

Determination of Cationic and Anionic Pollutants in the Groundwater of Chirang District in Assam and their Interrelationships Study

Valentina Basumatary¹ and K.G. Bhattacharyya²

^{1,2}Department of Chemistry, Gauhati University, Guwahati 781014, Assam
E-mail: ¹basumataryvalen@gmail.com, ²kgbhattacharyya@gmail.com

Abstract—Chirang is a land of agriculture and cultivation. A total of 15 ground water samples were collected from different stations (tube well) that are basically used for drinking purpose. From the anionic study it was found that the ground water in these places are mostly alkaline. Fluoride was found to be within the WHO permissible limit (i.e., 1.5 mg/L). Total dissolved solid was found to be low the desirable limit, highest is 151.98 mg/L (500mg/L WHO 2011). The electrical conductance EC ranges from 0.02-0.43 mS/cm. The nitrate concentration ranges from 3.25-127.90 mg/L(50mg/L WHO 2011). The sulphate was found in the range of 2.56-18.8 mg/L (250mg/L WHO 2011). The phosphate concentration ranges from 2.00-8.75mg/L. The total hardness in drinking water according to WHO limit should not exceed 200mg/L. For total hardness groundwater under study was found to be within the desirable limit. Since it is mainly an agricultural land the place is very less polluted by heavy metals like Pb, Ni, Cd, Cr and Cu. These metals were mostly found within the WHO permissible limit. While metals like Fe and As were found to be very high. The iron concentration was found in the range of 0.038-32.54mg/L (0.3mg/L WHO 2011) and the arsenic concentration was seen in the range of bdl-8.43mg/L (0.01mg/L WHO 2011). Zinc was found in the range of 0.056-0.781mg/L.

Keywords: Agriculture, concentration, cultivation, groundwater.

1. INTRODUCTION

Water is one of the indispensable part of our life. Natural water is not pure due to contaminants from both natural sources and from the man made activities [1]. Water is contaminated by cationic and anionic pollutants. Metals are required in very small amount for the normal functioning of plants and animals while at very high concentration they can be very harmful as these can lead to cancer risks in human. Heavy metals are not biodegradable and they persist in the environment or water system for a very long period of time. Many factors are responsible for the degradation of the water quality. These may include both anthropogenic and geogenic sources. Anthropogenic sources are due to human activities that include housing and rapid industrialisation while the geogenic sources can be due to leached from rocks and soils according to their geochemical mobility [2].

2. MATERIALS AND METHOD

2.1. Study Area and Sampling Procedure

A total of 15 groundwater (tube well) samples were collected from the agricultural areas of the Chirang district in the month of April. The name of the places from where water samples are collected are Lahatipara, Kablibagan, Pub-Kamarpara, Salbari, Kanipur, Deulguri, Bhur Tiniali, Ranipur, Bengtol, Kunguri, Nwlbwari, Banduguri, Sumliguri, Durgapur and Dohlapara. The sampling stations are named accordingly from GW1 to GW15 (Table 1). Geographical locations were recorded with the help of GPS (Geographical Positioning System) Samples were collected in pre-cleaned polyethylene containers. These containers were pre-cleaned by soaking in a solution of 10 % nitric acid and rinsed with lab water. The details of the sampling locations for the are given in Table 1.

2.2. Sample Preservation

In order to prevent adsorption losses, samples for the analysis of total arsenic were preserved by acidification to pH < 2. For As measurement, hydrochloric acid is the choice for sample preservation prior to analysis and ISO 11969:1996 (HGAAS technique) prescribes the addition of 20 ml of 50 % hydrochloric acid to each litre of water sample.

Table 1: GPS locations of the sampling sites.

SL NO	COORDINATES					
	LATITUDE			LONGITUDE		
	D	M	S	D	M	S
GW1	26 ⁰	33	10.5	090 ⁰	43	49.0
GW2	26 ⁰	30	06.3	090 ⁰	42	03.7
GW3	26 ⁰	32	38.7	090 ⁰	43	39.5
GW4	26 ⁰	36	30.5	090 ⁰	27	53.2
GW5	26 ⁰	39	38.7	090 ⁰	28	57.2
GW6	26 ⁰	39	05.8	090 ⁰	27	56.4
GW7	26 ⁰	39	55.6	090 ⁰	24	24.1
GW8	26 ⁰	39	48.3	090 ⁰	25	49.4
GW9	26 ⁰	38	03.8	090 ⁰	28	38.3

GW10	26 ⁰	39	22.4	090 ⁰	28	20.3
GW11	26 ⁰	37	45.7	090 ⁰	29	20.0
GW12	26 ⁰	37	43.4	090 ⁰	28	26.3
GW13	26 ⁰	37	57.8	090 ⁰	29	00.4
GW14	26 ⁰	38	55.6	090 ⁰	28	44.8
GW15	26 ⁰	38	13.1	090 ⁰	28	53.4

3. METHODOLOGY

All the water quality parameters are determined according to standard procedures laid down by American public Health Association.

4. RESULTS AND DISCUSSION

The pH in the study area ranges from 5.76 – 7.42. It was found to be in the neutral range and slightly approaches the alkaline range due to the formation of CaCO₃ in the particular geographical region [3]. The average bicarbonate concentration in the water is 43.817 mg/L. In the same manner the pH value also depends on the dissolution of carbonates [4]. The electrical conductance, EC, ranges from 0.02-0.43 mS/cm. Electrical conductivity is due to the high concentrations of ionic constituents present in the water bodies under study. The TDS in the region was found to be below 500 mg/L (desirable limit for drinking water) [5].

From Fig.1, it is found the total hardness of all the samples area below 100 mg/L. The World Health Organization (2004) has identified that water with a hardness of 200 mg/L or higher (measured as calcium carbonate) will produce scale and soft water with a value of 100 mg/L (as calcium carbonate) or less will have a low buffering capacity and be more corrosive to pipes [6]. Fluoride concentration was within the WHO desirable limit (1.5 mg/L). The high nitrate concentration can be due to anthropogenic influences and also due to the presence of oxidant environment.

Table 2: Ranges of analytical data of the ground water (tube well) samples

Non-metallic parameters	MIN	MAX	MEAN	STDEV
pH	5.7	8.3	7.1	1.9
EC (mS/cm)	0.02	0.43	0.11	0.12
TDS(mg/L)	32	152	115	110
Ca ²⁺ (mg/L)	12.0	90.2	25.5	18.7
Mg ²⁺ (mg/L)	1.2	40.2	7.8	9.5
Na (mg/L)	8.70	46.5	11.83	9.60
K (mg/L)	4.8	17.40	6.57	3.87
HCO ⁻ (mg/L)	16.7	83.3	43.8	28.2
Cl ⁻ (mg/L)	bdl	25.6	11.7	6.2
SO ₄ ²⁻ (mg/L)	2.6	18.8	9.5	5.3
NO ₃ ⁻ (mg/L)	3.2	127	24.6	33.1
PO ₄ ³⁻ (mg/L)	1.0	10.0	5.5	2.8
F ⁻ (mg/L)	bdl	0.8	0.1	0.2

The nitrate concentration in the region ranges from 3.25-127.90 mg/L. According to WHO 2011, 50 mg/L is the

guideline value for nitrate. Holland (1978) stated that in absence of other sources, the concentration of chlorides in natural water by atmospheric precipitation should not exceed 20 mg/L. The chloride concentration ranges from BDL-25.56 mg/L. Concentration above 250 mg/L are detected by taste, no specific guideline value is given by WHO 2011 [7]. Phosphate concentration in the present study ranges from 2.00-8.75 mg/L. This can be the reason for the high arsenic concentration (table 3) because the phosphate concentration is low. There is no specific guideline value for phosphate in water [8]. High level of sulphate in groundwater causes gastrointestinal irritation. 250mg/L is the WHO limit for drinking water [9]. In this study, 9.48 mg/L is the mean SO₄²⁻ concentration. The low level of sulphate could be the result of microbial action capable of reducing SO₄²⁻ to S⁻ leading to depletion of sulphate in the study area [10].

WHO limit 2011 has not given any specific guideline value for Na and K concentration because their presence in small amount in groundwater is not harmful. In our overall study, we have found Na in the range of 8.7-46.5 mg/L; K is in the range of 4.8-17.4mg/L.

The arsenic concentration was seen in the range of BDL-8.43 mg/L (WHO limit 2011 is 0.01 mg/L). In the present work, however, Mn concentration was found to be within the desirable limit. The average iron concentration is 5.30 mg/L. Lead was found in the range of BDL-0.047 mg/L. With the decrease in pH the Pb(II) solubility increases and also with the increase in depth the Pb concentration decreases [11].

Zn is an essential element for physiological processes in both plant and animals, the WHO has not given any guideline value for Zn but even Cadmium in the water samples was found to be below the desirable limit of 0.03 mg/L (WHO 2011).

In the study area, Cr concentrations were mostly below the detection limit but there are some stations where small concentrations within 0.05 mg/L (WHO limit 2011) were observed. This can be due to leaching of small amount of Cr from the household use of steel as utensils [12].

Cr, Cu and Ni concentrations were found to be within the WHO desirable limit. Cd is the most harmful of all the heavy metals found in groundwater, this is because Cd can cause the impairing of DNA/RNA and ribosomes [13]. It has been found that heavy metals are precipitated as their salts at high pH and are deposited as sediments [14].

From Fig. 2, it is found that Mn and Fe are strongly correlated in the groundwater under study because when Fe oxide reduction begins, high concentration of dissolved Mn is observed in the system due to the previous Mn oxide reduction [15]. linear regression coefficient is very week for Fe and SO₄²⁻ (Fig. 3) and Mn and SO₄²⁻ (Fig. 4). This explains that sulfide mineral oxidation in this case does not lead to an increase in the iron concentration in groundwater. No specific relationship was observed between arsenic and PO₄³⁻ (Fig. 5).

A weak correlation is seen between SO_4^{2-} - Mn and SO_4^{2-} -Fe. This happens when Mn oxide and Fe oxide reduction begin, producing high dissolved Mn and Fe, sulphate reduction is most likely lower. The lower correlation of As and Fe (Fig. 6) was most likely caused by reabsorption of As to residual Fe oxide[15].

Table 3: Concentration of trace metals (mg/L) in the groundwater (Tube well) (BDL below detection limit)

Conct (mg/L)	MIN	MAX	MEAN	STDEV	WHO (2011)
As	Bdl	8.43	4.04	2.48	0.01
Cd	bdl	0.03	0.01	0.01	0.03
Cr	bdl	3.08	0.57	1.00	0.05
Cu	bdl	bdl	bdl	0.00	2.00
Fe	0.04	32.55	5.30	8.44	0.30
Mn	bdl	2.34	0.32	0.65	0.40
Ni	bdl	0.11	0.01	0.03	0.07
Pb	11	.05	0.00	.01	0.01
Zn	0.06	0.78	0.22	0.18	---

From Fig. 7, it is found that Fe concentration increases as it approaches the pH range, 6-10.

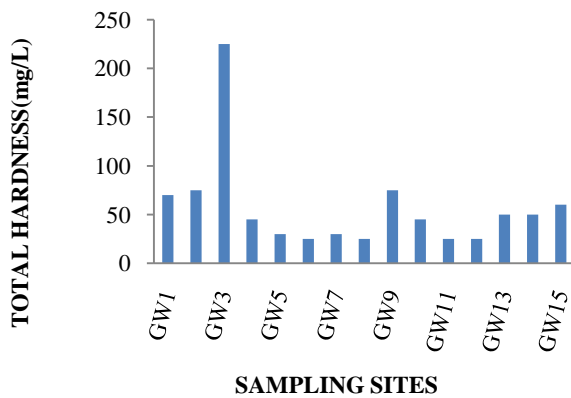


Fig. 1: Total hardness for the groundwater (tube well) sampling. The WHO limit 2011, for the total hardness is 200 mg/L.

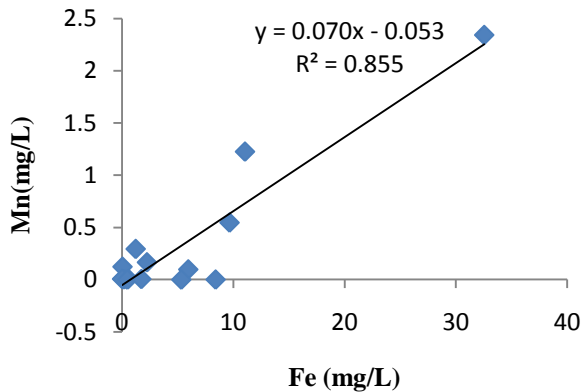


Fig. 2: Correlation between Mn and Fe.

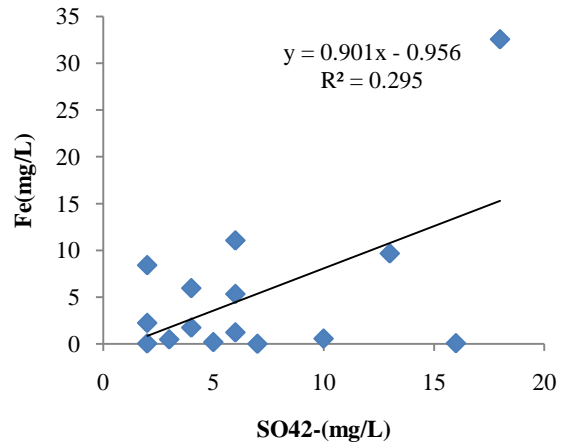


Fig. 3: Correlation between Fe and sulphate.

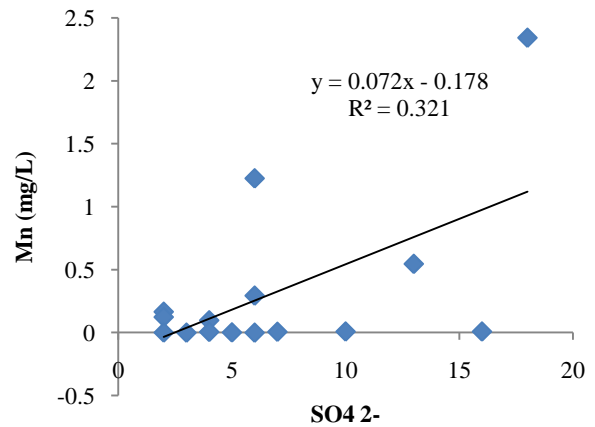


Fig. 4: Correlation between Mn and sulphate

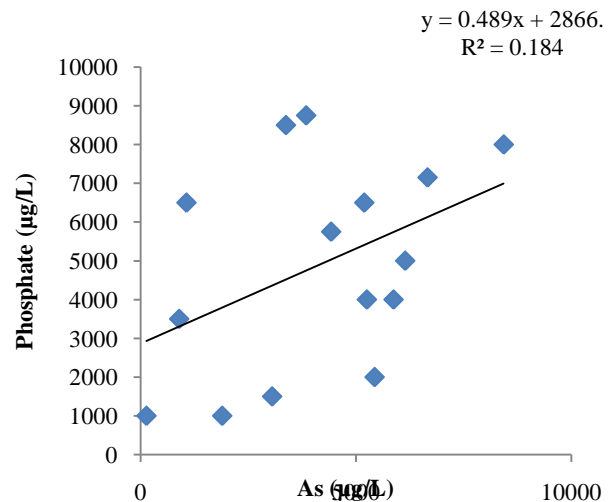


Fig. 5: Correlation between PO_4^{3-} and As.

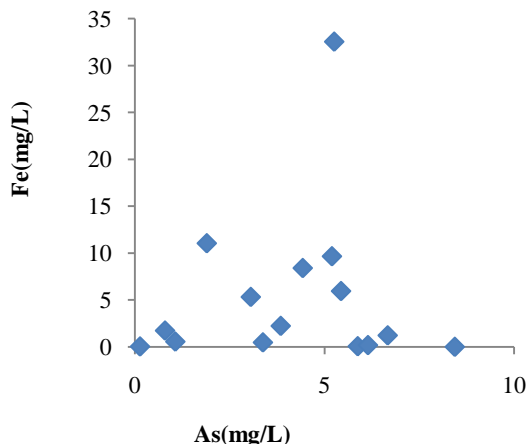


Fig. 6: Correlation between Fe and As.

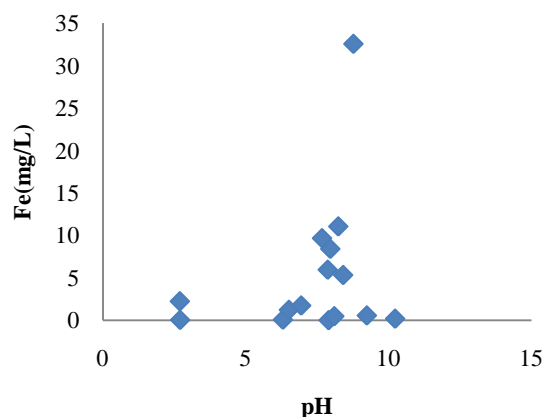


Fig. 7: Correlation between Fe and pH.

5. CONCLUSIONS

From the above studies it can be found that the places are highly contaminated by Fe and less by Mn and Zn. Lead (Pb), Ni, Cu, Cd and Cr are found to be below the desirable limit. The pH range was found to be neutral. The total hardness is found to be within the desirable limit of 200 mg/L. The fluoride concentration is within the WHO limit (1.5 mg/L). From the ion balance calculation, the value was seen in the range of 0.5 – 1.6.

6. ACKNOWLEDGEMENT

The work is supported by the Rajib Gandhi National Fellowship (UGC).

REFERENCES

[1] Raju, O.V.S., Prasad, P.M.N., Varalakshmi, V. Reddy, Y.V.R., "Determination of heavy metals in ground water by ICP-OES in selected coastal area of SPSR Nellore district, Andhra Pradesh, India", *International Journal of Innovative Research in Science*, 2014.

[2] Reddy, V.H., Prasad, P.M.N., Reddy, A.V.R. Reddy, Y.V.R., "Determination of heavy metals in surface and groundwater in and around Tirupati, Chittoor (Di), Andhra Pradesh, India", *Der Pharma Chemica*, 4, 6, 2012, pp. 2442 - 2448.

[3] Jameel, A.A., Sirajudeen, J., vahith, R.A., "Studies on heavy metal pollution of ground water sources between Tamilnadu and Pondicherry, India", *Advances in Applied Science Research*, 3, 2012, pp. 424 - 429.

[4] Blanes, P.S., Buchhamer, E.E., Giménez, M.C., "Natural contamination with arsenic and other trace elements in groundwater of the Central–West region of Chaco, Argentina", *Journal of Environmental Science and Health*, 46, Part A, 2011, pp. 1197 – 1206.

[5] Çelebi, A., Şengörür, B., Klove, B., "Human health risk assessment of dissolved metals in groundwater and surface waters in the Melenwatershed", *Turkey. Journal of Environmental Science and Health*, 49, Part A, 2014, pp. 153 – 161.

[6] World Health Organization. Guidelines for Drinking-Water Quality, 3rd edn, World Health Organization, Geneva, 542 pages. WHO (2004)

[7] Liu, X., Sun, S., Ji, P., Simunek, J., "Evaluation of historical nitrate sources in groundwater and impact of current irrigation practices on groundwater quality", *Hydrological Sciences Journal – Journal des Sciences Hydrologiques*, 58, 1 2013.

[8] Brunsting, J.H., McBean, E.A., "Phosphate interference during in situ treatment for arsenic in groundwater", *Journal of Environmental Science and Health*, 49, Part A, 2014, pp. 671 – 678.

[9] Thorbjornsen, K., Myers, J., "Identifying Metals Contamination in Groundwater Using Geochemical Correlation Evaluation", *Environmental Forensics*, 8, 2007, pp. 25 – 35.

[10] Charles, O.A., Olabanji, O.A., Abimbola, A.J., Olamide, A.O., "Assessing the Effect of a Dumpsite on Groundwater Quality: A Case Study of Aduramigba Estate within Osogbo Metropolis", *Journal of Environment and Earth Science*, Vol. 3, 2013, pp. 120 - 130.

[11] Clausen, J.,L.,Bostick, B., Korte, N., "Migration of Lead in Surface Water, Pore Water, and Groundwater With a Focus on Firing Ranges", *Environmental Science and Technology*, 41, 2011, pp. 1397 – 1448.

[12] Mudhaf, H.F.A., Astel, A.M., Hayan, M.N.A., Shady, A.I.A., "Chemometric exploration of the abundance of trace metals and ions in desalinated and bottled drinking water in Kuwait", *Journal of Environmental Science and Health*, Part A, 49, 2014, pp. 648 - 660.

[13] Gerhard, I.M.,B., Waldbrenner, A., Runnebaum, B., "Heavy metals and fertility", *Journal of Toxicology and Environmental Health*, Part A, 54, 1998, pp. 593 – 611.

[14] Jameel, A.A., Sirajudeen, J., vahith, R.A., "Studies on heavy metal pollution of ground water sources between Tamilnadu and Pondicherry, India", *Advances in Applied Science Research*, 2012, 3, pp. 424 - 429.

[15] Rotiroti, M., Sacchi, E., Fumagalli, L., Bonomi, T., "Origin of Arsenic in Groundwater from the Multilayer Aquifer in Cremona (Northern Italy)", *Environ. Sci. Technol.*, 48, 2014, pp. 5395 – 5403.