Journal of Current Chemical & Pharmaceutical Sciences

J. Curr. Chem. Pharm. Sc.: 3(3), 2013, 187-195
ISSN 2277-2871

GIS-BASED STUDY ON GROUND WATER TRACE METALS CONTAMINATION IN DHEMAJI DISTRICT OF ASSAM, INDIA

MRIDUL BURAGOHAIN[*] and HARI PRASAD SARMA[a]

Department of Chemistry, Lakhimpur Girls' College, NORTH LAKHIMPUR (Assam) INDIA
[a]Department of Environmental Science, Gauhati University, GUWAHATI – 14 (Assam) INDIA

(*Received : 17.06.2013; Accepted : 03.07.2013*)

ABSTRACT

In present work, trace metal contamination of the groundwater in Dhemaji district of Assam was assessed. Thirty ground water samples were analyzed using Atomic Absorption Spectrometer, Perkin Elmer AA 200 model for their Copper, Nickel, Manganese, Zinc and Chromium content and their levels compared with WHO specified maximum contaminant level. Multivariate Geospatial analyses were performed, using GIS (Geographic Information System) techniques and statistical analysis with the help of SPSS® statistical package (Window Version 10.0). According to the WHO, the Maximum Permissible Level (MPL) for Copper, Nickel, Manganese, Zinc and Chromium are 1.5 mg/L, 0.02 mg/L, 0.5 mg/L, 5.0 mg/L and 0.1 mg/L, respectively. Analysis reaveled that none of the samples analysed contained Copper and Zinc in concentrations above the MPL. But water samples of the area fall under alert category with respect to Ni, Mn and Cr, as most of the analysed samples exceed and some are approaching the MPL of WHO. The Ni, Mn and Cr contamination of ground water in the study area needs proper attention.

Key words: GIS, AAS, SPSS, Ground water, Trace metals, MCL, WHO, Dhemaji, etc.

INTRODUCTION

Water has unique chemical properties due to its polarity and hydrogen bonds, which means, it is able to dissolve, absorb, adsorb or suspend many different compounds[1]. Thus, in nature, water is not pure as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities[2]. One of the most important environmental issues today is ground water contamination[3] and between the wide diversity of contaminants affecting water resources, heavy metals receive particular concern considering their strong toxicity even at low concentrations[4]. Heavy metals are elements having atomic weights between 63.546 and 200.590 and a specific gravity greater than 4.0 i.e. at least 5 times that of water. They exist in water in colloidal, particulate and dissolved phases[5] with their occurrence in water bodies being either of natural origin (e.g. eroded minerals within sediments, leaching of ore deposits and volcanism extruded products) or of anthropogenic origin (i.e. solid waste disposal, industrial or domestic effluents, harbour channel dredging)[4]. Geographic Information System provides the techniques for measuring, modeling, manipulating, retrieval and analysis of spatial data. GIS database also helps in decision-making process by identifying the most sensitive zones that need immediate attention. Thus present

---

Available online at www.sadgurupublications.com
[*]Author for correspondence; E-mail: mbg_2007@rediffmail.com; Ph.: +91 94353-89548

research interrogates the spatial distribution of copper, nickel, manganese, zinc and chromium in ground water of Dhemaji district, Assam.

EXPERIMENTAL

The study area Dhemaji district (Figure 1) is situated in the remote corner of north east India on the north bank of the river Brahmaputra. The district is located between $27^{0}\ 05^{/}\ 27^{//}$ and $27^{0}\ 57^{/}\ 16^{//}$ northern latitudes and $94^{0}\ 12^{/}18^{//}$ and $95^{0}\ 41^{/}\ 32^{//}$ eastern longitudes. The district is divided into two sub-divisions viz. Dhemaji and Jonai, comprising of five development blocks viz. Dhemaji, Sissiborgaon, Bordoloni, Machkhowa and Morkongselek (Tribal). The soil of the district is broadly classified into four groups, namely new alluvial, old alluvial, red loamy and lateritic soil. The new alluvial soil is found in the flood plain areas subjected to occasional flood and consequently receives annual silt deposit when the flood recedes. The old alluvial soils are developed at higher level and are not subjected to flooding. Red loamy soils are formed on hill slopes under high rainfall conditions[6]. For the present study, thirty groundwater samples were collected from tubewells ringwells at different sites from each of the five development blocks of Dhemaji district to assess the qualitative changes in trace metal loads. Samples were collected by random selection and combined together in clean and sterile one-litre polythene cans to obtain a composite sample and stored in an ice box[7]. The locations of the sampling points were obtained with a hand held global positioning system (GPS, Germin 72 model) with position accuracy of less than 10 m. The sampling locations are shown in Figure 2 and block wise sample collection summary are given in Table 1. Samples were protected from direct sun light during transportation to the laboratory. All probable safety measures were taken at every stage, starting from sample collection, storage, transportation and final analysis of the samples to avoid or minimize contamination. Lead, arsenic, cadmium and aluminium were analysed by using Atomic Absorption Spectrometer (Perkin Elmer AA-Analyst 200) with Flow Injection Analyze Mercury Hydride Generation System (Model–FIAS-100) as per the standard procedures[8]. Univariate statistics were used to test distribution normality for each parameter. SPSS® statistical package (Window Version 10.0) was used for data analysis.

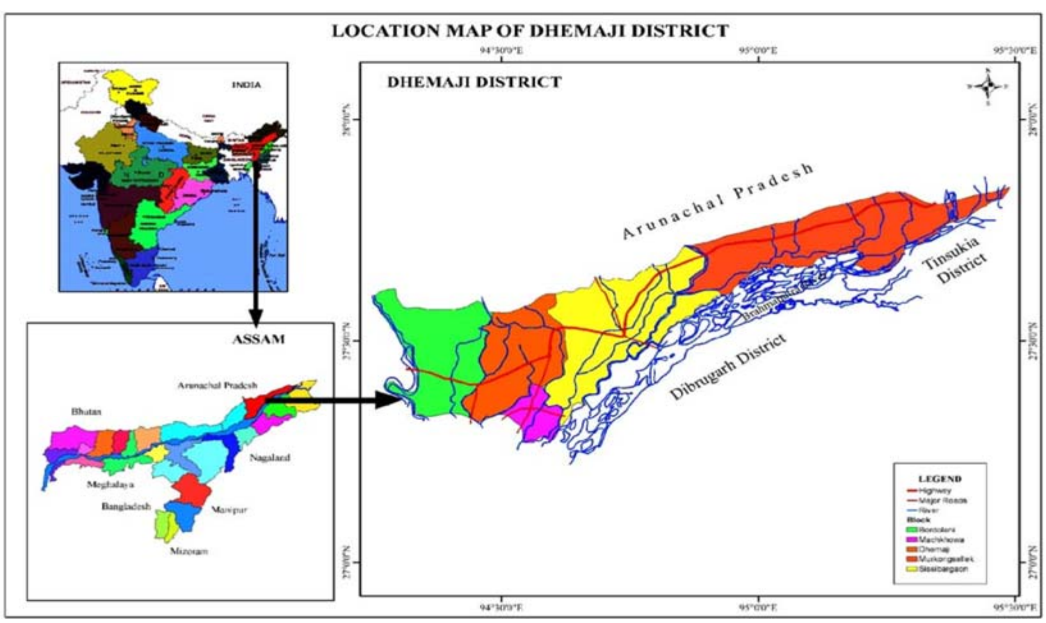


Fig. 1: A cross sectional view of the study area, Dhemaji district in Assam, India

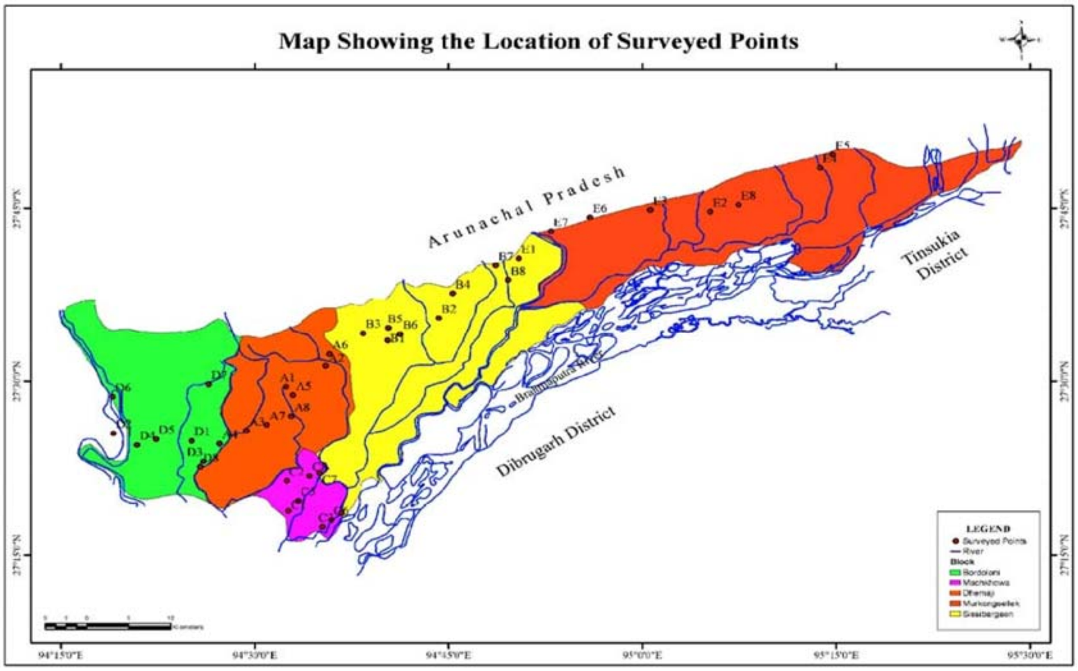


Fig. 2: Map showing the 30 sampling stations of the study area

Table 1: Block wise physical location of sampling stations in the study area

Sample No.	Name of block	Sampling location		Geographical location	
		Name of G.P.	Name of Village	North (N)	East (E)
A_1	Dhemaji	Bishnupur	No.2 Tekjuri	$27^{0}\ 29.546^{/}$	$94^{0}\ 32.426^{/}$
A_2		Lakhipathar	Jamuguri	$27^{0}\ 31.342^{/}$	$94^{0}\ 35.479^{/}$
A_3		Chamarajan	Kekuri	$27^{0}\ 25.690^{/}$	$94^{0}\ 29.345^{/}$
A_4		Naruathan	Balijan	$27^{0}\ 24.601^{/}$	$94^{0}\ 25.267^{/}$
A_5		Aradhal	Kulapathar	$27^{0}\ 28.792^{/}$	$94^{0}\ 32.949^{/}$
A_6		Moridhal	Perabhari	$27^{0}\ 32.353^{/}$	$94^{0}\ 35.776^{/}$
B_1	Sisiborgaon	Sissiborgaon	Takaobari	$27^{0}\ 33.567^{/}$	$94^{0}\ 40.267^{/}$
B_2		Silasuti	Silagaon	$27^{0}\ 35.475^{/}$	$94^{0}\ 44.219^{/}$
B_3		Siripani	Siripani	$27^{0}\ 34.156^{/}$	$94^{0}\ 38.387^{/}$
B_4		Malinipur	Khanamukh	$27^{0}\ 37.602^{/}$	$94^{0}\ 45.314^{/}$
B_5		Akajan	Akajan	$27^{0}\ 34.603^{/}$	$94^{0}\ 40.326^{/}$
B_6		Nilakh	Baligaon	$27^{0}\ 34.074^{/}$	$94^{0}\ 41.252^{/}$
C_1	Machkhowa	Machkhowa	Borpak	$27^{0}\ 18.806^{/}$	$94^{0}\ 32.608^{/}$
C_2		Begenagara	Kaitog	$27^{0}\ 21.363^{/}$	$94^{0}\ 32.471^{/}$
C_3		Jorkata	Kathgaon	$27^{0}\ 12.416^{/}$	$94^{0}\ 35.237^{/}$
C_4		Sissimukh	Sisi-Nepali	$27^{0}\ 13.623^{/}$	$94^{0}\ 36.706^{/}$
C_5		Machkhowa	Majgaon	$27^{0}\ 19.623^{/}$	$94^{0}\ 33.347^{/}$
C_6		Jorkata	Jorkata-Nepali	$27^{0}\ 30.023^{/}$	$94^{0}\ 35.932^{/}$

Cont…

Sample No.	Name of block	Sampling location		Geographical location	
		Name of G.P.	Name of Village	North (N)	East (E)
D_1	Bordoloni	Bordoloni	Kalitagaon	$27^{0}\,24.829^{/}$	$94^{0}\,25.117^{/}$
D_2		Gogamukh	Silimpur	$27^{0}\,25.477^{/}$	$94^{0}\,19.058^{/}$
D_3		Borbam	Salmari	$27^{0}\,43.037^{/}$	$94^{0}\,26.012^{/}$
D_4		Gugamukh	Tajik Nepali	$27^{0}\,24.489^{/}$	$94^{0}\,19.882^{/}$
D_5		Bhebeli	Bhebeli	$27^{0}\,24.983^{/}$	$94^{0}\,22.354^{/}$
D_6		Mingmang	Mingmang	$27^{0}\,48.643^{/}$	$94^{0}\,19.012^{/}$
E_1	Morkongselek (Tribal)	Simen Chapari	Baghagaon	$27^{0}\,41.672^{/}$	$94^{0}\,50.436^{/}$
E_2		Laimekuri	Adikata	$27^{0}\,44.719^{/}$	$95^{0}\,05.241^{/}$
E_3		Telem	Telem-pathar	$27^{0}\,45.865^{/}$	$95^{0}\,00.611^{/}$
E_4		Jonai	Jonai Bazar	$27^{0}\,49.493^{/}$	$95^{0}\,13.735^{/}$
E_5		Silley	No.1 Jelem	$27^{0}\,50.618^{/}$	$95^{0}\,14.726^{/}$
E_6		Dekapam	Bijoypur	$27^{0}\,45.218^{/}$	$94^{0}\,55.934^{/}$

RESULTS AND DISCUSSION

The experimental findings and statistical analysis of the experimental data are summarized in Table 2 and Table 3. The GIS map for trace metals distribution has been presented in Figure 3.

Table 2: Trace metal content in ground water of Dhemaji at 30 different stations

Sample No.	Cu (mg/L)	Ni (mg/L)	Mn (mg/L)	Zn (mg/L)	Cr (mg/L)
A_1	BDL*	0.02	0.08	0.15	0.02
A_2	BDL*	0.02	0.23	1.78	0.11
A_3	BDL*	0.03	0.09	0.27	0.10
A_4	BDL*	0.06	0.43	0.80	BDL*
A_5	0.02	0.05	0.23	0.40	BDL*
A_6	0.01	0.04	0.24	0.02	BDL*
B_1	0.04	0.07	0.36	1.10	0.17
B_2	0.07	0.02	0.31	1.20	0.12
B_3	0.27	0.04	0.25	1.20	0.26
B_4	0.25	0.02	0.22	1.75	0.17
B_5	0.06	0.01	0.15	0.56	0.23
B_6	0.02	0.02	0.17	0.36	0.15
C_1	0.05	0.05	0.30	1.02	0.05
C_2	0.01	0.04	0.47	0.40	0.16
C_3	BDL*	0.01	0.26	1.15	0.14
C_4	0.08	0.07	0.19	1.12	0.02

Cont…

Sample No.	**Cu (mg/L)**	**Ni (mg/L)**	**Mn (mg/L)**	**Zn (mg/L)**	**Cr (mg/L)**
C_5	0.20	0.03	0.24	1.25	0.01
C_6	0.16	0.06	0.25	1.05	BDL*
D_1	0.17	0.05	0.21	0.42	0.23
D_2	0.21	0.01	0.36	0.36	0.18
D_3	0.30	0.06	1.14	0.46	0.21
D_4	0.25	0.06	0.46	0.56	0.03
D_5	0.21	0.03	0.28	0.46	0.05
D_6	0.05	0.02	0.27	0.65	0.31
E_1	0.08	0.04	0.14	0.35	0.01
E_2	0.03	0.01	0.32	0.67	0.03
E_3	0.05	0.05	0.21	0.32	0.05
E_4	0.12	0.03	0.26	0.07	0.01
E_5	0.04	0.07	0.31	0.82	BDL*
E_6	0.12	0.05	1.01	0.32	0.25

*BDL= Below detection limit

Table 3: Statistical analysis for water testing values for metal contents in ground water

Metals		**Cu**	**Ni**	**Mn**	**Zn**	**Cr**
Mean		0.094	0.037	0.315	0.693	0.119
Std. error of mean		0.016	0.003	0.041	0.069	0.018
Median		0.050	0.030	0.250	0.560	0.105
Mode		0.000	0.020	0.250	0.360	0.000
Std. deviation		0.102	0.020	0.261	0.437	0.114
Variance		0.010	0.000	0.068	0.191	0.013
Skewness		1.331	0.221	2.706	0.671	0.716
Std. error of skewness		0.374	0.374	0.374	0.374	0.374
Kurtosis		1.348	-1.02	7.367	-0.111	-0.31
Std. error of kurtosis		0.733	0.733	0.733	0.733	0.733
Range		0.420	0.070	1.220	1.760	0.430
Minimum		0.000	0.000	0.080	0.020	0.000
Maximum		0.420	0.070	1.300	1.780	0.430
Sum		3.760	1.460	12.610	27.710	4.770
Percentiles	25	0.020	0.020	0.180	0.360	0.013
	50	0.050	0.030	0.250	0.560	0.105
	75	0.168	0.050	0.318	1.088	0.225

Copper (Cu)

Analysis of water samples showed that concentration of Cu varied from BDL to 0.30 mg/L. Study revealed that 100% samples were within the maximum permissible limit (MPL) set by WHO for drinking purposes (1.5 mg/L). Cu enters the water system through mineral dissolution, industrial effluents, because of its use as algaecide, agricultural pesticide sprays and insecticide[9]. Cu may be dissolved from water pipes and plumbing fixtures, especially by water whose pH is below 7. Cu salts are sometimes purposely added in small amounts to water supply reservoirs to supress the growth of algae. Therefore Cu is more readily available for solution in surface and ground water than its low average abundance in rocks might imply[10].

Cu is not an accumulative poison, excreted by the body[11]. However, very large single or long-term intakes of Cu may cause health problems like vomiting diarrhea, stomach cramps and nausea. The tests for Cu is essential because of dissolved Cu salts even in low concentrations are poisonous to some biota. The soft or corrosive water can accelerate the leaching of Cu and other metals from household plumbing and water fixtures[12].

Nickel (Ni)

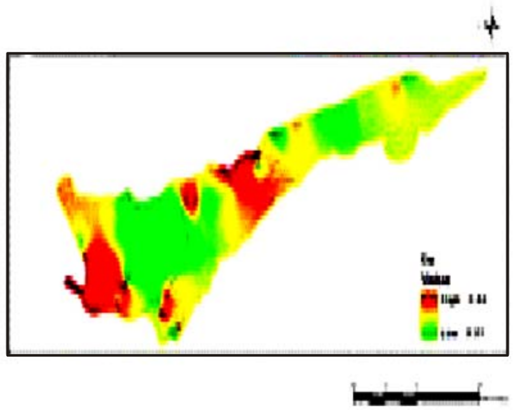
The concentration of Ni varied from 0.01 to 0.07 mg/L and at some of the sampling sites exceeds the MPL of WHO (0.02 mg/L). Ni enters groundwater and surface water sources by dissolution from rocks and soils, from biological recycling, from atmospheric fallout and especially from industrial wastes. Through leaching from Ni-containing pipes etc, water soluble Ni-compounds have been known to manifest a variety of clinical symptoms (nausea, vomiting, abdominal discomfort, diarrhea, visual disturbance, headache, giddiness, and cough). The most common type of reaction to Ni exposure is a skin rash at the site of contact. Skin contact with metallic or soluble Ni compounds can produce allergic dermatitis[13].

Manganese (Mn)

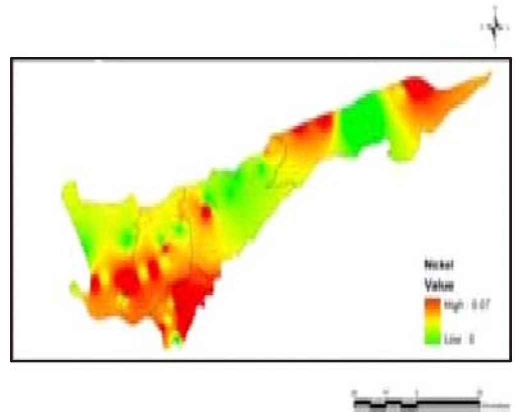
The concentration for Mn content in the water samples ranges from 0.08 to 1.14 mg/L and 23% of the analysed samples exceed and some are approaching the MPL value of WHO (0.5 mg/L). Mn is a very reactive element, found in nature and used extensively in industry for the manufacture of glass, ceramics, batteries, paints, varnishes, inks, dyes and fireworks[14]. However, in ground waters subject to reducing conditions Mn can be leached from the soil and occur in high concentrations. Mn often accompanies iron in ground waters[15]. The deficiency of Mn may cause improper growth, disrupt the nervous system and interfere with reproductive system[11]. At high concentrations in water it will cause an unpleasant taste, deposits on food during cooking, stains on sanitary ware, discolouration of laundry, deposits on plumbing fittings and cooking utensils, and will foster the growth of micro-organisms in water supply systems[16].

Zinc (Zn)

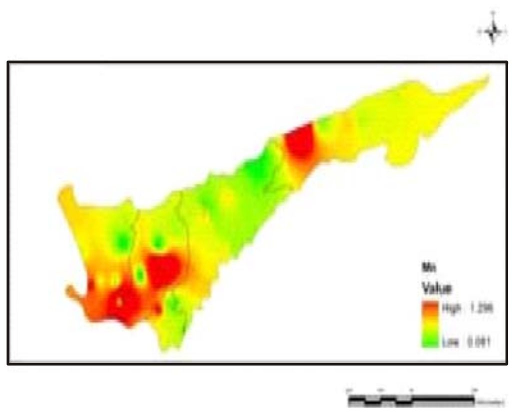
The water testing values for Zn ranges from 0.02 to 1.78 mg/L and 100% of the samples have Zn concentration below the MPL of WHO (5.0 mg/L). Zn has lots of use like galvanization of steel, preparation of negative plates in electric batteries, vulcanization of rubber, wood preservatives and antiseptics and in rat and mouse poison (Zn-phosphide)[17]. Zn is also used extensively as a white pigment, zinc oxide (ZnO) in paint and rubber. Very low amount of the Zn may cause loss of appetite, decreased sense of taste and smell, slow wound healing and skin sores. Zn-shortages can even cause birth defects. However large amount of Zn can cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anemia, damage of the pancreas and disturb the protein metabolism, cause arteriosclerosis and respiratory disorder[18].



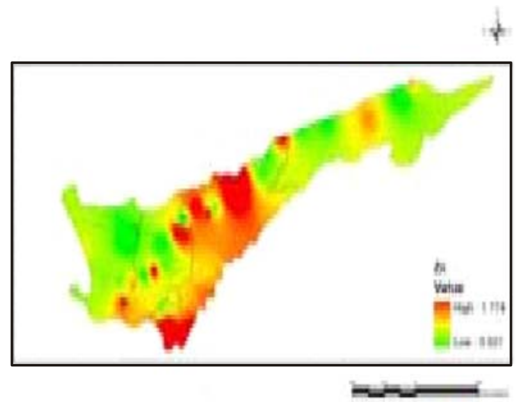
Copper (Cu)



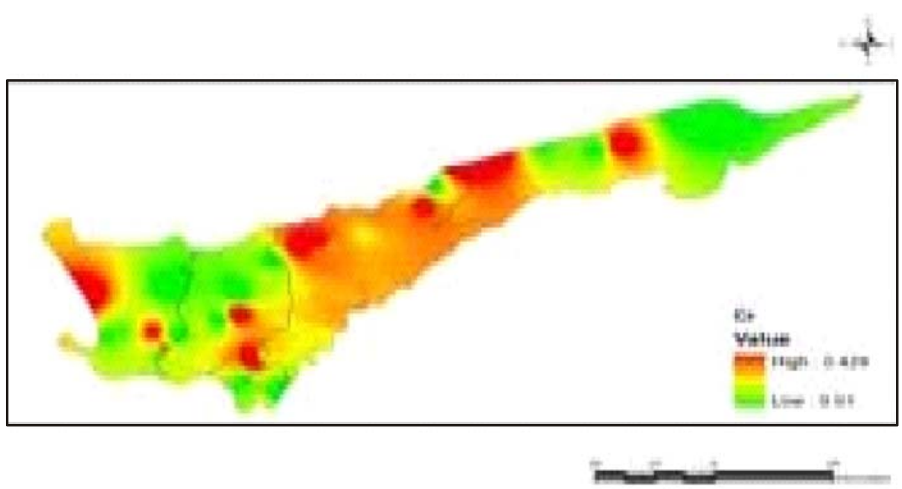
Nickel (Ni)



Manganese (Mn)



Zinc (Zn)



Chromium (Cr)

Fig. 3: Spatial distribution maps for Cu, Ni, Mn, Zn and Cr among the sampling stations

Chromium (Cr)

The Cr content in the water samples ranges from BDL to 0.31 mg/L. It was observed that water samples of the study area fall under alert category with respect to Cr, as most of the analysed samples exceed and some are approaching the MPL of WHO (0.1 mg/L). The compounds of Cr are very persistent in water as sediments. Chromium as Cr^{+3} is an essential and harmless metal, but Cr^{+6} is irritating and corrosive to the mucous membranes and may cause lung cancer, ulceration, nasal septum perforation, and other respiratory and skin diseases[19]. Cr is found naturally in rocks, plants, soil and volcanic dust, humans and animals. Cr^{3+} occurs naturally in many vegetables, fruits, meats, grains and yeast. At many locations, chromium compounds have been released to the environment via leakage, poor storage, or improper disposal practices[20].

CONCLUSION

A comprehensive analytical and statistical analysis with spatial distribution of trace metals in ground water of Dhemaji district, Assam has been presented in this study. Analysis reaveled that water samples of the area fall under alert category with respect to Ni, Mn and Cr as most of the analysed samples exceed and some are approaching the MPL of WHO. So, the Ni, Mn and Cr contamination of ground water in the study area needs proper attention. Significant positive skewness and kurtosis values observed for Cu and Mn are indicative of departure of sample frequency distribution curve from normal. It seems that Cu and Mn distribution in the area is sharp with a long asymmetric right tail. On the otherhand significant positive skewness and negative kurtosis value point towards flat Ni, Zn and Cr distribution with a long right tail in the study area. Large differences between mean, mode and median also imply that distribution of trace metals in the study area is widely off normal. Spatial analysis shows that the hot spot or stress zone for Cu can be seen traced in the western part of Bordoloni block and eastern part of Sissiborgaon block. For Ni, it can be seen traced in the southern parts of Sissiborgaon, Bordoloni and Jonai town of Morkongselek block. Moreover, for Mn, it can be seen traced in the southern parts Dhemaji and Bordoloni block and Jonai town. Again for Zn, it can be seen traced in different locality of Sissiborgaon and Machkhowa blocks. Finally for Cr, it can be seen traced in the Sissiborgaon and a small part in western boarder of Bordoloni block.

On the basis of these data, it is easy to formulate sound public policies and to implement water quality improvement programmes. This study outlines that academia is needed to make water related research more strategic and effective at a regional level so that early identification of the affected sources can be made. However, further studies are needed to assess the relationship between levels of contaminants with health risks.

ACKNOWLEDGEMENT

Mridul Buragohain is thankful to the University Grants Commission, New Delhi and Regional Office, Guwahati for financial assistance in the form of minor research project vide no. F. 5- 511/2011-12 (MRP/NERO)/15292 dated 23rd March, 2012. Authors are also thankful to Mr. Monjit Borthakur, Research Fellow, OKD Institute of Social Change & Development, V.I.P Road, Upper Hengerabari, Guwahati for his kind help in using Arc View GIS software.

REFERENCES

1. WHO, Water for Pharmaceutical Use, In, Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials, 2nd Updated Edn. (2007).
2. U. Mendie, The Nature of Water, In, The Theory and Practice of Clean Water Production for Domestic and Industrial Use. Lagos: Lacto-Medals Publishers (2005) pp. 1-21.
3. J. K. Vodela, J. A. Renden, S. D. Lenz, W. H. Mchel Henney and B. W. Kemppainen, Drinking Water Contaminants. Poult. Sci., **76**, 1474-1492 (1997).

4. J. E. Marcovecchio, S. E. Botte and R. H. Freije, Heavy Metals, Major Metals, Trace Elements, in, Handbook of Water Analysis. L.M. Nollet, (Ed.). 2nd Edn. London: CRC Press (2007) pp. 275-311.

5. A. A. Adepoju-Bello, O. O. Ojomolade, G. A. Ayoola and H. A. B. Coker, Quantitative Analysis of some Toxic Metals in Domestic Water Obtained from Lagos Metropolis, The Nig. J. Pharm., **42(1)**, 57-60 (2009).

6. Ground Water Information Booklet, Dhemaji District, Assam, Ministry of Water Resources, Guwahati, http://cgwb.gov.in/District_Profile/Assam/.pdf (2008).

7. D. P. H. Laxen and R. M. Harrison, Cleaning Methods for Polythene Containers Prior to the Determination of Trace Metals in Fresh Water Samples, Analytical Chemistry, **53**, 345-350 (1981).

8. APHA, Standard Methods for the Examination of Water and Wastewater, New York, 20th Edition (1998), (APHA, AWWA and WEF).

9. http://www.cdc.gov/ncidod/dpd/healthywater/factsheets/copper.htm

10. J. D. Hem, Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Edition, Scientific Publishers, Jodhpur (1991) pp. 73-122.

11. N. K. Singh and D. S. Kadam, A Study on Ground Water Quality of Dabra Municipal Area, Gwalior, M. P., Int. J. Chem. Sci., **5(2)**, 549-554 (2007).

12. http://dnr.wi.gov/org/water/dwg/copper.htm

13. D. C. Aleksandra and B. Urszula, The Impact of Nickel on Human Health, J. Elementol, **13(4)**, 685-696 (2008).

14. http://www.answers.com/topic/pyrolusite.

15. http://www.oregon.gov/DHS/ph/dwp/docs/gwater/FeMnInGroundwater.pdf.

16. http://www.usfa.dhs.gov/downloads/pdf/publications/Water_Supply_Systems_Volume_II.pdf.

17. http://www.lenntech.com/periodic/elements/zn.htm, Zinc(Zn)-Chemical Properties, Health and Environmental Effects.

18. A. K. Bhattacharya, S. K. Das and S. N. Mandal, Removal of Zinc from Waste Water, Res. J. Chem. Environ., **8(4)**, 77-79 (2004).

19. Allan H. Smith and M. Craig Steinmaus, Health Effects of Arsenic and Chromium in Drinking Water: Recent Human Findings, Annu. Rev. Public Health, **30**, 107-122 (2009).

20. http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=221433.