INTERNATIONAL JOURNAL OF RESEARCH CULTURE SOCIETY
Monthly Peer-Reviewed, Refereed, Indexed Journal
Volume - 7, Issue - 2, February - 2023
ISSN(O): 2456-6683
[Impact Factor: 6.834]
Publication Date: 20/02/2023

DOIs:10.2017/IJRCS/202302005 --:-- Research Paper / Article

Trace Element Contamination and Human Health Risk Assessment in Drinking Water of a Small Town of Lower Assam

[1]Basanta Kumar Das, [2]Himojjal Medhi

[1]Associate Professor, Department of Chemistry, Kokrajhar Govt. College, Kokrajhar, India
[2]P.G. Final Semester Student, Department of Chemistry, Kokrajhar Govt. College, Kokrajhar, India
Email – [1]bkdkgc@gmail.com, [2]hrajmedhi97@gmail.com

Abstract: *The degradation of the environment and some illegal human intervention in the natural system has increased the concern for the betterment of healthy living. In the name of so-called development, some activities of people are creating an imbalance in the natural system. Due to such activities, the first and most affected part of nature is the aquatic system. It is known that a balanced intake of some trace metals is important for human health. But their excessive amount or prolong consumption is harmful. Contamination of trace elements has become a major source of global environmental pollution. The present paper mainly shows the trace elements (As, Cr, Fe, Ni, and Pb) concentrations in the drinking water of Basugaon town and their possible effect on the health of the inhabitants. Some other physicochemical parameters are also analysed. The statistical analysis of the data shows a positive correlation between some parameters. For this purpose, 10 different sampling stations were selected from different parts of the town. The water samples are then analysed by standard methods for temperature, pH, electrical conductivity; total dissolved solids (TDS), hardness, calcium, magnesium, chloride, sulphate, nitrate, fluoride, arsenic, iron, nickel, chromium, and lead. The average concentration of chromium, nickel, and lead was found more than the prescribed limit of WHO in most of the sources. The study shows that the water quality of the town is not satisfactory with respect to some parameters like Cr, Ni, and Pb. However, most of the water samples did not have high concentrations of toxic contaminants, such as fluoride and arsenic. As the whole town is industrially underdeveloped, chemical contamination from industrial sources is insignificant, yet the water cannot be categorized as pollution free.*

Key Words: *Trace element, Water quality, Human health, Contamination, Correlation.*

1. INTRODUCTION:

Water is the essential compound required by every living organism on earth. It constitutes 50 to 90 percent mass of all kinds of the living organism. In spite of its abundance, most of the earth's water is unusable as 97 percent of it is saline seawater. Groundwater provides approximately 85 percent of the water used for human consumption. As groundwater flows from the recharge area to the discharge area. The quality of groundwater degrades due to some chemical changes. From different studies, it is found that anthropogenic involvement mainly by agricultural activities, and industrial and domestic wastewater discharges are the prime causes of water quality degradation [1-3]. Anthropogenic activities like mining, urbanization, municipal activities, etc. are also enhancing the amount of trace metal in groundwater. Over usage of fertilizers containing heavy metals in agriculture is also one of the reasons of contamination of ground water [4]. Though high content of trace metals is hazardous for health, they are also essential nutrients for maintenance of good health but in trace amount. Such elements include Co, Cu, Fe, Mg, and Zn [5]. Increase in population is also one of the reasons of water quality degradation. Discharge of urban sewage to surface water without treatment increases contamination. When water flows over soil surface due to dissolution of different constituents it becomes turbid. As the residence time of the surface run-off increases, the extent of soil-water adsorption and ion-exchange reaction increases, and the quality of water degrades. Road run-off increases heavy metals in the surface as well as groundwater. Industrial waste increases toxic organic and inorganic chemicals in groundwater.

1.1 THE STUDY AREA:

Basugaon is a small town in the Chirang district under the Bodoland Territorial Region (BTR) in the state of Assam, India (Fig 1.). The geographical coordinates of Basugaon town are 26º28′0″ North latitudes and 90º24′0″ East longitude. The town has a mild subtropical climate. Its principal characteristics are a slightly cool and foggy winter, a moderately cool spring, and a fairly hot and humid summer. The main sources of water are ring well and tube well. In this work, an attempt has been made to evaluate the water quality of 10 of the most used shallow tube well by monitoring the common quality parameters (Table 1).

2. MATERIAL AND METHOD:

Water samples for physical and chemical analysis were collected in pre-cleaned polyethylene containers and were brought to the laboratory immediately after collection. Standard methods were followed in the collection; storage and analysis of water samples [6]. Water samples were collected from one of the most used tube wells of every ward. Parameters monitored are -Temperature (°C), pH, Electrical Conductivity (µS/cm), Total Dissolved Solid (mg/L), Hardness (mg/L), Calcium (mg/L), Magnesium (mg/L), Chloride (mg/L), Sulphate (mg/L), Nitrate (mg/L), and Fluoride (mg/L), Arsenic (µg/L), Chromium (mg/L), Iron (mg/L), Manganese (mg/L), Nickel (mg/L) and Lead (mg/L).

The heavy metals As, Cr, Fe, Mn, Ni, and Pb were measured in each water sample with an atomic absorption spectrometer (Perkin-Elmer AAnalyst 200 Atomic Absorption Spectrophotometer). Three-point calibration was done for each metal with certified AAS standards of 1000 mg/L (Merck, Germany). Arsenic was determined by hydride generation atomic absorption spectrometry (HGAAS) using Varian VGA-77 vapour generation assembly with ETC-60 temperature controller as a heat source to atomize the hydride generated with the reducing agent $NaBH_4$ (Merck) and 8M HCl. Here Varian SpectrAA-220 Atomic Absorption Spectrophotometer was used. All the other metals were estimated in the air-acetylene flame.

3. RESULTS AND DISCUSSION:

The water quality of a place provides information about the geological formation, watershed recharge characteristics, the chemical composition of the soil, farm practices, drainage system, land use pattern, waste disposal methods, etc. of the region. The range of temperature was 19^{o}C (TW8) to 23^{o}C (TW3) (Table 2.). Variations in temperature may be due to the different amounts of inorganic and organic loads present in the water bodies. A rise in temperature increases the odour of water because of the higher volatility of odour-causing substances. At higher temperatures, microorganisms like bacteria die away rapidly in the environment [7]. Water treatment processes are also affected by temperature. The effectiveness of chlorination is decreased at low temperatures. At higher temperatures, trihalomethanes are formed in drinking water and contaminated with chlorine which is associated with an increased occurrence of bladder, rectal, and colon cancer along with adverse reproductive effects [8-9]. Temperature also affects the self-purification capacity of the water system. At higher temperatures, bio-degradation of organic materials is enhanced, which increases the demands on dissolved oxygen. But at higher temperatures as oxygen becomes less soluble in water may lead to total oxygen depletion and obnoxious septic conditions [10].

The range of electrical conductivity (EC) is 12 to 47.5 µS/cm. Electrical conductance in water indicates the presence of a higher amount of ionic substances and it may due to perfect entrapment and groundwater recharge as well as solubilization of minerals from the underground soil structure. The importance of EC in the measurement of salinity greatly affects the test and thus has a significant impact on the acceptance of the potability of water [11]. The pH values lie between 6.6 and 7.1. Low pH causes corrosion of equipment and piping in the distribution system and increases metal contamination of drinking water introducing metal ions such as copper, lead, zinc, and cadmium.

The TDS ranges from 49 to 68.5 mg/L. Higher TDS imparts physiological effects and unpalatable mineral taste in water. Water with a dissolved solid content of more than 1000 mg/L is not allowed for drinking purposes [12].

The range of hardness lies between 102 and 119 mg/L. Calcium is an important nutrient for the human body. The maximum (20.5 mg/L) and minimum (8.4 mg/L) value of calcium was obtained in sample no. TW3 and TW7 respectively (Fig 2.). Different types of rocks, sewage, and industrial wastewater are the principal sources of magnesium and it is also a hardness contributor to water. The presence of magnesium in drinking water along with sulphate has a laxative effect. The range of magnesium obtained in the study area is 2.2 mg/L (TW10) to 8.5 mg/L (TW3).

The ranges of sulphate concentrations lie between 1.5 to 20.2 mg/L (Fig 3). Sulphate produces an unpleasant taste at 300 to 400 mg/L concentration and it also has a toxic effect on human health. The WHO recommends 400 mg/L sulphate as the highest desirable limit in water. The ranges of nitrate lie between 2.4 to 4 mg/L. Fertilizers used in cultivation, decayed vegetables, animal bodies, domestic effluents, sewage, sludge, industrial discharge, etc. add nitrate to the water bodies. Nitrate is hazardous to health if its maximum admissible concentration of 50mg/L is exceeded. It is particularly dangerous to infants less than six months old, causing methemoglobinemia. A limit of 10mg/L for nitrate has been fixed for drinking water [13]. The range of chloride is between 17 to 24 mg/L. Chloride occurs naturally in all types of water. The most important source of chlorides in the water is the discharge of domestic sewage. Man, and other animals excrete very high quantities of chlorides together with nitrogenous compounds. Chloride is responsible for the brackish taste of water. The high chloride contents in water bodies may harm metallic pipes and structures as well as agricultural crops if such water is used for irrigation purposes. The fluoride concentrations of all the water samples are below the detectable level (BDL). The presence of fluoride in groundwater may be due to geological deposits, geochemistry of location, and the application of fertilizers like rock phosphate. Irrigation containing a small amount of fluoride ions would tend to concentrate these ions in soil water. The use of rock phosphate or fluoro appetite fertilizer can also introduce fluoride ions on dissolution. Fluoride is beneficial to a certain extent when present in concentrations of 0.8 to 1.0 mg/L for calcification of dental enamel, especially for children below 8 years of age. But it causes dental fluorosis if present in excess of 1.5 mg/L and skeletal fluorosis beyond 3mg/L if such water is consumed for about 8 to 10 years. WHO recommended permissible limit for fluoride in drinking water is 1.0 mg/L.

The range of arsenic obtained was BDL to 0.004µg/L. The arsenic content of all the sources was found below the WHO permissible limit (10 µg/L). The results indicate that arsenic is not a problem in the study area till now. High concentration of arsenic in groundwater in the north-eastern states of India has become a major cause of concern. Chronic arsenic exposure is detrimental to human health being associated with cancer of the skin, lung, liver, urinary bladder, and kidney [14-16] and other diseases, including cardiovascular and peripheral vascular diseases, diabetes, peripheral neuropathies, portal fibrosis, and adverse birth outcomes [17]. The chromium content of all the water samples was found higher than the WHO limit (0.05 mg/L). The major portion of chromium in water exists in hexavalent form because the solubility of its trivalent form in water is very less in pH > 5. pH values of all samples collected for this study are found to be higher than 6 and this indicates the possible presence of chromium in hexavalent form, which is carcinogenic in nature. The respiratory problems prevalent among common people in the study area may be due to the presence of Cr in water bodies. Gastrointestinal ulceration and perforation of the nasal septum and a number of other respiratory problems and skin effects have been reported to be caused by chromium (VI) [10]. The iron contents of water samples were found in the range BDL to 0.07 mg/L. Iron in excess of 0.3 mg/L is known to cause staining of clothes and utensils. Iron in higher concentrations may also cause vomiting. Ni concentration was obtained in the range 0.058 to 0.073 mg/L. The average Ni concentration of most of the water sources of the study area is higher than the WHO permissible limit (0.07 mg/L) and is a matter of concern. Allergic contact dermatitis is the most widely found effect of nickel in the general population. Some nickel compounds are found to be responsible for causing respiratory tract irritation and asthma in industrial workers through inhalation [18]. The highest concentration of lead (0.39 mg/L) was observed in sample no. TW10 and the lowest value (0.21 mg/L) was found in sample no TW1. WHO (2008) has recommended 0.05 mg/L lead in drinking water. Thus, the concentration of lead in the present study area was observed higher than WHO. Chronic exposure to lead cause weight loss, constipation, loss of teeth, and gums may show a blue line due to the deposition of colloidal lead phosphate [12].

CHEMICAL CORRELATION:

The correlation coefficient among the different parameters of water samples collected from 10 different parts of the study area is furnished in Table 3. EC was found to be excellently and positively correlated to TDS, hardness, and Ni (0.78, 0.79, and 0.54) respectively. The mutual significant correlations existing among pH, EC, TDS, and hardness bring to the obvious conclusion that the hardness-causing constituents remain in solution along with other inorganic salts which as a whole contributed to the TDS contents of water samples. The dissolved inorganic matter is responsible for the electrical conductance of water, pH is dependent on the hydrolysis of salts that produce conducting ions. The anions chlorides, sulphate, nitrate, and the cations like calcium and magnesium are the principal inorganic constituents of groundwater samples. It is seen that the anions, chloride, sulphate, and cations, like calcium and magnesium were the major inorganic ions in the groundwater samples. The significant correlation of each of the major anions with each of the major cations helped to predict the composition of principal inorganic compounds in the water samples to be chlorides, sulphates of calcium, and magnesium. The same observation was made by Adak and Purohit in 2001[19]. Nitrate was found to be correlated to calcium and magnesium which indicated the possible presence of nitrate in groundwater in the form of nitrate of calcium, and magnesium. It is observed that fluoride is present in a very less amount in the present study area. It was observed to bear a positive correlation with some parameters. Arsenic bears positive correlation with EC, TDS, Sulphate, etc. From the study, it is seen that some trace metals also bear good correlations with other ions.

Figures/ Tables:

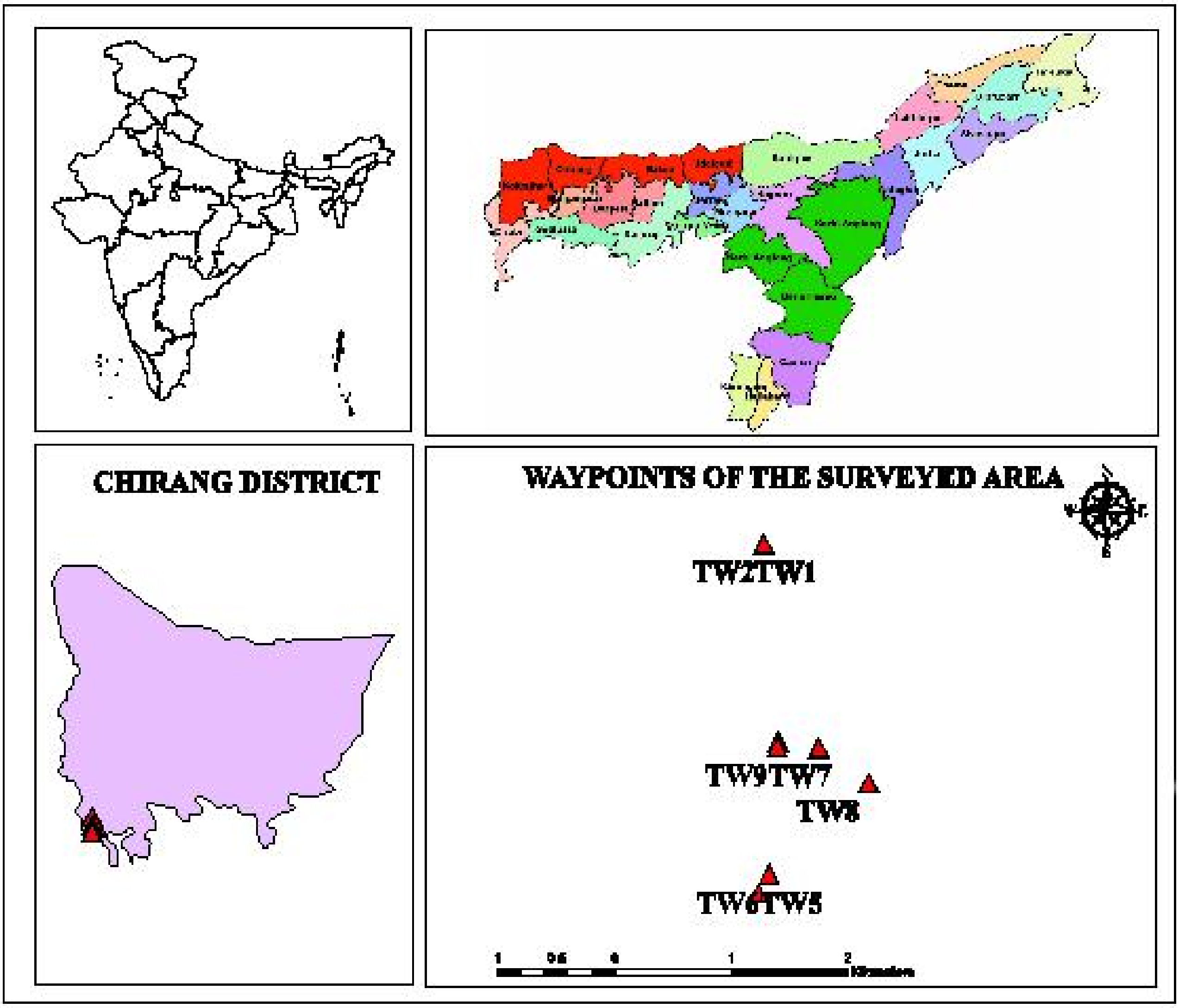

Fig 1. Map of the study area.

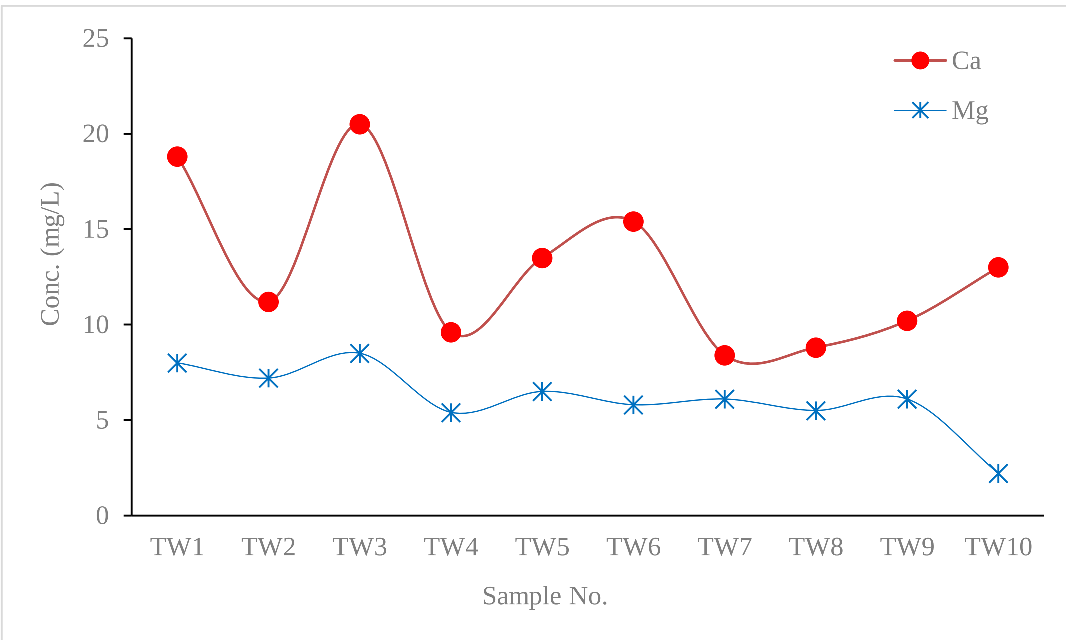

Fig 2. Station wise variation of Ca and Mg

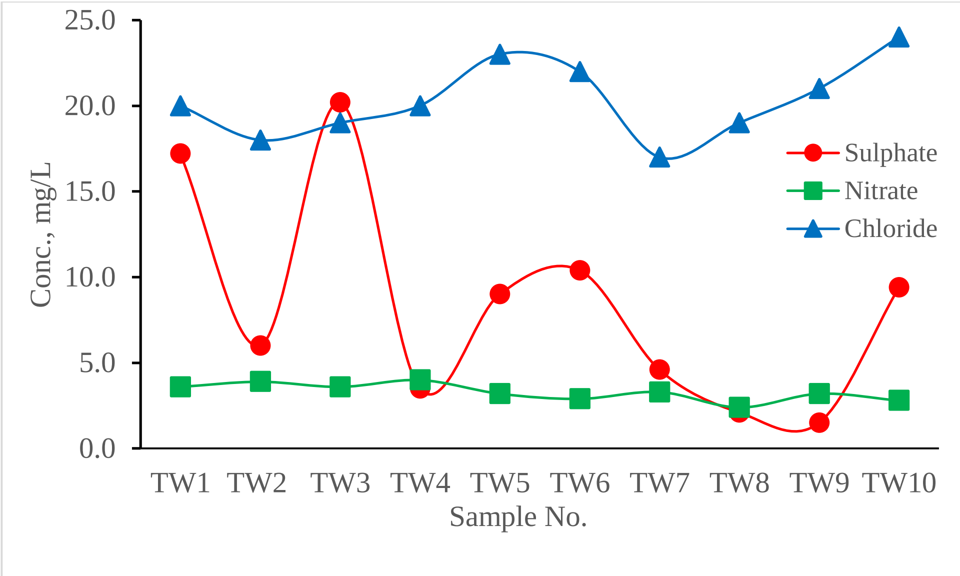

Fig 3. Station wise variation of major anions

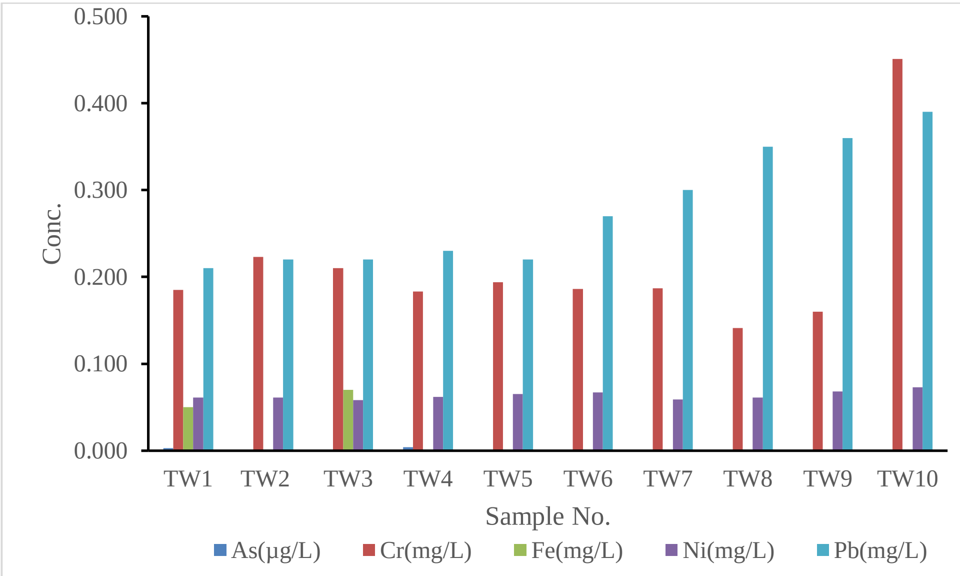

Fig 4. Station wise variation of trace metals

Table 1. Locations and other features of the sampling sites:

Sample no.	Location name	Latitude (N)	Longitude (E)
TW1	Ward No. 2	N $26^{0}28^{/}32^{//}$	E $90^{0}25^{/}16^{//}$
TW2	Ward No. 3	N $26^{0}28^{/}32^{//}$	E $90^{0}25^{/}16^{//}$
TW3	Ward No. 2	N $26^{0}27^{/}40^{//}$	E $90^{0}25^{/}21^{//}$
TW4	Ward No. 3	N $26^{0}27^{/}39^{//}$	E $90^{0}25^{/}21^{//}$
TW5	Ward No. 4	N $26^{0}27^{/}6^{//}$	E $90^{0}25^{/}20^{//}$
TW6	Ward No. 1	N $26^{0}27^{/}6^{//}$	E $90^{0}25^{/}20^{//}$
TW7	Ward No. 1	N $26^{0}27^{/}39^{//}$	E $90^{0}25^{/}34^{//}$
TW8	Ward No. 4	N $26^{0}27^{/}30^{//}$	E $90^{0}24^{/}50^{//}$
TW9	Ward No. 2	N $26^{0}27^{/}39^{//}$	E $90^{0}25^{/}21^{//}$
TW10	Ward No.3	N $26^{0}24^{/}1^{//}$	E $90^{0}16^{/}8^{//}$

Table 2. Physico-chemical parameter:

Sample No.	Temperature (°C)	pH	EC (µS/cm)	TDS (mg/L)	Hardness (mg/L)
TW1	21.0	6.6	12.0	49.0	112.0
TW2	20.0	6.6	21.5	54.4	102.0
TW3	23.0	6.6	41.2	50.9	106.0
TW4	20.0	6.6	45.8	57.2	110.0
TW5	20.6	7.1	26.4	66.2	116.0
TW6	21.2	7.0	47.5	68.5	118.0
TW7	19.5	6.6	41.3	54.1	108.0
TW8	19.0	6.6	39.6	59.6	106.0
TW9	20.7	6.6	28.6	59.6	112.0
TW10	19.3	6.9	32.0	66.2	119.0
Min	19.0	6.6	12.0	49.0	102.0
Max	23.0	7.1	47.5	68.5	119.0
Mean	20.4	6.7	33.6	58.6	110.9

Table 3. Correlation coefficient

	Temp	pH	EC	TDS	Hard	Ca	Mg	SO_4^{2-}	NO_3^-	Cl^-	As	Fe	Ni	Cr	Pb
Temp	1.00														
pH	0.01	1.00													
EC	0.11	0.07	1.00												
TDS	-0.28	0.32	0.78	1.00											
Hard	-0.01	0.05	0.79	0.73	1.00										
Ca	0.83	-0.24	0.25	-0.24	0.19	1.00									
Mg	0.67	-0.27	-0.28	-0.67	-0.55	0.48	1.00								
SO_4^{2-}	0.76	-0.22	0.21	-0.32	0.12	0.97	0.47	1.00							
NO_3^-	0.36	-0.23	-0.36	-0.60	-0.40	0.19	0.52	0.22	1.00						
Cl^-	0.01	-0.08	0.75	0.77	0.89	0.21	-0.55	0.11	-0.38	1.00					
As	0.00	-0.10	-0.30	-0.38	0.00	0.08	0.12	0.08	0.56	-0.07	1.00				
Fe	0.77	-0.21	-0.23	-0.65	-0.22	0.85	0.65	0.87	0.32	-0.21	0.19	1.00			
Ni	-0.26	-0.05	0.54	0.78	0.80	-0.10	-0.77	-0.21	-0.45	0.86	-0.21	-0.47	1.00		
Cr	-0.23	-0.10	0.30	0.32	0.45	0.11	-0.68	0.18	-0.16	0.53	-0.17	-0.46	-0.31	1.00	
Pd	-0.54	0.21	-0.04	0.43	0.29	-0.48	-0.75	-0.51	-0.73	0.28	-0.42	-0.46	0.61	0.39	1.00

4. CONCLUSION:

The study shows that the water quality of the study area is not satisfactory with respect to some parameters like Cr, Ni, Pb, etc. However, most of the water samples did not have high concentrations of toxic contaminants, like fluoride and arsenic. The present study, based on random selection of 10 water sources one from each ward may not be sufficient to arrive at some definite correlation between water quality and health status. But the study has fulfilled the limited purpose of strengthening the data base on water quality which may help in making a strategy for supply of good quality water. It is also expected that this study will encourage further work on the major needs of the regions like awareness generation about safe water and general hygiene, regular monitoring of water quality particularly that of drinking water, needs for water treatment, etc.

REFERENCES:

1. Alam, J.B., Hossain, A., Khan, S.K., Banik, B.K., Islam, M.R., Muyen, Z. and Rahman, M.H. (2007) Deterioration of water quality of Surama River. *Environ.Monit. Assess*. 134:233-242.
2. Venugopal, T., Giridharan, L. Joyprakash, M and Velmurugan, P.M. (2009) A Comprehensive Geochemical Evaluation of the Water Quality of River Adyar, India. *Bull Environ Contam Toxicol*. 82: 211-217.
3. Bhardwaj, V., Singh, D.S. and Singh, A.K. 2010. Water quality of the Chhoti Gandak River using principal component analysis, Ganga plain, India. *J. Earth. Syst. Sci.* 119(1), 117-127.
4. Ullah, R, Malik, R. N., Qadir, A. (2009) Assessment of groundwater contamination in an industrial city Sialkot, Pakistan, African Journal of Environmental Science and Technology, 3 (12), 429-446.
5. Chen H.W., Frey M.M., Clifford D., Mcneill L.S., and Edwards M. (1999) Arsenic Treatment Considerations. Journal of the American Water Works Association, 91, 74-85.
6. *Standard Methods for the Examination of Water and Wastewater* (1995). 19th edition, American Public Health Association/American Water Works Association/Water Environment Federation, Washington DC, USA.
7. Kannan, K. (1991) Fundamentals of environmental pollution. S.Chand and Company Ltd. New Delhi.
8. Boorman, G.A., Dellarco, V., Dunnick, J.K., Chapin, R.E., Hunter, S., Hauchman, F., Gardner, H., Cox, M. and Sills, R.C. (1999) Drinking water disinfection byproducts: Review and approach to toxicity evaluation. *Environ. Health Perspect*. 107 (Suppl.1), 207-217.
9. Hassan, A.A.M., Benfentai, E. and Fanelli, R. (1996) Detection and quantification of trihalomethanes in drinking water from Alexandria, Egypt. *Bull. Environ.Contam Toxicol*. 56, 397-404.
10. Train R.E. 1979 Quality criteria for water. USEPA, Washington, D.C.
11. Jain, C.K., Bandyopadhyay, A and Bhadra, A. (2010) Assessment of ground water quality for drinking purpose, District Nainital, Uttarakhand, India. *Environ Monit Assess*. 166:663–676
12. WHO, 2008. Guidelines for drinking water quality, 3rd edn, incorporating the first and second addenda, Volume-1 recommendations. World Health Organization, Geneva, 668 pages
13. De, A.K. (2003). Environmental Chemistry. 5th ed.,New Age International Publishers, New Delhi
14. Tchounwou, P. B., Patlolla, A. K., and Centeno, J. A. (2003) Carcinogenic and systemic health effects associated with arsenic exposure- a critical review. *Toxicology Pathology*, 31(6), 575–588.
15. Bunnell, J. E., Finkelman, R. B., Centeno, J. A., and Selinus,O. (2007) Medical geology:Aglobally emerging discipline. *Geologica Acta*, 5(3), 273–281
16. Jie, L., and Waalkes, M. P. (2008) Liver is a target of arsenic carcinogenesis. *Toxicological Sciences*, 105(1), 24–32.
17. Xia, Y.,Wade, T. J.,Wu, K., Li, Y., Ning, Z., Le, X. C. (2009) Well water arsenic exposure, arsenic induced skin-lesions and self-reported morbidity in inner Mongolia. *International Journal of Environment Resource Public Health*, 6, 1010–1025.
18. Fishbein L. (1991) In Metals and their compounds in the environment (E. Merian ed.) *VCH Weinheim*, P. 1153-1190.
19. Adak, M.D. and Purohit, K.M. (2001). Status of surface and ground water quality of Mandiakudur- Part-III: Corelation coefficient and regression equations. *Poll. Res*. 20(2), 227-232.