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ARSENIC CONTAMINATION IN GROUNDWATER IN NORTH-EASTERN BANGLADESH

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Abstract: In recent years, presence of elevated levels of arsenic in groundwater has become a major concern in Bangladesh. Based on the experience of arsenic contamination in the neighboring West Bengal, India, it was initially thought that arsenic contamination would most likely concentrate in the south-western region of Bangladesh. As a result, arsenic testing of groundwater were mostly performed on samples collected from this region; only limited data from other regions of the country were available. This paper presents status of arsenic contamination of groundwater in the north-eastern region of Bangladesh. A total of 1,210 groundwater samples from the north-eastern districts of Kishoregonj, Netrokona, Sylhet, Moulavibazar, Sunamgonj and Hobigonj were analyzed for arsenic. It has been found that water in about 61.1% of the tubewells in the north-eastern zone have arsenic concentration exceeding the acceptable limit set by the WHO (0.01mg/L) for drinking water and about 33.2% exceed the Bangladesh EQS (0.05 mg/L). Among the six districts Sunamgonj appears to be the worst affected with 74.1% of the wells exceeding the Bangladesh EQS for arsenic. Results from this study and data from other areas of the country suggest that arsenic contamination of groundwater in Bangladesh is much more widespread than initially thought.

KEYWORDS: Arsenic, Bangladesh, North-eastern

INTRODUCTION

In Bangladesh, water supply, particularly the rural water supply, is almost entirely dependent on groundwater extracted from shallow tubewells. Presence of high concentration of arsenic in tubewell water has become a major concern in Bangladesh in recent years. Reports on arsenic contamination of groundwater in the West Bengal state of India bordering western Bangladesh was first published in 1983. Awareness about the presence of arsenic in Bangladesh has been growing since late 1993 when arsenic was first detected in the Barogharia Union of Chapainawabgonj district bordering West Bengal, India. Since then a number of organizations have been testing tubewell water samples for detecting the presence of arsenic. Based on the experience of arsenic

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contamination in West Bengal, India which has significant hydro-geological similarities with western parts of Bangladesh, it was initially thought that arsenic affected areas in Bangladesh would fall in the south-western region, below the line joining the districts of Chapainawabgonj, Natore, Pabna, Dhaka, Narayangonj, Brahmanbaria, Noakhali, and Feni. As a result much of the arsenic testing on groundwater samples was concentrated in this region. While most of the areas of this region were found to have high arsenic concentration, only limited data were available from other regions of the country.

The north-eastern region of the country having somewhat different hydro-geological characteristics was initially thought to be safe from arsenic contamination. This paper presents results of arsenic contamination in the north-eastern region of the country. Arsenic contamination of six districts of this region were assessed. The districts are Kishoregonj, Netrokona, Hobigonj, Sylhet, Sunamgonj and Moulavibazar with a combined area of about 19,095 km^2 and a combined population of about 11.326 million (1991 estimate).

SAMPLE COLLECTION AND ANALYSIS

In 1997, the Ministry of Agriculture of the Government of Bangladesh approached the Environmental Engineering Division of the Department of Civil Engineering, BUET to examine the arsenic contamination of groundwater in the north-eastern region of the country. An elaborate sampling program was chalked out to collect tubewell water samples from six districts of the north-eastern region of the country. The districts were Kishoregonj, Netrokona, Hobigonj, Sylhet, Sunamgonj and Moulavibazar with a combined area of about 19,095 km^2. Population in these districts are as follows: 2.388 million in Kishoregonj, 1.791 million Netrokona, 1.611 million in Hobigonj, 2.281 million in Sylhet, 1.802 million in Sunamgonj, and 1.454 million in Moulavibazar. A total of one thousand two hundred and ten tubewell water samples were collected of which 375 were from Kishoregonj, 333 from Netrokona, 249 from Hobigonj, 119 from Sylhet, 75 from Moulavibazar and 55 from Sunamgonj. Each sample, collected in plastic container, was labeled separately with the information on the name of the owner of the tubewell, village, mouza, union, thana and district. It also included the information on the collection date, depth and type of the tubewell. Each sample was marked with a unique identification number and the information on the label were recorded in a database as well as in a register book corresponding to that identification number. This was done to prevent possible contamination with other samples in the laboratory. The samples were first acidified using nitric acid and then pre-concentrated in water baths. Pre-concentration was done in order to detect lower levels of arsenic in the

water samples. Following pre-concentration, arsenic concentration in the samples were determined following the Silver diethyle dithiocarbamate (SDDC) method (Greenberg et. al., 1992) using a HACH DR EL/4 spectrophotometer. A series of arsenic standards were prepared every few days prior to the testing of samples. These were tested for arsenic and standard curve was prepared, which was used for determining arsenic concentration in the samples.

The arsenic concentration data were arranged first according to District. The distribution of arsenic in the tubewells of the six districts provide a microscopic view of the arsenic contamination status in the north-eastern zone. For assessing arsenic contamination in the north-eastern zone of Bangladesh, the results of arsenic analysis were divided into four groups. These groupings were made depending on the various acceptable limits of arsenic in drinking water. The WHO guidelines for arsenic in drinking water is 0.010 mg/L, thus, the first range was set for the wells having arsenic concentration between <0.001 to 0.010 mg/L. Since the Bangladesh standard set in the EQS for arsenic in drinking water is 0.050 mg/L, the second range was set between >0.010 to 0.050 mg/L (DOE, 1991). Again, since the severity of the effect of arsenic depends on its level in drinking water, the wells having high concentration of arsenic were classified into two groups ranging between >0.050 to 0.100 mg/L, and >0.100 mg/L.

In this study, more detailed analysis of test results were performed for the Kishoregonj, Netrokona and Hobigonj districts, for which relatively larger data sets were available compared to the other three districts. For these three districts, arsenic concentration data were arranged according to Thana in order to identify the most severely affected thanas. The relationship between arsenic contamination and depths of tubewells were also analyzed for these three districts.

DISTRICT-WISE DISTRIBUTION OF ARSENIC

Data on arsenic concentration in the north-eastern region of the country were relatively scarce. The data on arsenic concentration of 1210 groundwater samples provided a solid basis for evaluating arsenic contamination in the north-eastern region of Bangladesh. These data were particularly useful because arsenic testing in this study was done using standard testing method and procedure instead of using field kits, which often provide unreliable results. The following sections summarizes the arsenic contamination in the six districts of the north-eastern region of Bangladesh.

Kishoregonj District

Figure 1a represents the distribution of Arsenic in the tubewells located in the Kishoregonj district. It indicates that arsenic concentrations in about 39.7 % of the tubewells in this district are within the acceptable limits set by the WHO and about 67.2 % of the tubewells contain arsenic within the acceptable limit set by the Bangladesh EQS. Fig. 1a shows that 32.8 % of the tubewells exceed the Bangladesh of 0.05 mg/L arsenic and 14.9% have arsenic concentration above 0.10 mg/L.

The thana-wise distribution of the tubewells in the Kishoregonj district is shown in Fig. 1b. It indicates that the majority of the tubewells in the Sadar, Hossainpur, Tarail, Katiadi and Pakundia thanas in the Kishoregonj district are within the acceptable limit set in the Bangladesh standard. However, the Karimgonj thana seem to be the worst affected with more than half the tubewells exceeding the above limit and about half of those wells have arsenic concentration over 0.100 mg/L. The tubewells in the Bajitpur thana seem to be in a similar condition. In addition, the tubewells in Nikli, Kuliarchar and Itna thanas are also relatively bad condition with respect to arsenic levels.

A depth-wise variation of arsenic concentration in the wells of the Kishoregonj district is shown in Fig. 1c. It indicates that the deeper wells exceeding the 300ft margin are relatively less contaminated; while the shallower wells are relatively more contaminated.

Netrokona District

Figure 2a shows distribution of arsenic concentration in the Netrokona district. From Fig. 2a it is apparent that the Netrokona district is in better shape than the Kishoregonj district. About 50.8 % of the tubewells in the Netrokona district are within the WHO standard and about 72.4 % are within the limit set by the Bangladesh EQS. Fig. 2a shows about 27.6 % of the tubewells exceed the 0.05 mg/L limit and 14.4% have arsenic above 0.100 mg/L.

According to Fig. 2b, the majority of the tubewells in the Sadar, Purbadhola, Kendua and Atpara thanas contain arsenic within the acceptable limit of 0.05 mg/L set in Bangladesh standard. However, about half of the tubewells in the Mohongonj, Khaliajuri and Madan thanas exceed the above limit. In Mohongonj the number of tubewells exceeding the 0.100 mg/L level is among the highest in Netrokona.

Figure 2c provides a depth-wise distribution of arsenic concentration in the district. Fig. 2c indicates that majority of the tubewells having depths ranging from 100-300ft have arsenic within the acceptable limit set by WHO and also by the Bangladesh standard. However, a larger percentage of tubewells in the 0-100ft and above 300ft ranges have high arsenic concentration.

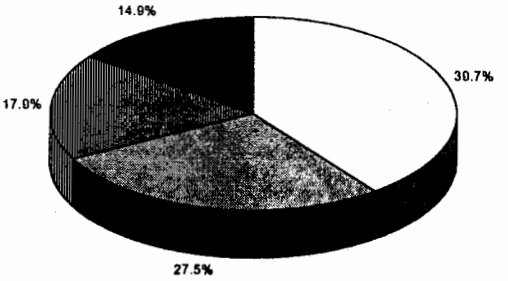

Fig 1a. Distribution of arsenic in tubewells of Kishoregonj

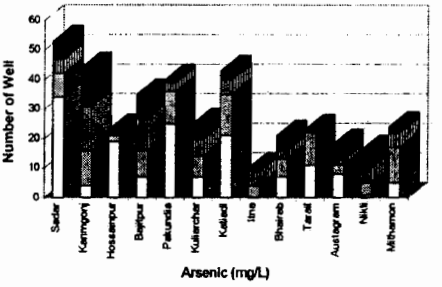

Fig 1b. Thana-wise distribution of arsenic in tubewells of Kishoregonj

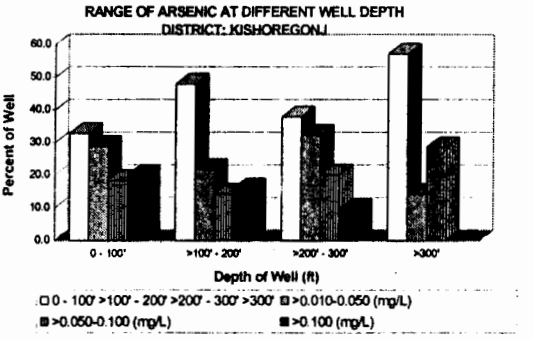

Fig 1c. Depth-wise distribution of arsenic in tubewells of Kishoregonj

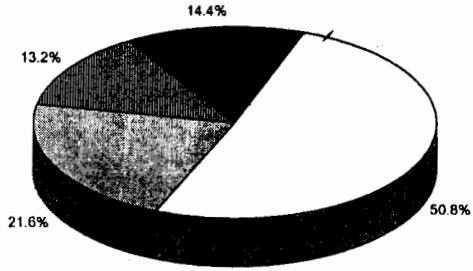

Fig 2a. Distribution of arsenic in tubewells of Netrokona

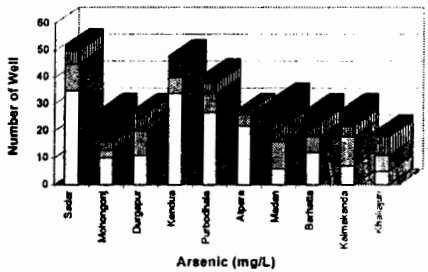

Fig 2b. Thana-wise distribution of arsenic in tubewells of Netrokona

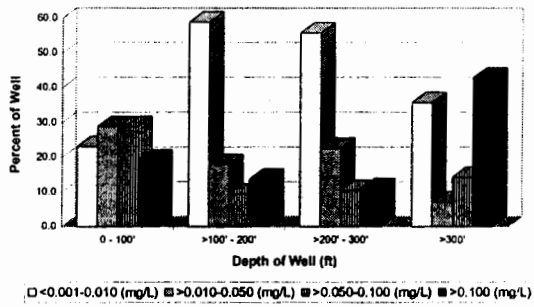

Fig. 2c Depth-wise distribution of arsenic in tubewells of Netrokona

Hobigonj District

Although the Hobigonj district shows a lesser percentage of tubewells satisfying the WHO limit (37.3 %) than the Netrokona district, a comparable number (71.8 %) of tubewells satisfy the Bangladesh standard (Fig. 3a). On the other hand, only 9.6 % of the tubewells in this district exceed the 0.100 mg/L level.

Figure 3b represents thana-wise distribution of arsenic in the Hobigonj district. The tubewells in the Lakhai, Sadar, Baniachung, Chuarughat and Nabigonj thanas have the least fractions of arsenic affected tubewells in the Hobigonj district. However, Bahubal, Ajmirigonj and Madhabpur thanas show a larger number of tubewells with arsenic level exceeding the Bangladesh EQS. The depth-wise distribution of arsenic in Hobigonj district is shown in Fig. 3c. However, no clear variation with depth could be observed from this figure.

Sylhet, Moulavibazar and Sunamgonj Districts

Figure 4 shows distribution of arsenic concentration in the tubewell water of Sylhet district. In Sylhet, about 27.7% of the tubewells exceeded the Bangladesh EQS of 0.05 mg/L arsenic, while about 65.5% exceeded the WHO standard of 0.01 mg/L. In the Moulavibazar district more than 50 % (about 54.6 %) of the tubewells exceeded the Bangladesh EQS of which about 53.7 % exceeded the 0.100 mg/L level indicating a cause for concern in that district (Fig. 5). In the Sunamgonj district the condition appears to be worse with 74.1% of the tubewells exceeding the Bangladesh EQS; with only 9.3 % satisfying the limit set by the WHO (Fig. 6).

It should be noted, however, that compared to the other districts a smaller number of tubewells (75 and 55, respectively) were tested for arsenic in the Moulavibazar and the Sunamgonj districts. Thana-wise and depth-wise analysis of the samples tested from these three districts could not be performed due to lack of adequate data which warrants further sample collection and testing from these districts.

OVERALL PERSPECTIVE OF THE NORTH-EASTERN ZONE

Out of the total 1,210 tubewells from six districts (Kishoregonj, Netrokona, Hobigonj, Sylhet, Sunamgonj and Moulavibazar) in the north-eastern region, arsenic concentrations in 471 were found to be below 0.010 mg/L, 337 were found to be in the range of >0.010 to 0.050 mg/L, 230 were found to be in the range of >0.050 to 0.100 mg/L, and 172 were found to be above 0.100 mg/L. Thus, about 61.1% of the tubewells in the north-eastern zone of Bangladesh have arsenic concentration exceeding the WHO acceptable limit of 0.010 mg/L; while

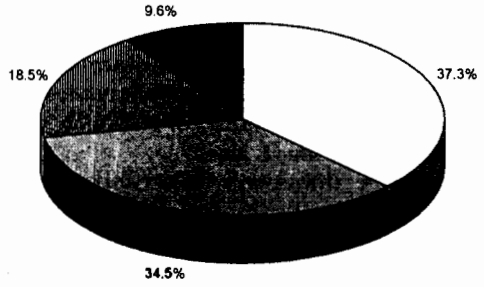

Fig 3a. Distribution of arsenic in tubewells of Hobigonj

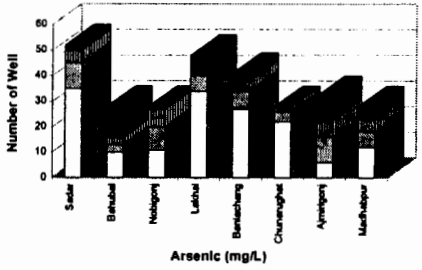

Fig 3b. Thana-wise distribution of arsenic in tubewells of Hobigonj

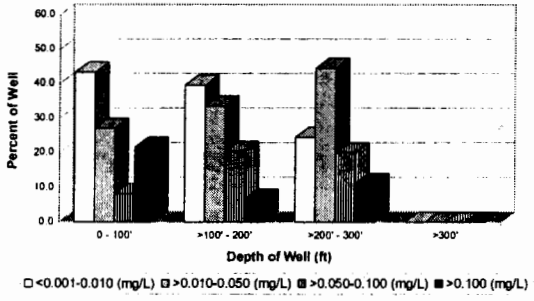

Fig 3c. Depth-wise distribution of arsenic in tubewells of Hobigonj

about 33.2 % of the tubewells in this region exceed the Bangladesh EQS for arsenic of 0.050 mg/L. About 14.2% of the tubewells contain arsenic over 0.100 mg/L posing a potential threat to human health. Fig. 7 represents the overall distribution of arsenic in groundwater of six districts of the north-eastern zone of Bangladesh.

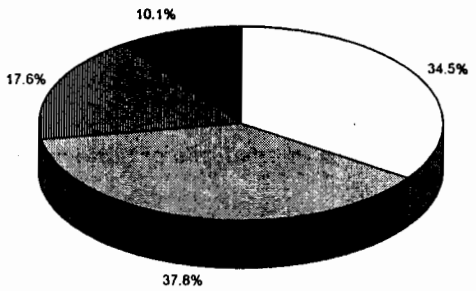

Fig 4. Distribution of arsenic in tubewells of Sylhet

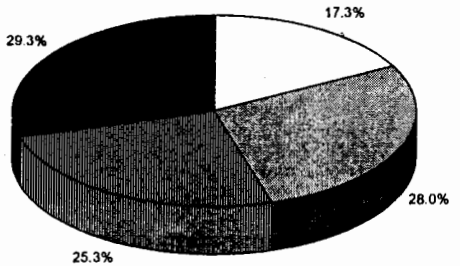

Fig 5. Distribution of arsenic in tubewells of Moulavibazar

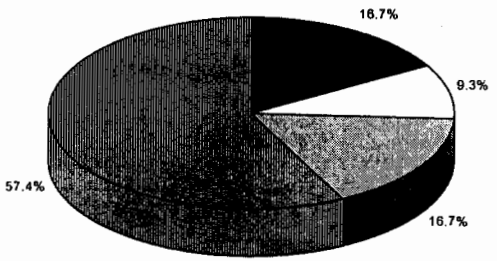

Fig 6. Distribution of arsenic in tubewells of Sunamgonj

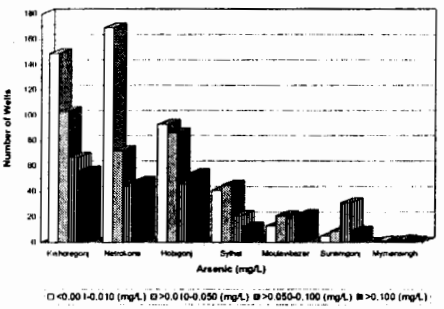

Fig 7. Overall distribution of arsenic in six districts of the N-E zone of Bangladesh

CONCLUSION

In this study, arsenic contamination of the north-eastern region of Bangladesh has been assessed based on analysis of 1,210 groundwater samples from six districts in that region. The districts are Kishoregonj, Netrokona, Sylhet, Moulavibazar, Sunamgonj and Hobigonj. It has been found that about 61.1% of the tubewells in the north-eastern region contain arsenic exceeding the acceptable limit set by the WHO (0.01mg/L) for drinking water and about 33.2% of the tubewells exceed the Bangladesh EQS (0.05 mg/L). Of the tubewells exceeding the

Bangladesh EQS about 42.8% contain arsenic over 0.100 mg/L posing a potential threat to human health. Among the six districts arsenic contamination in Sunamgonj appears to be the worst with 74.1% of the wells exceeding the Bangladesh EQS. In a thana-wise perspective the Karimgonj, Nikli, Itna and Kuliarchar thanas in Kishoregonj district appears to be the worst affected. Similarly, in Netrokona district Mohongonj, Khaliajuri and Madan thanas have the higher percentages of tubewells contaminated with arsenic. In Hobigonj district the Bahubal, Ajmirigonj and Madhabpur thanas have the larger shares of tubewells affected with arsenic. However, more tubewells need to be tested in all the six districts to identify the pattern of arsenic contamination, if any, in the north-eastern region of Bangladesh. Based on the experience of arsenic contamination of groundwater in West Bengal, India, it was initially thought that arsenic contamination of groundwater would be concentrated in the south-western and central regions of the country. However, as more data from other regions are becoming available, it appears that arsenic contamination in Bangladesh is much more widespread. This study clearly shows that the north-eastern region of the country is severely affected by arsenic contamination of groundwater. Similar systematic study is needed to ascertain arsenic contamination in other regions of the country.

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