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Ground Water Quality of Three Blocks of Bhojpur District: A Middle Gangatic Plain

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Abstract. This communication presents result of survey on groundwater quality of three blocks of Bhojpur district of Bihar. The three blocks selected for this study were Bihinya, Koelwar and Udwantnagar. Total 60 numbers of groundwater samples were collected from different locations of these blocks and analysed for the parameters pH, electrical conductivity (EC), total dissolved solid (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), fluoride (F^-), iron (Fe), sulphate (SO_4^{2-}) and arsenic (As). Water samples were collected from shallow hand pumps, deep hand pumps and public water supply.

Key words: Groundwater, contamination, quality, permissible limit, Bhojpur district

1. Introduction

Groundwater is an important source of water supply throughout the world[1]. For many rural and small communities, groundwater is the only source of drinking water. The geology of a particular area has a great influence on quality of water and its environment. Many a time ground water carries higher mineral contents than surface water, because there is slow circulation and longer period of contact with sediment materials in case of groundwater. Changes of groundwater quality with the passage of time have hydrologic significances. The quality also varies due to a change in chemical composition of the underlying sediments and aquifer[2,3]. The groundwater chemistry is controlled by the composition of its recharge components as well as by geological and hydrologic variations within the aquifer.

Water quality plays an important role in the overall water balance of the environment. Polluted groundwater is the cause for the speed of epidemics and chronic diseases in human beings. A large number of people has to die because of water borne diseases every year in our country. Bihar is of no exception. Very few parts of Bihar are having a proper water supply system. Mostly, the people are dependent on their own sources for getting water. There is lack of detailed information regarding the over-all quality of water sources of this region. The water of this region has the affinity to dissolve metals and therefore trace metal contamination is also expected. Acharya[4] et al. has reported that the groundwater of Utter Pradesh and Bihar has low concentration of iron (0-700µg/L) and on this basis, commented that the relatively low value of dissolved iron upstream of the Ganges Delta indicates that the environment may not be sufficiently reducing to mobilize iron and arsenic. Study by Chakraborty[5] et al. revealed moderate to high concentration of arsenic in Bihar in middle gangatic plain. Chakraborty[6] et al. also reported moderate to high concentration of arsenic in 2003 in Utter Pradesh. With this background, the present study was initiated to determine the concentration of contamination and the suitability of groundwater for drinking purpose.

2. Experimental Location

The area and population of Bhojpur situated in middle Gangatic plain are 2474 km^2 and 1.80 million (census 2001), respectively. The climate of the district is tropical monsoon but variations exist due to differences in altitude. The majority of the population depends on farming as its main occupation. Infant mortality is below 60 (per 1000) in the region. The administrative structure of Bhojpur consists of 14 blocks each having several Gram Panchayets (GP), which are the clusters of villages. To understand the severity of contamination and consequent health effects in West Bengal, we studied Bhojpur district and undertook a detail survey in these blocks.

Physical setting: The large-scale features of the Ganga plain correspond to major climate changes in the late Quaternary[7]. The geomorphic surfaces identified in the regional mapping of the Quaternary deposits of the Ganga plain are upland interfluves surface (T_2), marginal fan upland surface (MP), mega fan surface (MF), piedmont fan surface (PF), river valley terrace surface (T_1) and active flood plain surface (T_0). A significant aspect of these surfaces is that all of them are depositional surfaces, having a succession of overlying sediments. The Bihar Ganga plain (50–200m above the ASL, and

550–1000 km from the sea coast) shows prominent distinction between T_0, T_1 and T_2 surfaces. The Holocene aggradations, mostly due to rising base level and climate-driven sediment supply, are more pronounced here compared with U.P. plain. The Ganga plain foreland basin is a repository of sediments derived from the Himalayas and from Peninsular Craton. The weathered material brought from the Himalaya is deposited in the alluvial plain where they undergo further chemical weathering, mobilizing several anions and cations. In Ganga river sediments As, Cr, Cu, Pb, U, Th, W, etc. are concentrated significantly[7].

Materials and Methods: The physico-chemical analysis of groundwater samples collected from these blocks was carried out, according to the standard method APHA[8]. A total of 60 water samples were collected in pre-monsoon season. All the samples were collecting in poly propylene bottles. Before collecting the samples, bottles were thorough cleaned by 8MHNO_3, followed by repeated washing with deionized water. Adding 1:1 HNO_3 for analysis of arsenic and other heavy elements preserved 1 L of each of the collected water samples. The reagents used in the study were all analytical grade reagents and demonized water was used throughout for the reagent preparation. The pH of the water samples was determined in the field at the time of sample collection by using portable pH meter (Merck, India). Fluoride contents were determined by SPANDS method using spectrophotometer (Analytik-Jena, Specord – 40, Germany). Sulphate was determined by spectrophotometer method (Analytik – Jena, Specord-40, Germany). Total hardness (TH) of the samples was determined by titrimetric method. The analysis of magnesium and calcium were determined by the method of titration. The concentrations of heavy elements and arsenic in the water samples were determined by atomic absorption spectrometer (Perkin Elmer Analyst 200, USA).

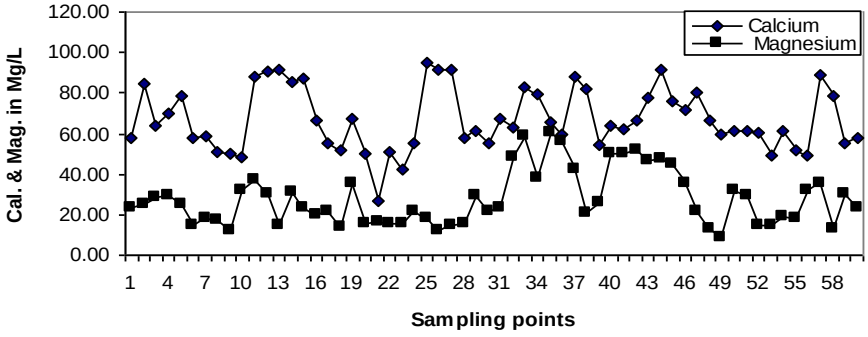

Figure 2. Variation of Ca & Mg content with different sampling points

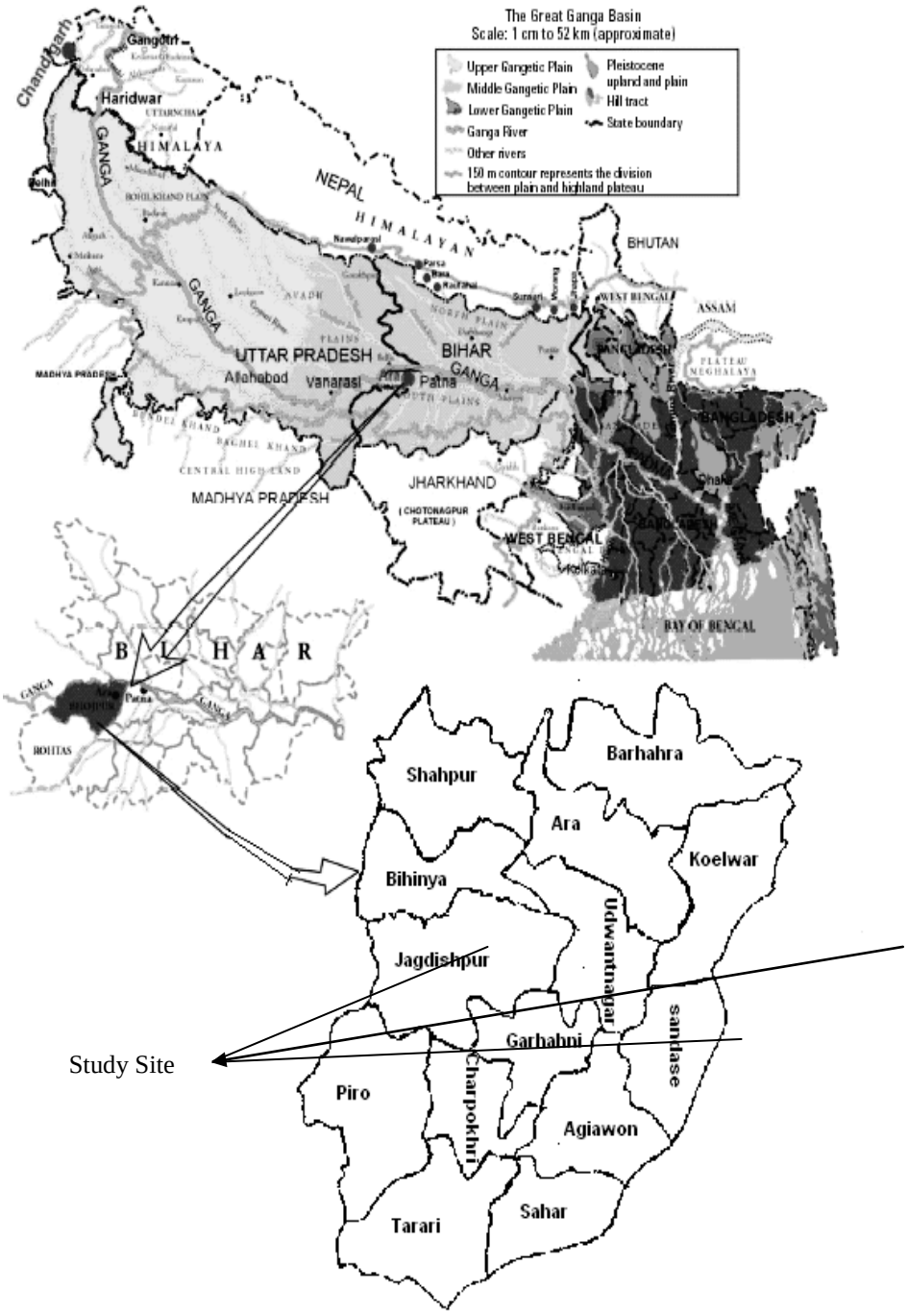

Figure1. Position of upper, middle and lower gangatic plains and location map of Bhojpur district

3. Results and Discussion

The result of pH, EC, TDS, TH, Ca^{2+} and Mg^{2+}, are presented in table 1 and arsenic and other heavy elements such as F^-, Fe, and SO_4^{2-} are presented in table 2**.**

Table 1. Results of different physico-chemical parameters**.**

Block	pH Min-Max	EC Min-Max	TDS Min-Max	TH Min-Max	Ca^+ Min- Max	Mg^+ Min-Max
Bihinya	7.1-7.9	0.60-0.85	270-557	214-322	42.3-91.5	12.5-60.8
Koelwar	6.9-8.1	0.55-0.87	311-597	250-330	27.1-91.7	14.9-48.6
Udwant-nagar	6.4-7.5	0.65-0.80	290-616	225-325	49.9-95.3	8.42-59.02

Table 2. : Results of arsenic and other heavy elements in Mg/L

Block	F^- Min-Max	Fe Min-Max	SO_4^- Min-Max	As Min-Max
Bihinya	0.07-0.51	0.11-1.11	0.38-12.3	0.001-0.059
Koelwar	0.11-0.8	0.18-0.65	0.34-6.15	0.004-0.073
Udwantnagar	0.11-1.05	0.19-0.91	3.0-22.3	0.001-0.072

Ph : The pH of 90% of the water samples analyzed were within the desirable limit of 6.5 – 8.5 given by WHO standard and most of the samples were slightly alkaline in nature. In this study pH of water samples from Bihinya, Koelwar and Udwantnagar blocks varied from 7.1 to 7.9, 6.9 to 8.1 and 6.4 to 7.5 respectively. The minimum value recorded was 6.4 in Udwantnagar block and maximum 8.1 in Koelwar block.

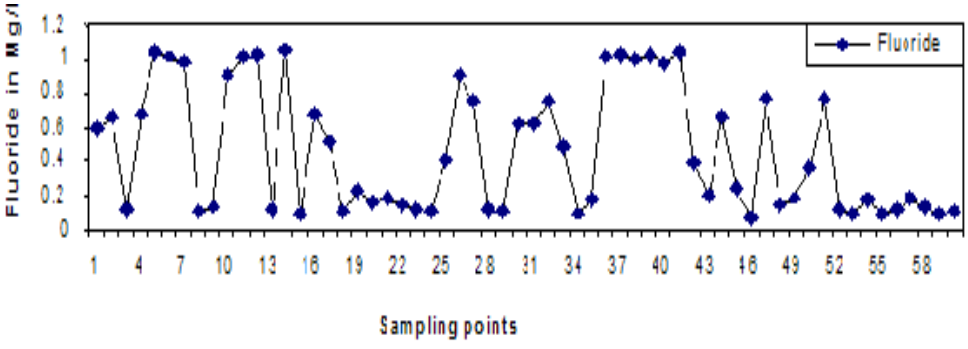

Figure 3 Variation of F content with different sampling points

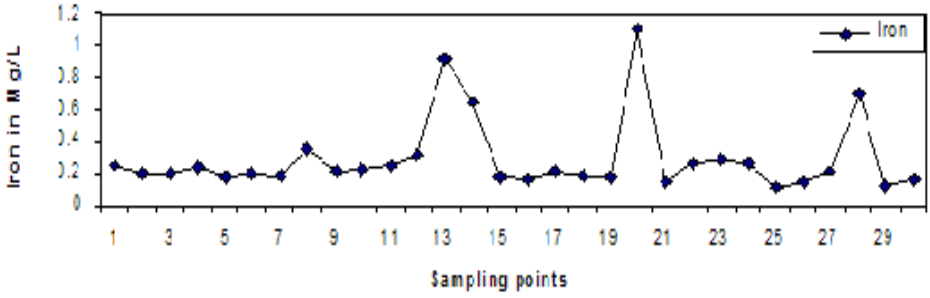

Figure 4. Variation of Fe content with different sampling points

Electrical conductivity and Total dissolved solid: The EC which is highly correlated with TDS is ranged from 0.55 to 0.87 mmho cm^{-1}. Indian standards for drinking water propose no standards for EC, however, the standard for T.D.S are proposed which are 500 to 2000 Mg/L. From table 1 it is seen that T.D.S of water samples from Bihiya, Koelwar, and Udwant-Nagar varies from 270 to 557, 311 to 597 and 290 to 616 Mg/L respectively. The minimum value recorded is 270 from Bihinya Block and the maximum value recorded is 616 Mg/L from Udwantnagar block.

Total Hardness: It is the measure of the capacity of water to precipitate soap. Though hardness is not harmful to health, it has been suspected to be plying some role in heart disease. In this study, total hardness of all samples found to be below the permissible limit 600 Mg/L for drinking water. From *table 1* it is seen that total hardness of water samples from Bihinya, Koelwar and Udwantnagar block varies from 214 to 322, 250 to 330 and 225 to 325 Mg/L respectively. The minimum and maximum values recorded were 214 and 330 Mg/L from Bihinya and Koelwar block respectively.

Calcium: In order of abundance it is the fifth element which is commonly present in all water bodies where it usually comes from the leaching of rocks. Calcium is very essential for nervous systems and for formation of bones. In this study calcium concentration of water samples from Bihinya, Koelwar and Udwantnagar block varied from 42.3 to 91.5, 27.1 to 91.7 and 49.9 to 95.3 Mg/L, respectively. The concentration of calcium in potable water ranges from 75 to 200 Mg/L. The maximum value recorded was 95.3 Mg/L in Udwantnagar block.

Magnesium: Magnesium tolerances by human body are lower than that of calcium. High concentration of magnesium in drinking water gives

unpleasant taste to the water. The concentration of magnesium in potable water ranges from 30-100 Mg/L. In this study magnesium concentration of water samples from Bihinya, Koelwar and Udwantnagar block varied from 12.5 to 60.8, 14.9 to 48.6 and 8.42 to 59.02 Mg/L, respectively. The minimum and maximum recorded values of magnesium was minimum 8.42 and maximum 60.8 Mg/L, in Udwantnagar and Koelwar block respectively. The variation of calcium and magnesium content with different sampling point are given in figure 2.

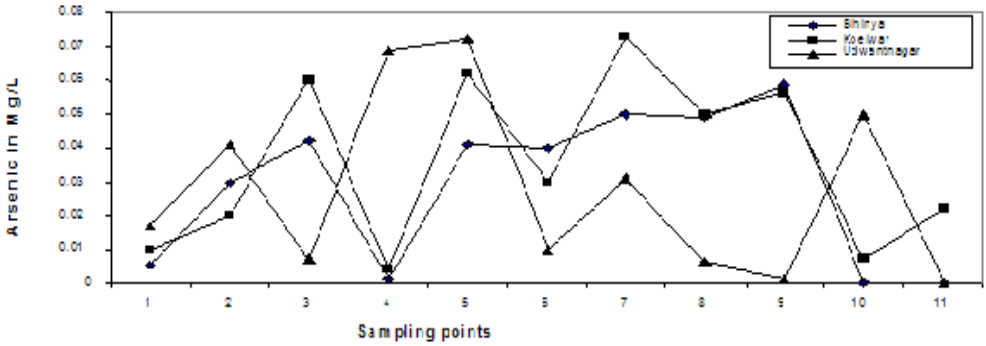

Figure 5. Variation of arsenic content with different sampling points from different blocks of Bhotpur

Fluoride: High concentration of fluoride in drinking water can cause an adverse effect on human beings. Continuous consumption of water having high fluoride content can cause diseases, like fluorosis, dental carries and bone diseases[9]. The concentration ranges observed in this study were 0.07 to 0.51, 0.11 to 0.8 and 0.11 to 1.05 Mg/L for Bihinya, Koelwar and Udwantnagar block, respectively. Maximum value recorded was 1.05 Mg/L in Udwantnagar block. The variation of fluoride content with different sampling points is shown in figure 3.

Iron: Iron is considered to be the most essential element to all organisms. It is present in hemoglobin and myoglobin systems. Presence of iron in water can cause staining laundry and porcelain. It gives stringent taste to water when water contains iron concentration above the permissible limit 1 Mg/L of drinking water. In this study iron concentration of water samples from Bihinya, Koelwar and Udwantnagar block varied from 0.11 to 1.11, 0.18 to 0.65 and 0.19 to 0.91 Mg/L respectively. The maximum concentration observed was 1.11 Mg/L in Bihinya block. The variation of iron content with different sampling points is presented in figure 4.

Sulphate: It is the common ion in water. Sulphate can produce bitter taste at high concentration. Sodium and magnesium sulphate exert a cathartic action in human beings. It is also associated with respiratory

diseases. The permissible limit and desirable limit of sulphate in drinking is 200 to 400 Mg/L, respectively. In this study minimum recorded value of sulphate were 0.34 Mg/L and maximum 22.3 Mg/L in Udwantnagar block. From table 2 it shows that sulphate content of the three blocks of Bhojpur district are all within the permissible limit of drinking water.

Arsenic: Water contaminated by arsenic is a burning problem affecting the whole world. Arsenic at high concentrations in water can cause skin lesion, cancers, vascular diseases, and hypertension and diabetes mellitus[10]. It is observed that drinking water with more than 300 µg/L arsenic for several years may cause arsenic skin lesions[11]. Ingestion of Inorganic As is an established cause of skin bladder and lung cancer[12, 13]. The results reveal that out of three blocks of Bhojpur district of Bihar, Koelwar block shows maximum (36.36%) groundwater contamination by arsenic followed by Udwantnagar block (20%). In Bihinya block only 11.11% ground water samples have been found to be arsenic contaminated. In this study an average of 22.49% water samples have arsenic concentration above the permissible limit of 0.05 Mg/L. The maximum value recorded was 0.073 Mg/L in Koelwar block.

Conclusions

Analysis of groundwater samples collected from these blocks shows that pH of 90 % water samples analyzed were within the desirable limit of 6.5-8.5 given by WHO standard and most of the samples were slightly alkaline in nature. Similarly TDS, TH, Ca^{+} and Mg^{+} concentration in the water samples are all within the permissible limit of drinking water. SO_4^{2-}, F^{-} and Fe content in the groundwater samples from these blocks are also found within thee permissible for drinking water. From the study it shows that groundwater of the region is contaminated by arsenic. The results reveal that out of three blocks of Bhojpur district of Bihar, Koelwar block shows maximum (36.36%) groundwater contamination by arsenic followed by Udwantnagar block (20%). In Bihinya Block only 11.11% ground water samples have been found to be arsenic contaminated. Analysis also shows that groundwater samples of shallow tube-wells of Bihinya block have high arsenic concentration compared to the deep tube-wells. But in Koelwar and Udwantnagar blocks, the groundwater samples have high arsenic concentration in deep tubewells as compared to shallow tube-wells. This may be due to geological composition of those areas and there further study is needed for the same. Though the groundwater of the three blocks has been contaminated by arsenic, no symptoms of arsenic poisoning are observed till

date. This is most probably due to the presence of As^{5+} in groundwater in high amount as compared to As^{3+}. But in near future, the problem of Arsenicosis may arise and, therefore, speciation of arsenic should be taken into consideration. Thus without prior analysis and removal of arsenic, ground water of those areas cannot be used for drinking purposes. So far no arrangement is made to tackle the mentioned problems. Rural population of this area is still consuming the water, which is detrimental to the health. Previous experiences of Bangladesh and West Bengal suggest that the arsenic problem tend to grow with passage of time. Hence a scientific measure to combat this problem is the demand of the hour.

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