International Journal of ChemTech Research
CODEN(USA): IJCRGG ISSN : 0974-4290
Vol. 3, No.1, pp 516-522, Jan-Mar 2011

Heavy Metal Contaminants of Underground Water in Indo Bangla Border Districts of Tripura, India

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Abstract: The present research work investigated seasonal variation of water quality of North and South Tripura viz. pre monsoon, monsoon and post monsoon periods. The physico-chemical parameters including pH, Sulphate, and heavy metals like Iron, Copper, Manganese, Mercury, Cadmium, Chromium, Zinc, Lead and Arsenic of water samples were analysed using standard procedure. In South Tripura, during monsoon period higher acidic and alkaline pH of water was observed as compared to North Tripura. Further, manganese concentration was higher (26.9%) as compared to North Tripura (18.55%) whereas iron contain was higher (14.67 ppm) in monsoon time as compared to South Tripura. Seasonal changes did not affect the iron contents in North and South Tripura. The present investigation also showed that arsenic level was beyond the limit as prescribed value of World Health Organization. Overall this study found that metallic contamination of underground water was as follows: Fe>Mn>As>Zn>Cd. Correlation analysis among the variable parameters showed that iron concentration was linearly increased with increasing concentration of manganese. In addition, correlation analysis also reflected that both iron and manganese decreased linearly with pH.
Key Words: water quality, ferruginous, potability of water, correlation.

INTRODUCTION:

Water is symbolic heritage of Indian continent in the nature of Ganga and Brahmaputra. Groundwater is main source for irrigation and industrial purposes. A variety of land and water based activities are causing pollution of water and over-exploitation is causing aquifer contamination in certain instance[1]. Therefore, for maintaining sound health of people, progress and prosperity, provision of safe drinking water is one of the basic necessities. Iron, manganese are generally found in greater amounts as dissolved ferrous Fe(II) and bivalent Mn(II) i.e. in the reducing condition in a great part of aquifer[2]. The existence of arsenic mainly favour in four major oxidation states, among which As(V) and As(III) species are predominant in natural aquatic environments[3]. Arsenic is found in both surface and subsurface, however, it is more abundant in ground water than in surface water [4].

Available literature reflects that arsenic concentration in groundwater affects major parts of Ganga delta down stream of Rajmahal hills in West Bengal, India and other low lying areas in Bangladesh[5-7]. High Arsenic contamination in groundwater of the North Eastern region has been reported[8]. Severe contamination of fluoride in groundwater of North Eastern region of India and its manifestation in the form of fluorosis also reported[9-10]. Further, literature shows that groundwater of Assam valleys are highly ferruginous[11]. Information of groundwater quality in the state of Tripura is scanty. Even though this is one of the most important states in the North Eastern region but the lack of potable water possess a threat to service as well as civil population. Geographically, Tripura is situated between the bordering areas of West Bengal and Bangladesh. Therefore probable chance of arsenic along with iron concentration of an alluvial aquifer of this state can not be ruled out. Recognizing the enormity and severity of the problem, groundwater quality survey of North and South Tripura was conducted in various seasons to identify the suitability or otherwise of groundwater quality for drinking purposes. The water quality of Tripura is not reported so far, therefore, the present investigation is undertaken.

MATERIALS AND METHODS:

Water sampling was done from both dug wells and tube wells where depths vary from 30-350 feet in different seasons during the year July and September, 2007 and August, 2008. A total of 173 water samples were collected from both the North and South districts of Tripura. Tube wells were operated at least 5 minutes before collection to flash out the stagnant water inside the tube and to get fresh groundwater. The water samples were collected in Polyvinyl chloride container and preserved with 6(N) HNO_3 solution to pH < 2, (10 ml/L sample) for estimation of arsenic and others heavy metals such as iron, copper, manganese, cadmium, chromium, mercury and zinc. pH was determined in the field at the time of sample collection using calibrated portable pH meter (Eutech Instruments) and Sulphate anion content was determined by using UV-Vis Spectrophotometer (Specord-40, Analytik Jena). The heavy metals viz. iron, copper, manganese, zinc, mercury, cadmium, chromium and arsenic were measured using Atomic Absorption Spectrophotometer (Perkin Elmer AAnalyst 200).

Arsenic was quantified by AAS. Assuming As(V) may be present in the water samples along with As(III), reduction of As(V) to As(III) was performed with potassium iodide solution and ascorbic acid in moderately concentrated (5 mol/L) HCL solution. Time for reduction was 30 minutes. 10 ml of reduced water samples were analysed using Atomic Absorption Spectrophotometer with MHS-15 (Mercury Hydride Generation System).

The selected data were subjected to statistical analysis to test the Multiple Analysis of Variance (MANOVA) and correlation among the parameters.

The state of Tripura is located between 22.5^0N-24.32^0N latitude and 90^0E-92.22^0E longitude. Average annual rainfall in the state is about 2000 mm and the temperature varies between a maximum of $35.2C^0$ and a minimum of $7.4\ C^0$ [12]. Tripura is a hilly state and well developed water distribution system is almost nil in this state. Main water sources of Tripura are tube wells, dug well, Kuccha well and river etc.

RESULTS AND DISCUSSION:

The results of physico-chemical parameters and heavy metals of water sample of North and South Tripura are summarized in Table 1. For convenience in description, water sample are categorized as pre monsoon, monsoon and post monsoon periods.

The pH of water samples in North and South Tripura ranges from 5.4 - 9.0 and 4.9 - 7.4 respectively in Monsoon Period. In North Tripura, pH of water samples ranges 5.8 - 9.5 and 5.7 - 9.3 in Post and Pre Monsoon period respectively. In case of South Tripura, pH ranges 5.5 - 9.5 and 5.6 - 8.4 in Post and Pre Monsoon period respectively. The pH of water of South Tripura was found to be more acidic during Monsoon Period. Overall observation reveals that 62.3% and 63.1% water samples in North and South Tripura are not fit for consumption as far as pH is concerned. Throughout the three seasons, comparable higher pH was observed than the permissible limit of World Health Organization (WHO) in North and South Tripura [13].

Seasonal Variation of iron, manganese and arsenic:

The concentration of iron in water of North Tripura during Monsoon period ranges from 0.004-3.78 ppm as reflected in Table-1. The variations of iron during Pre Monsoon period is 0.008 - 1.37 ppm. During Post monsoon Period the content of iron varies from Tr - 14.67 ppm. During Monsoon Period iron contents in water of South Tripura varies from Tr - 1.86 ppm and during Pre and Post Monsoon period iron concentration are Tr - 7.35 ppm and 0.03 - 12.5 ppm respectively.

Figure 1 denotes the graphical representation of seasonal variation of iron concentration in water samples of North and South Tripura. The figure reflects the presence of high concentration of iron (14.67 ppm) in Post Monsoon season. The high concentration of iron in this season indicates that Fe in +2 states remains more in aquifers comparing to that state compact with the soil texture itself [14].

The concentration of manganese in South Tripura ranges from Tr - 1.05 ppm and Tr - 0.13 ppm respectively during Pre and Post monsoon Period. In Monsoon Period, manganese concentration varies Tr - 0.96 ppm and Tr - 2.68 ppm respectively in North and South Tripura The concentration of manganese in North Tripura ranges from 0.008-1.37 ppm and Tr-1.74 ppm respectively during Pre and Post monsoon Period. The common coexistence between iron and manganese is also reported. However, where this occurs, the concentration of iron is generally found greater because iron has greater crustal abundance [15].

Table-1: Analysis of physico-chemical parameters (pH & sulphate) and heavy metals of water samples with respect to seasonal variations

Parameter	WHO/BIS limit (ppm) (Min-max)	Pre monsoon period		Monsoon period		Post monsoon period	
		North Tripura (ppm) (Min-max)	South Tripura (ppm) (Min-max)	North Tripura (ppm) (Min-max)	South Tripura (ppm) (Min-max)	North Tripura (ppm) (Min-max)	South Tripura (ppm) (Min-max)
pH	6.5 – 8.5	5.7 - 9.3	5.6 - 8.4	5.4 - 9.0	4.9 - 7.4	5.8-9.5	5.5 – 9.5
Sulphate	200 – 400	2.66 - 58.53	3.42- 49.88	9.39 - 27.38	9.98 - 130	Tr* -17.53	Tr-32.18
Iron	0.3 – 1.0	Tr -3.63	Tr - 7.35	0.004 - 3.78	Tr - 1.86	Tr-14.67	0.03-12.5
Copper	0.05 – 1.5	Tr - 0.107	Tr - 0.078	Tr - 0.015	0.002 - 0.097	Tr-2.525	Tr-0.091
Manganese	0.1 – 0.3	0.008 - 1.37	Tr - 1.05	Tr - 0.96	Tr - 2.68	Tr-1.74	Tr-0.13
Arsenic	0.01 – No relaxation	Tr -0.016	Tr - 0.009	Tr - 0.002	Tr - 0.025	Tr-0.011	Tr-0.004
Zinc	5 – 15	0.015 - 0.235	Tr	Tr - 1.67	Tr - 2.47	0.009-2.296	0.011- 1.97
Mercury	0.001- No relaxation	Tr	Tr	Tr	Tr	Tr	Tr
Cadmium	0.01 - No relaxation	0.002 - 0.003	0.0026 - 0.0034	0.001 - 0.006	Tr - 0.004	0.005-0.014	0.004-0.008
Chromium	0.05 - No relaxation	Tr	Tr	Tr	Tr	Tr	Tr
Lead	0.05 - No relaxation	Tr	Tr	Tr	Tr	Tr	Tr

*Tr: Traces

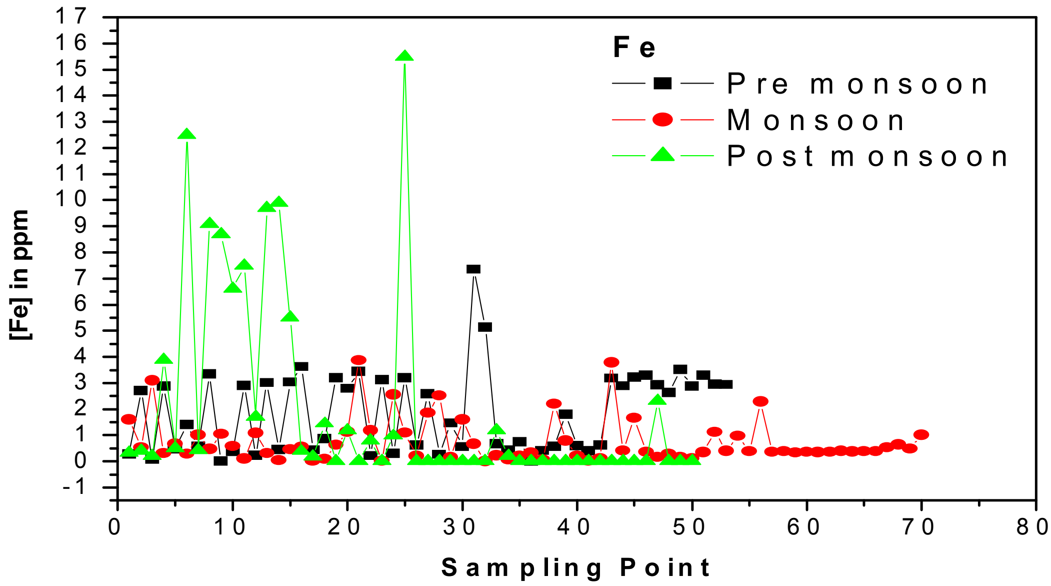

Figure 1: Time course change in concentration of iron with sampling points.

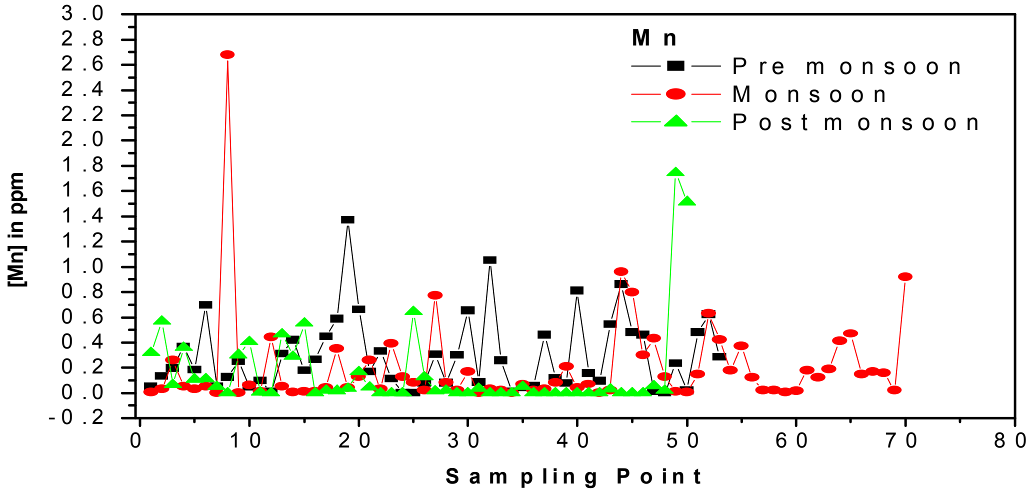

Figure 2: Time course change in concentration of manganese with sampling points

Figure 2 reflects the maximum concentration of manganese (2.68 ppm) in Monsoon period. With respect to arsenic concentration of groundwater it is observed from Table-1 that concentration of arsenic in North Tripura during Pre and Post Monsoon Period were 0.016 ppm and 0.011 ppm respectively, which are beyond the desirable limit of BIS/WHO standard. An interesting result also reflected in Table-1 is about arsenic concentration in Monsoon Period. In this season, arsenic concentration of groundwater in South Tripura was found to be 0.025 ppm, which is beyond the desirable limit of WHO standard as in Figure 3. Particularly concentration of manganese and iron in this season also exceeds their permissible limit.

This overall picture reveals that 23.2% and 53.65% water samples in North and South Tripura respectively were having iron concentration beyond the permissible limit. In case of manganese it is observed that 20.3% and 28.65% water samples in North and South Tripura respectively are not fit for consumption as per WHO limit. Further, in case of arsenic concentration (6.35%) exceeds the potability of water in South Tripura.

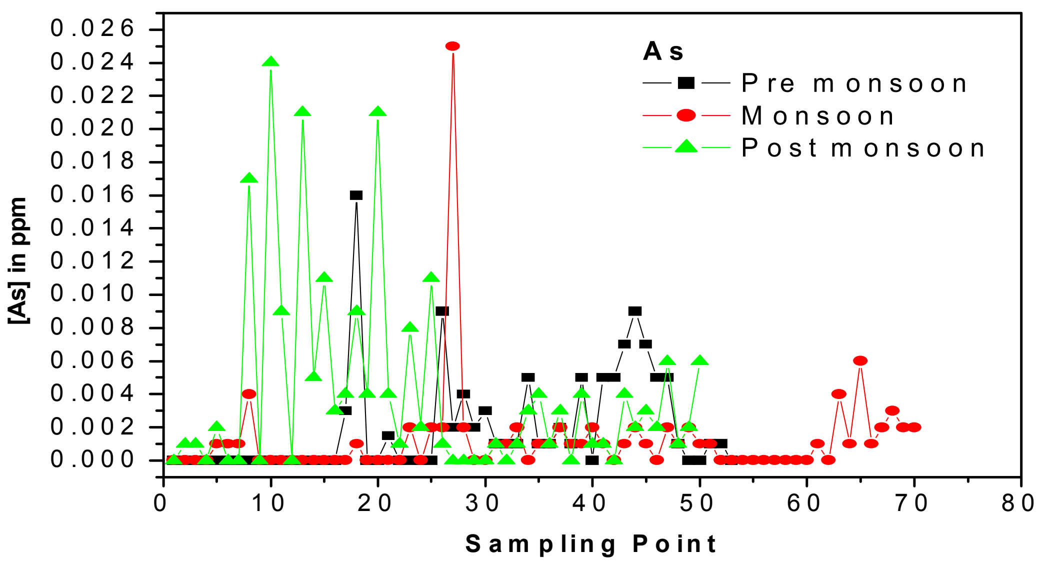

Figure 3: Time course change in concentration of arsenic with sampling points.

Table: 2: Correlation matrix

	pH	Fe	Mn	As	SO_4
pH	1				
Fe	-0.175	1			
Mn	-0.051	0.147	1		
As	0.022	0.355	0.177	1	
SO_4	0.114	-0.082	0.0328	-0.067	1

Table-3: Overall Percentage of water with respect to potability

Parameters	% of water samples conforming the BIS limits	
	North Tripura	South Tripura
pH	35.6	34.8
Iron	77.8	48.5
Manganese	81.45	73.1
Arsenic	97.55	93.65

Correlation between pH and other substances (viz. iron, arsenic, manganese and sulphate):

Correlation matrix was calculated in order to find out the relationship between pH with iron and manganese, iron with manganese and arsenic with sulphate respectively. Table: 2 summarized all the results. pH shows significant correlation with Iron ($P < 0.01$)) and manganese ($P < 0.05$). The regression values of pH with iron and manganese are (-) 0.175 and (-) 0.051 respectively. This statistical analysis indicates that at comparable lower pH of water (acidic in nature) manganese remain mobilized in aquifer along with iron; both the ions favour +2 states in this condition.[16] Manganese also shows positive correlation with iron with regression value of 0.147. It indicates that mostly under anaerobic conditions manganese is preferably reduced from its ore itself to more soluble +2 state along with iron[17], which also favours +2 state in soluble condition. In order to visualize the relationship of arsenic, sulphate, manganese, the matrix scatter plots was drawn as shown in Figure 4. The positive correlation between arsenic with manganese and arsenic with iron was observed. Their correlation values are 0.177 and 0.355 respectively. Higher arsenic concentration along with the concentration of manganese and iron in groundwater may be supported by the fact that iron-rich groundwater is also caused due to activities of iron-reducing bacteria, which preferentially reduces least crystalline Fe-Mn-oxyhydroxide phases. The latter have great capacity specifically for adsorbing or co-precipitating arsenic and other trace elements, which are released to the groundwater on their reductive dissolution and oxidation of co-deposited organic matter[18-19].

The relationship between sulphate ion with arsenic, iron and manganese is clearly portrayed in the 5th column of Figure 4. It is apparent from Figure 4. that sulphate ion partially show inverse proportion to arsenic. This tendency also supports that arsenic contamination in ground water mainly occurs under reductive condition[20-21]. The overall percentage of potability of water with respect to physicochemical parameters is given in Table 3.

CONCLUSION:

The reflections from the over all survey which was carried out in the State of Tripura in different seasons revealed that the water quality of Tripura is questionable particularly in respect to pH, iron and manganese. Overall studies mostly indicate high contamination of iron and manganese in the groundwater of Tripura. In so far as non-potability of water in North and South Tripura is concerned, South Tripura was found having high contamination of water with respect to iron (51.5 %), manganese (26.9 %) and arsenic (6.35 %). A good correlation has been obtained between iron and manganese. Iron and manganese also showed good correlation with pH. The correlation study provides an idea of inherent interaction among influence of different metals, which are responsible for contamination of water. The correlation study is also the pioneer step to asses the water quality of any region, keeping in view the usual high concentration of iron and manganese in North and South Tripura followed by slightly higher concentration of arsenic also in some parts of this region, it is mandatory to test the potability of groundwater before using it for drinking/ cooking purpose.

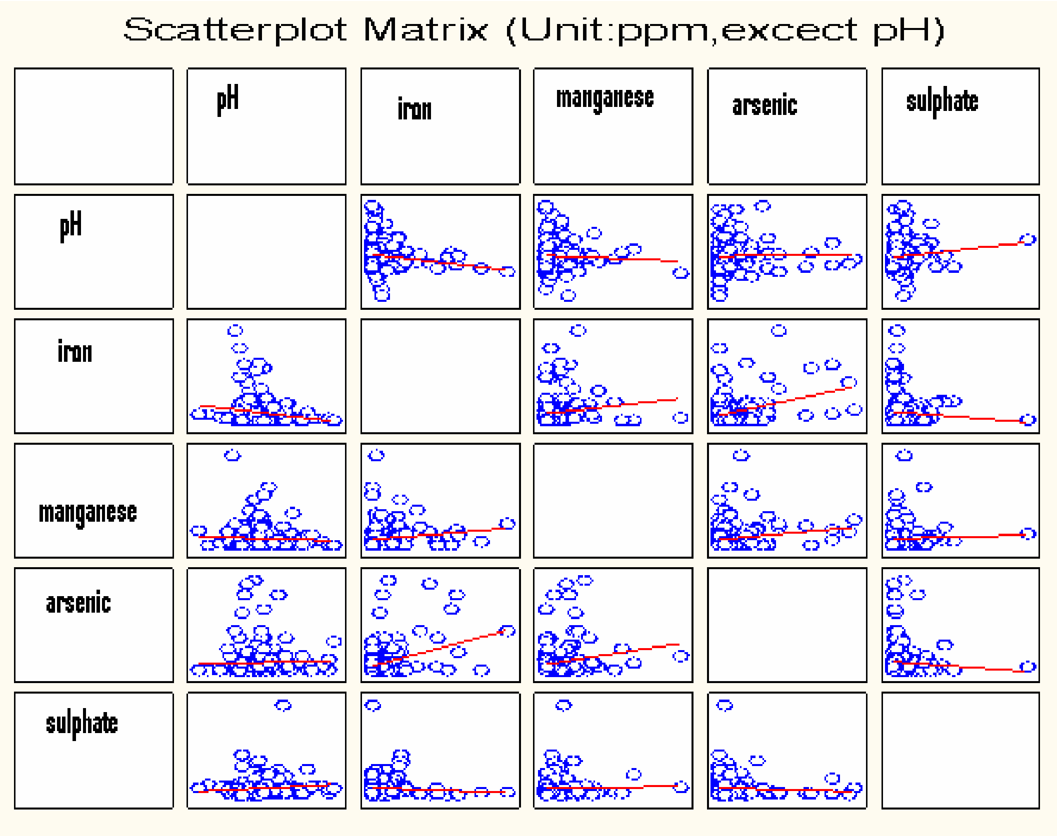

Figure- 4: Scatter plot Matrix (Unit: ppm, except pH)

Acknowledgement:

The authors are thankful to Head Quarter, Defence Research & Development Organization, Ministry of Defence, New Delhi for providing necessary financial assistance to carry out the research work in Tripura. The authors are also grateful to the Government of Tripura for providing logistic support.

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