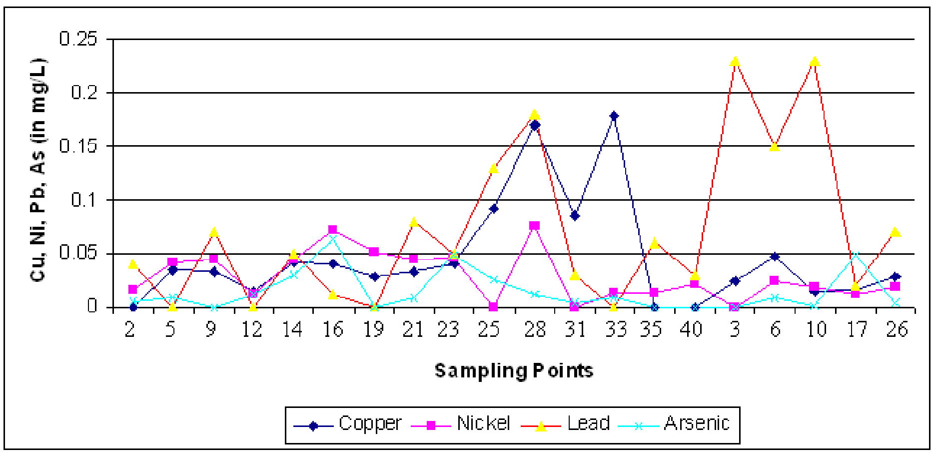


Fig.2(b): Average content of Cu, Ni, Pb and As for ring wells, PWS and river water.

monsoon season. Among the ring wells, the highest nickel content (0.076 mg/L) was observed in sampling point 28 (Ring well, Pathalipam). Nickel was found to be at below detection level in sampling points 13, 18, 29, 34, 25, 31 and 3. Surface water contains 0.015mg/L to 0.020 mg/L of nickel and drinking water usually contains less than 0.020 mg/L of nickel. Trace amount of nickel is regarded as essential for human, plant and animal nutrition with a maximum limit of 0.1 mg/L in drinking water (Barman 2002). The all season average values of nickel in all the sampling points were found within 0.1 mg/L.

**Arsenic**: The highest arsenic concentration (0.118 mg/L) was observed in sampling point 15 (Tube well, Badati) and the second highest value (0.082 mg/L) in sampling point 36 (Tube well, Matmora). These two sampling sites are located near the bank of River Brahmaputra. Higher value of arsenic was detected in tube well waters compared to the other sources. Singh (2004) also reported the presence of high arsenic content in the groundwater samples in various locations of Assam and its neighbouring states. In the present study, arsenic content in a number of the sampling points was found to lie in the range of 0.04 mg/L to 0.05 mg/L. Although, arsenic content beyond the guideline value of WHO (0.01 mg/L) and ISI (.05 mg/L) have been found in a number of samples. There is no report of arsenocosis from the area till date. According to experts, long term use of arsenic contaminated water for drinking and cooking may lead to, among others, carcinogenic diseases.

## CONCLUSION

It can be concluded that drinking water quality in the District Lakhimpur of Assam is not safe for human consumption considering the heavy metal content. The overall health status of the people in the district appears to be unsatisfactory. Illiteracy and lack of awareness about their health and environment, poor drainage and sanitation, and improper waste disposal system are the main reasons for the poor health conditions of the people in the district. Recognizing the problem of high arsenic

Table 4: Average values of heavy metal content in ring well, PWS and supply water.

| Sampling No. | Zn | Cu | Ni | Pb | As |
|---|---|---|---|---|---|
| 2 | 1.74 | BDL | 0.016 | 0.04 | 0.006 |
| 5 | 0.41 | 0.034 | 0.041 | BDL | 0.008 |
| 9 | 1.37 | 0.033 | 0.044 | 0.07 | BDL |
| 12 | 1.85 | 0.015 | 0.011 | BDL | 0.012 |
| 14 | 0.12 | 0.042 | 0.045 | 0.05 | 0.030 |
| 16 | 0.10 | 0.040 | 0.072 | 0.12 | 0.069 |
| 19 | 0.09 | 0.029 | 0.051 | BDL | BDL |
| 21 | 1.60 | 0.033 | 0.045 | 0.08 | 0.009 |
| 23 | 0.75 | 0.040 | 0.046 | 0.05 | 0.048 |
| 25 | 0.87 | 0.019 | BDL | 0.13 | 0.026 |
| 28 | 2.20 | 0.170 | 0.076 | 0.18 | 0.012 |
| 31 | 1.70 | 0.085 | BDL | 0.03 | 0.004 |
| 33 | 1.05 | 0.178 | 0.013 | BDL | 0.009 |
| 35 | 1.30 | BDL | 0.013 | 0.06 | BDL |
| 40 | 1.10 | BDL | 0.021 | 0.03 | BDL |
| 3 | 0.37 | 0.025 | BDL | 0.23 | BDL |
| 6 | 0.87 | 0.047 | 0.024 | 0.15 | 0.008 |
| 10 | 1.03 | 0.014 | 0.019 | 0.23 | 0.002 |
| 17 | 0.62 | 0.016 | 0.011 | 0.02 | 0.048 |
| 26 | 0.53 | 0.028 | 0.018 | 0.07 | 0.004 |

content in some locations of the study area, simple and cheap methods to produce arsenic free water in rural areas is an urgent need. Since, arsenic is a deadly poisonous metal, environmental planning is essential to blunt the danger from arsenic pollution.

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