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Research Article

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Arsenic contamination in ground water is a serious threat in the North Karimganj block of Karimganj district, Southern part of Assam, India

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ABSTRACT

Arsenic contamination in ground water resource has become a serious worldwide problem. In India there are many such contamination cases reported in different parts of the country. Assam is one of such states in India which is under the threat of ground water arsenic contamination and many cases have been reported in its several districts. On this backdrop, the present study was carried out to assess the scenario of ground water quality of the North Karimganj Block of Southern Assam by collecting and analyzing 195 ground water samples during April-June, 2014 for As and Fe. The analytical report showed that, Sadarashi GP is the highest arsenic contaminated Gaon Panchayat compared to other three Gayon Panchayats in North Karimganj block of Karimganj district, Assam. It has also been noticed that, the Iron concentration in the 32 arsenic contaminated water samples are well above the permissible limit (0.3mg/l) prescribed by WHO. The results of our study indicated that the average concentration of arsenic in tube well water in contaminated villages ranged from (10.1 to 93.05) and that of Iron ranges from (2.404 to 45.34). Comparison of collected samples for both arsenic and iron with non-contaminated water shows p-value (<.01).

Key words: Arsenic contamination, ground water quality, health hazard, Karimganj, South Assam.

INTRODUCTION

Arsenic contamination in ground water is nowadays a worldwide problem. Contamination of ground water with arsenic and its impact on human health has been reported from 23 countries. In Bangladesh [1-7] and West Bengal, [5-11] this problem is severe. From other Asiatic countries including China, the Lao People's Democratic Republic, Cambodia, Myanmar and Pakistan, severe groundwater arsenic contamination has also been reported [12]. As the source of arsenic is the Himalaya Mountain and the Tibet Plateau, the flood plains of all the rivers that originated from these sources are expected to be arsenic contaminated [13]. From the reports of groundwater arsenic contamination study in the Ganga plain for the last 21 years, it was noticed that the overall groundwater arsenic concentration increases from the upper plain to the middle and to the lower plain. In January 2004, the arsenic contamination in the groundwater of the upper Brahmaputra plain in Assam has been detected [14].School of Environmental studies, Jadavpur University, Kolkata analyzed 241 hand pump water samples from Dhemaji and Karimganj districts of Assam and got 42.3% of the samples contained arsenic above 10 µg/l and 19.1% above 50 µg/l. Ground water arsenic contamination in 2 districts namely Thoubal, and Imphal of Manipur was detected in the year 2006. It was reported that out of 584 water samples from Thoubal and Imphal, 41.27% had arsenic

concentration above 50µg/l and 64.72% samples having arsenic level higher than10 µg/l. In this backdrop we have collected 195 ground water samples from North Karimganj Block of Karimganj District, Assam during the month of April-June, 2014 and the concentration of Arsenic in the collected water samples and the concentration of Iron in the arsenic contaminated water samples were estimated.

1.2 About Study Site

Karimganj district occupies an area of 1,809 square kilometers (698 sq mi), It is bounded on the northeast by Cachar District, on the east by Hailakandi District, on the south by Mizoram state, on the southwest by Tripura state, and on the west and northwest by Bangladesh. Karimganj town is located on the northern fringe of the district adjoining Bangladesh, by the river Kushiara. The Kushiyara River is one of the many rivers in Bangladesh that crosses international boundaries. It is a branch of the Barak River, which originates in the state of Manipur in India and runs along the border of the Indian states of Manipur and Mizoram before getting split into Surma and Kushiara prior to entering Bangladesh. Flanked on two sides by the rivers kushiara and Longai, Karimganj town is located just on the Bangladesh border with the river Kushiara flowing in between. We have collected water samples from North Karimganj Block of Karimganj District in order to access arsenic concentration in ground water. Out of the 12 G.P.s, we have selected 4 G.P.s namely Sadarashi, Akbarpur, North Karimganj and Purahuria as our experimental sites because in these four Gaon Panchayats we have found greater numbers of different kinds of cancer patients compared to the other G.Ps. The officials of Public health engineering department (PHE) of Karimganj district collected only 53 samples from North Karimganj Block and they got 8 Arsenic contaminated samples. Sadarshi and North Karimganj G.P.s are situated on the bank of river Kushiara shown in Figure 1 and 2 respectively.

EXPERIMENTAL SECTION

2.1 Sample collection and analysis The depth of all hand tube wells were in the range 100-120ft and water samples were collected in pre-washed(with 1:1 HNO_3) polyethylene bottles after pumping off at least 15-20 times. After collection, concentrated HNO_3 (1 drop per 10 ml) was added as preservative. The water samples were then analyzed by flow injection hydride generation atomic absorption spectrometry (FI-HG-AAS) [15]. A Perkin-Elmer Model 3100 atomic absorption spectrometer equipped with a Hewlett-Packard Vectra Computer with GEM software, Perkin-Elmer EDL system-2, arsenic lamp (lamp current 400 mA) and Varian AAS Model Spectra AA-20 with hollow cathode arsenic lamp (lamp current 10 mA) were used. The total concentration of Arsenic in the water (As (III) +As (V)) was measured after Potassium bromate oxidation. The accuracy of our analytical method using FI-HG-AAS was verified by analyzing standard reference materials Water SRM (quality control sample for trace metal analysis) from the US Environmental Protection Agency. Concentration of Iron was estimated with the help of Shimatzu UV-VIS spectrophotometer at department of environmental science Jadavpur University Kolkata, India.

2.2 Statistical Analysis

For the collected sample statistical analysis such as regression t-test, correlation, ANOVA (analysis of covariance) were applied to brief our findings. For the purpose of analysis R.3.2.1 software and MS excel 2007 have been used. Linear regression models were used to find whether the Iron content is a cause due to the Arsenic availability in water samples. Linear regression models are basically used to find, how much proportion of the dependent variable could be explained by independent variable. In this study if we consider Arsenic samples as independent variable then from the results of linear regression we may conclude that the Iron content in the sample in controlled by a certain percentage due to the presence of Arsenic.

Suppose $(\mathrm{Y}_{n\times1}, \mathrm{X}_{n\times1})$ be a data matrix, where the suffix denotes the size of data set. Then the linear regression model between Y and X is

$$Y_i = a + bX_i + \varepsilon_i \quad (1)$$

Where, 'b' is the regression coefficient and 'a' is the intercept and ε_i's are the error terms follows Gaussian distribution with zero mean and constant standard deviation.

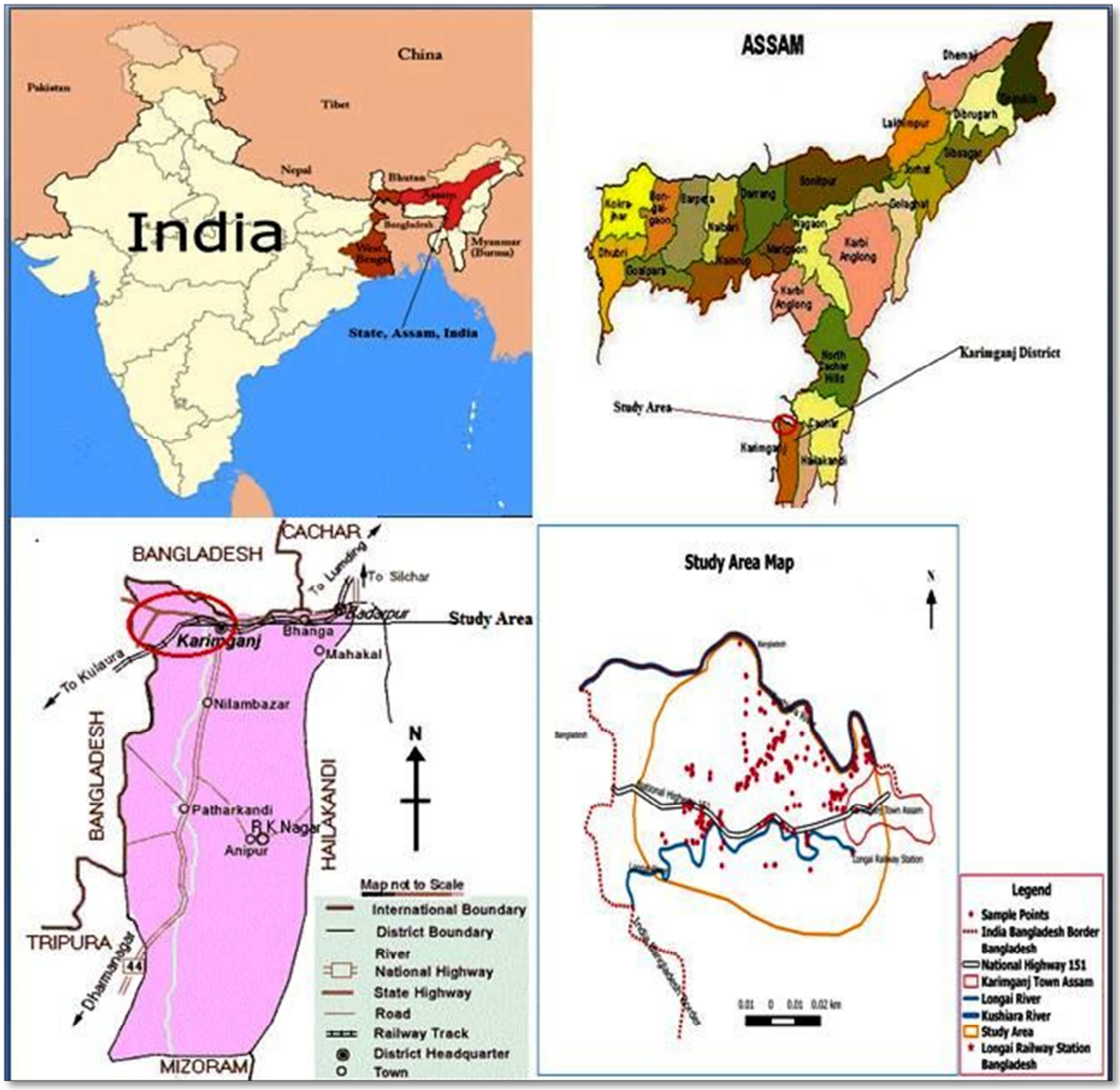


Fig1: Study Area showing in state of Assam and in India

Coefficient of determination or Multiple R^2 are used to measure the level of dependency of dependent variable (Y) over independent variable (X)

Where,

$$\left.\begin{aligned} &= \frac{SS_{reg}}{SS_{tot}} \\ R^2 &= \frac{SS_{tot} - SS_{res}}{SS_{tot}} \\ &= 1 - \frac{SS_{res}}{SS_{tot}} \end{aligned}\right\} \quad (2)$$

$$SS_{Tot} = SS_{reg} + SS_{res} \tag{3}$$

$$\left.\begin{aligned} SS_{tot} &= \sum_{i=1}^{n}(y_i - \bar{y})^2 \\ SS_{reg} &= \sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2 \\ SS_{res} &= \sum_{i=1}^{n}(y_i - \hat{y}_i)^2 \end{aligned}\right\} \tag{4}$$

$\bar{y} = \frac{1}{n}\sum_{i}^{n} y_i$ is the mean and $\hat{y}_i$ are the estimated values of Y.

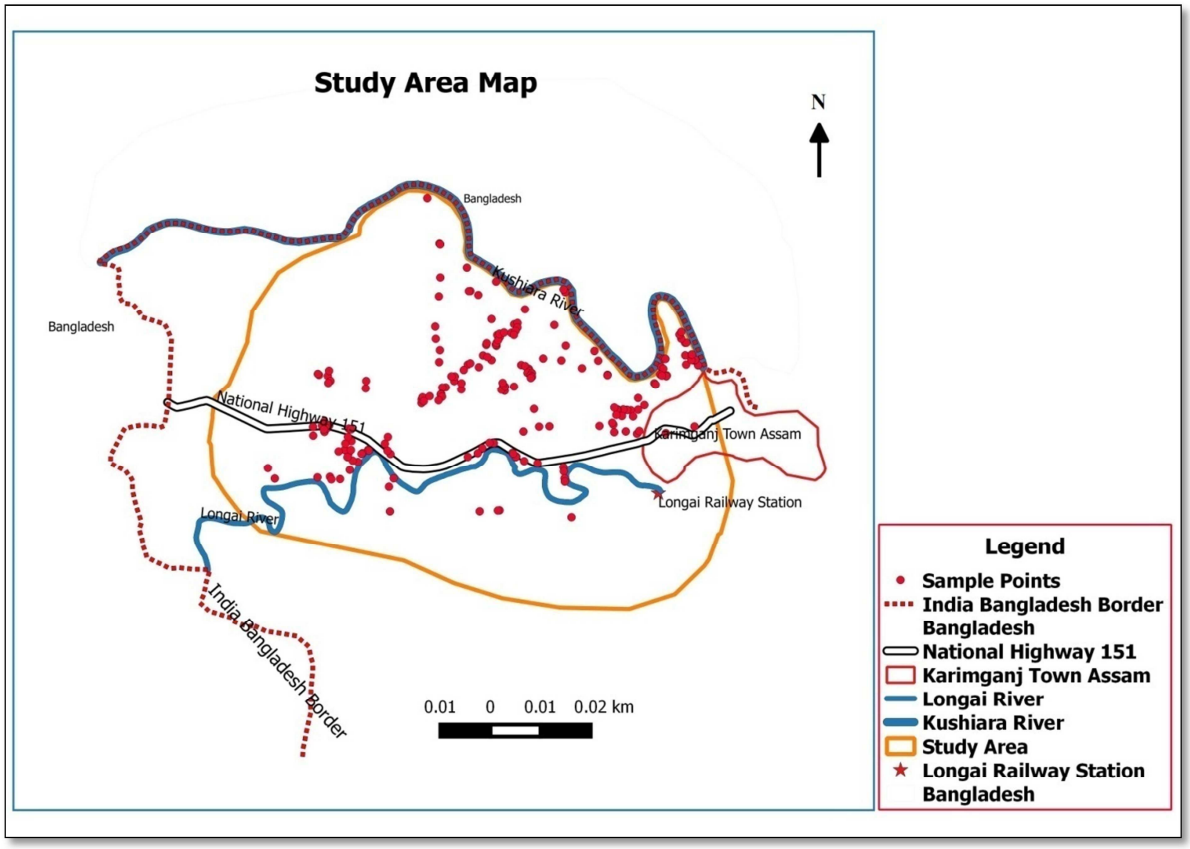


Fig 2: Map showing of significant sample points of study

RESULTS AND DISCUSSION

Arsenic contamination in ground water: From the present study of North Karimganj Block of Karimganj district it is obvious the magnitude of arsenic concentration exceeded the limit prescribed by WHO which is (10µg/l). All the four Gaon Panchayats selected for the experimental study are not equally contaminated. Detail of the analytical results was shown in the Table1.Where from North Karimganj G.P a total of 46 samples have been collected. It is observed that 3(7%) arsenic contaminated samples are in the range of 10-30µg/l and the remaining 43 (93%) water samples contain arsenic concentration below 3µg/l i.e. samples are not contaminated. In Sadarashi G.P. 8% of the total (73) samples contain arsenic in the range 10-30µg/l. 3% and 12% of the total samples contain Arsenic in the

range 31-50µg/l and >50µg/l respectively and the rest 72% of the total samples are free of arsenic contamination. We have collected 30 water samples from Akbarpur Gaon Panchayat and 46 from Purahuria, Gaon Panchayat.

Table 1- Concentration of Arsenic (ppb) in ground water samples collected from 195 hand pumps of North Karimganj Block of Karimganj District, Assam

Name of the GP	Name of the Sample	Concentration (ppb)	Name of the GP	Name of the Sample	Concentration (ppb)
Akbarpur	AP-2	51.24	Sadarashi	SD-15	80
Akbarpur	AP-12	66	Sadarashi	SD-16	42.86
Akbarpur	AP-13	20.74	Sadarashi	SD-17	25.85
Akbarpur	AP-24	12.86	Sadarashi	SD-24A	70.29
Akbarpur	AP-26	12.22	Sadarashi	SD-24B	79.75
North Karimganj	NK-14	28.61	Sadarashi	SD-27	45.41
North Karimganj	NK-15	16.46	Sadarashi	SD-28	75.32
North Karimganj	NK-46	21.6	Sadarashi	SD-30	62.03
Purahuria	PH-10	20.76	Sadarashi	SD-32	53.14
Purahuria	PH-28	10.1	Sadarashi	SD-34	66.46
Purahuria	PH-33	71.14	Sadarashi	SD-41	21.23
Purahuria	PH-43	12.46	Sadarashi	SD-42	27.69
Sadarashi	SD-5	18.4	Sadarashi	SD-43	12.18
Sadarashi	SD-7	56.25	Sadarashi	SD-46	27.5
Sadarashi	SD-12	93.05	Sadarashi	SD-49	61.85
Sadarashi	SD-13	43.2	Sadarashi	SD-72	60.86
Sadarashi	SD-14	62.5			

In Akbarpur G.P we got 7% of the total water samples contains Arsenic above 50µg/l, 10% in the range 10-30µg/l and the remaining 83% have the arsenic < 3µg/l. Out of the 46 samples collected from Purahuria G.P, only 2% of the total samples contain arsenic in the range 51-100µg/l ,7% have arsenic 10-30µg/l and the remaining 91% water samples are free of arsenic contamination i.e. below 3µg/l. Analytical data reflects that out of the four Gaon Panchayats of North Karimganj block, Sadarashi G.P. is highly arsenic contaminated and North karimganj G.P. is least so. From the Table1 it is clear that in a few samples the concentration of arsenic is as high as 8 to 9 times the limit of (10µg/l). Sadarashi G.P. is situated on the bank of the river Kushiara and Kushiara originates from the hill of Manipur, a state in the North Eastern region of India and this river is flowing in between Karimganj Town and Bangladesh (Fig.2). It was already reported that ground water of Manipur and Bangladesh is severely Arsenic contaminated and this is the main reason of the Arsenic contamination of ground water in Karimganj District. According to the census report 2011, the total population of sadarashi G.P. is ~ 10,000. The main source of drinking water of people of Sadarashi G.P. is hand tube well. Although after the declaration of Arsenic contamination in Karimganj District during 2008, the Government of Assam commissioned water supply plant in different villages including Sadarashi[16], but during our survey we have collected information from the villagers that the water supply plant of The Sadarashi G.P is now totally inactive due to the lack of proper maintenance. Many water samples have been collected from Schools, Mosques and Temples of these four G.P.s. Some of these samples also contain very high concentration of arsenic. Use of such water will affect the health of the villagers, mainly the younger generation in long term. But during our survey work no such patient suffering from arsenical diseases have been found.

3.1 Presence of Iron in ground water Out of 195 hand tube well samples from North Karimganj Block of Karimganj District, 32 samples which contained Arsenic above 10 ppb have been analysed for iron. Concentrations of iron estimated in the arsenic contaminated samples are presented in the (table 2). The mean concentration was found to be 14.6 mg/l (range = 2.4-45.3 mg/l), very higher than the WHO recommended maximum value of 0.3 mg/l. Statistical parameters were calculated and given in the table 3. This finding is just opposite to the findings from a study of arsenic in borehole sediments, which found a positive correlation [17].

Statistical Analysis

From the collected 195 samples, only those samples were used in the analysis which is arsenic contaminated. The study is divided in parts, the average Arsenic and Iron content in the water samples along with the other measures are listed in table.3. Analysis was carried out for the whole sample as well as in parts (belonging to each sub parts considered in study). A scatter plot between Arsenic and Iron data of the whole sample is in plot.1.

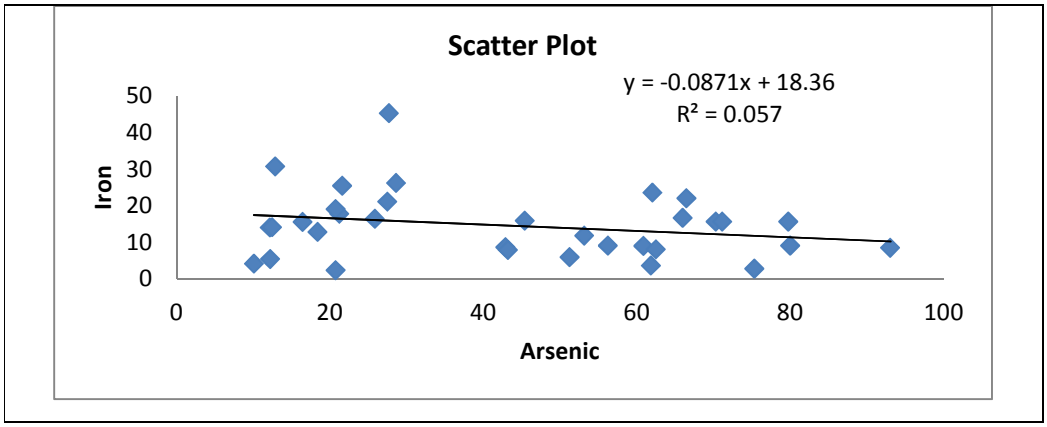
Table 2- Concentration of iron (mg/l) in Arsenic contaminated ground water samples collected from North Karimganj Block of Karimganj district, Assam

Name of the GP	Name of the Sample	Concentration Of Iron mg/l	Name of the GP	Name of the sample	Concentration Of Iron mg/l
North Karimganj	NK-14	26.27	Sadarashi	SD-34	22.09
North Karimganj	NK-15	15.58	Sadarashi	SD-41	17.83
North Karimganj	NK-46	25.48	Sadarashi	SD-42	45.34
Sadarashi	SD-5	12.86	Sadarashi	SD-43	14.04
Sadarashi	SD-7	9.12	Sadarashi	SD-46	21.17
Sadarashi	SD-12	8.56	Sadarashi	SD-49	3.68
Sadarashi	SD-13	7.91	Sadarashi	SD-72	9.06
Sadarashi	SD-14	8.10	Akbarpur	AP-2	5.98
Sadarashi	SD-15	9.10	Akbarpur	AP-12	16.69
Sadarashi	SD-16	8.72	Akbarpur	AP-13	2.40
Sadarashi	SD-17	16.44	Akbarpur	AP-24	30.79
Sadarashi	SD-24A	15.66	Akbarpur	AP-26	5.49
Sadarashi	SD-24B	15.66	Purahuria	PH-10	19.09
Sadarashi	SD-27	15.90	Purahuria	PH-28	4.17
Sadarashi	SD-28	2.85	Purahuria	PH-33	15.69
Sadarashi	SD-30	23.57	Purahuria	PH-43	14.19
Sadarashi	SD-32	11.88			

Table 3-Descriptive statistics of the areas from which data have been collected. (NK, SD, AP, PH are the names in short form of the places)

Sample name	Contamination	Mean	Standard Error	Median	Skewness	Range	CL(95.0%)
NK N=3	Arsenic	22.2233	3.5212	21.6000	0.4551	12.1500	15.1506
	Iron	22.4427	3.4395	25.4780	-1.6976	10.6920	14.7988
SD N=21	Arsenic	51.7057	4.9932	56.2500	-0.1450	80.8700	10.4156
	Iron	14.2640	1.9865	12.8570	2.0328	42.4920	4.1438
AP N=6	Arsenic	32.6120	10.9742	20.7400	0.7282	53.7800	30.4694
	Iron	12.2718	5.2228	5.9790	1.2865	28.3890	14.5007
PH N=4	Arsenic	28.6150	14.3581	16.6100	1.8540	61.0400	45.6939
	Iron	13.2838	3.2067	14.9360	-1.3808	14.9230	10.2051

Plot 1- Scatter plot of Iron and Arsenic for the whole collected sample along with the fitted linear model and R^2 value



Regression analysis for the whole data is in table.4. The result shows multiple R value .239 that is almost 24% of the variability of the dependent variable (Iron) controlled by the independent variable (Arsenic). A moderate value of Multiple R is well supported by t-test for regression coefficient. The pair (t-stat, p-value) = (-1.369, .181) suggests that the influence is not significant at both 5% and 10% level of significance. For further details regression analysis was carried out for each part of study area and the details are in table 5.

Table 4- Regression output obtained using MS excel 2007 for the whole data

Regression Statistics					
Multiple R	0.239				
Standard Error	24.467				
Observations	33				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1121.37	1121.37	1.87	0.18
Residual	31	18557.11	598.62		
Total	32	19678.48			
Variable	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	
Intercept	52.880	8.172	6.471	0.000	
X Variable 1	-0.654	0.478	-1.369	0.181	

Table 5- Multiple R and Standard error of regression analysis considering each study part at a time

Regression analysis of partial data				
Regression Statistics	NK	SD	AP	PH
Multiple R	0.855	0.373	0.070	0.381
Standard Error	4.476	21.784	28.266	32.512

Plot 2- Shows the variation of Arsenic and Iron collected from four location of Study area

Multiple regression coefficients computed for the different location of the study area shows that R^2 value for (AP) is very low. That is the independent variable (arsenic) controls only 7% of the variation of the independent variable (Iron). Whereas moderate relation is shown in cases of SD, PH and NK show high association.

CONCLUSION

From the present study on arsenic contamination in ground water of North Karimganj Block of Karimganj District, Assam it has been observed that the Arsenic concentration in Sadarashi G.P is highest among all the four GPs studied. Other three GPs are also arsenic contaminated, but to lesser extent. Thus if safe water is not provided to these villagers in immediate future they will suffer from Arsenic related diseases. Iron concentration in the 32 arsenic contaminated water samples is well above the limit (0.3mg/l) declared by WHO. The findings of the present study have been communicated to the Administration and requesting to provide safe drinking water to the villagers as Arsenic is a carcinogen. In our survey we found that majority of the villagers do not know about the presence of

arsenic in ground water and its destructive effect on human health. Elimination of arsenic from drinking water could be achieved by increasing awareness, educating villagers about the issues of arsenic in ground water, future effect of the use of arsenic contaminated water on health leading to Arsenical Skin lesions, Skin cancer etc. Such problem can be solved when there will be a collaboration between Government, researchers, Technocrats and villagers.

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