I Research Journal of Environment Sciences _________________________________ I Res. J. Environment Sci.
Vol. 1(1), 7-11, August (2012)

Physico-chemical analysis of groundwater of the Budhi Gandak belt in Muzaffarpur district, India

Mumtazuddin S., Azad A.K., Bharti Prabhat and Ranjan Rakesh
University Department of Chemistry, B.R. Ambedkar Bihar University, Muzaffarpur – 842001, Bihar, INDIA.

Available online at: www.isca.in
Received 30th June 2012, revised 6th July 2012, accepted 9th July 2012

Abstract

The present investigation was carried out to analyse water samples from bored tube wells at different sites along the Budhi Gandak belt from Kanti to Motipur in Muzaffarpur district of Bihar state during winter season (January and February) of 2012. Parameters such as pH, conductivity, TDS, DO, total hardness, alkalinity, sodium, potassium, calcium, magnesium and chloride as well as heavy metals such as Cu, Zn, Fe and As have been studied. TDS of some samples exceeded the maximum permissible limit of WHO. Iron was also found much above the maximum permissible limit of WHO in almost all the samples. Some water samples along Budhi Gandak belt under study had arsenic contamination which even exceeded the maximum permissible limit of WHO. The arsenic contamination in the groundwater of this area is a serious concern for human health.

Keywords: Groundwater quality, physico-chemical and heavy metal parameters, Budhi Gandak belt, Kanti to Motipur, Muzaffarpur.

Introduction

Water has always been an important and life-sustaining drink to humans and is essential to the survival of all organisms. Excluding fat, water composes approximately 70% of the human body by mass. It is a crucial component of metabolic processes and serves as a solvent for many bodily solutes. Groundwater is an invisible natural resource and is present beneath our feet, in the dark pores and fissures of sands and rocks of the upper portion of the earth's crust[1].

Groundwater, which is the water that remains under the ground and is tapped into to provide drinking water for homes is generally polluted by the activities that occur just above it. Groundwater pollution is harder to recognize until after illness has occurred. People are the number one cause of groundwater pollution and it has been major problem in the global context[2-5].

Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use, like serving as drinking water, or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish[6]. Natural phenomena such as volcanoes, algae blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water.

It has been suggested that water pollution is the leading worldwide cause of deaths and diseases and that it accounts for the death of more than 14,000 people daily and 1,000 Indian children die of diarrheal sickness every day. Thus having water samples tested regularly is the only way to be sure that the groundwater is not contaminated.

In continuation of our earlier work[7-10], we have, in the present work, studied quality of water samples from bored tube wells at different stations along the Budhi Gandak belt from Kanti to Motipur in Muzaffarpur district of Bihar state during winter season (January and February) in 2012 with respect to water quality parameters such as Na, K, Ca, Mg, Cu, Zn, Fe and As besides several physico-chemical parameters such as pH, TDS, EC,TH, DO, alkalinity and chloride and comparisons have been made with a series of national and international standards for drinking water.

Material and Methods

Water samples of bored tube wells were collected from 9 different sites of different regions along the Budhi Gandak belt from Kanti to Motipur in Muzaffarpur district during winter season (i.e., January and February) in 2012. The samples were collected in precleaned polythene bottles with necessary precautions[11]. The pH and DO were measured at the sampling sites. The other parameters like total hardness (TH), calcium, magnesium, sodium, potassium, iron, copper, zinc and arsenic were estimated by using standard methods[11-13]. Table 1 describes the methods employed by us to determine the physico-chemical and metal parameters. Table 2 gives the GPS locations of the sampling sites. Figure 1 depicts the course of the river Budhi Gandak.

Results and Discussion

The pH of water is an important indication of its quality and provides significant information in many types of geochemical equilibrium solubility calculation[14]. The pH of the groundwater in the study area varied from 7.33 to 7.65. The pH values of the samples under study are well within the limits prescribed by BIS and WHO for various uses of water including drinking and other domestic supplies.

The EC varied from 540 to 951 μScm^{-1}. All the samples were above the permissible limit of WHO. The TDS of the groundwater in the study area varied from 355 to 572 mg/L. Out of 9 samples, 4 samples were found to be above the maximum permissible limit of WHO. As water moves through soil and rock, it dissolves very small amounts of minerals and holds them in solution. Calcium and magnesium dissolved in water are the two most common minerals that make water "hard" along with their carbonates, sulphates and chlorides in groundwater[15]. Total hardness in the study area varied from 130 to 237 mg/L in the groundwater.

DO is an important parameter for water purity. DO content varied from 3.8 to 4.7 mg/L. The presence of carbonates, bicarbonates and hydroxides is the main cause of alkalinity in natural water. The alkalinity value in the groundwater varied from 142 to 170 mg/L. The calcium content of water samples fluctuated in the range of 45 to 87 mg/L. The results show that nearly 33% of the samples exceeded the limit of WHO. The magnesium concentration varied from 21.2 to 37.2 mg/L. All the samples were within the permissible limit of WHO. The sodium concentration varied from 8.60 to 41.63 mg/L in the study area. All the samples fall within the permissible limit of WHO.

The main sources of potassium in ground water include rain water, weathering of potash silicate minerals, use of potash fertilizers and use of surface water for irrigation. It is more abundant in sedimentary rocks and commonly present is felspar, mica and other clay minerals. The potassium concentration ranged from 4.05 to 11.57 mg/L in the groundwater samples. When compared with European Union (EU) standards, the concentration of potassium exceeded in two sample location. The potassium concentration in water is low because of high degree of stability of potassium bearing minerals.

The concentration of chloride in the study area ranged from 58.4 to 135.2 and hence all the samples under study fall within the desirable limit of 250 mg/L of WHO. The limits of chloride have been laid down primarily from taste considerations. However, no adverse health effects on humans have been reported from intake of waters containing even higher content of chloride[16].

Copper in drinking water arises from corrosive action of water, leaching Cu from copper pipes[17]. The copper content in water samples under study ranged from 0.022 to 0.078 mg/L. Excess copper in human body causes sporadic fever, coma and even death. The water samples under study are free from copper hazard.

Zinc enters in the drinking water from the deterioration of galvanized iron. Accumulation of zinc in human body causes vomiting, renal damage, cramp, etc[18]. The Zn content in water samples varied from 0.26 to 0.75 mg/L and hence water samples are free from zinc contamination.

Limits of iron in water supplies for potable use have not been laid down from health consideration but due to the fact that iron in water supplies may cause discoloration of cloths, plumbing fixtures and porcelain wares besides imparting bitter taste. In drinking water, iron[19] may be present as Fe^{2+}, Fe^{3+} and $Fe\ (OH)_3$ in suspended or filterable forms. However, excessive concentration may cause problems like rapid increase in respiration, hypertension and drowsiness. The iron concentration in water samples under study ranged from 0.35 to 1.80 mg/L. All the samples in the study area exceeded the permissible limit of WHO. This indicates high content of iron in groundwater of the study area.

In typical ground water environments, arsenic may be present in both the As(III) and As(V) states. As(III) is generally more mobile in water than As(V), and has higher toxicity[20]. Due to the withdrawal of excessive amounts of groundwater, problems of increased iron, fluoride and arsenic contamination have been reported in different parts of India[21-26]. Two (i.e., S_3 and S_6) out of nine groundwater samples in the study area were found to have arsenic contamination, exceeding the maximum permissible limit of 10 ppb set by WHO. The results obtained by us regarding the various water quality parameters have been incorporated in Table 3.

Conclusion

The physico-chemical properties studied revealed that the groundwater from Kanti to Motipur in Muzaffarpur district have high electrical conductivity values which indicates the presence of high ionic concentrations. Besides, some samples showed high content of TDS which may cause aesthetic problems and nuisance. However, other physico-chemical parameters were well within the respective maximum permissible limits. As far as heavy metals concern, iron was found much above the maximum permissible limit of WHO in almost all the samples. Surprisingly, arsenic was found above the permissible limit of WHO in a couple of samples which is a matter of great concern and is a potential health risk to the people living in this area.

Thus it calls for an urgent need of an efficient planning and implementation of programmes of water resources appraisal, development, management and remediation besides frequent monitoring to check further increase in the concentration of heavy metals especially arsenic in the study area.

Acknowledgement

The authors are grateful to the University Grants Commission, New Delhi for providing financial assistance under Major Research Project Scheme.

References

1. Kumar T.J.R., Balasubramanian A., Kumar R.S. and Manoharan K., Groundwater Hydrogeochemical Characterization of Chittar sub Basin, Tambaraparani river, Tiirunelveli District, Tamil Nadu, *Nature Environment and Pollution Technology*, **9(1)**, 133-140 **(2010)**

2. Trivedy P.R. and Gurdeep Raj, Encyclopedia of environmental science. Akashdeep publishing house, New Delhi, **12**, 1279-95 **(1992)**

3. Parikh Ankita N. and Mankodi P.C., Limnology of of Sama pond, Vadodara city, Gujarat, *Res. J. Rec. Sci.*, **1 (1)**, 16-21 **(2012)**

4. Murhekar Gopalkrushna Haribhau, Trace metal contamination of surface water samples in and around Akot city in Maharashtra, India, *Res. J. Rec. Sci.*, **1 (7)**, 5-9 **(2012)**

5. Parihar S.S., Kumar Ajit, Kumar Ajay, Gupta R.N., Pathak Manoj, Shrivastav Archana and Pandey A.C., Physico-chemical an microbiological analysis of underground water in and around Gwalior city, MP, India, *Res. J. Rec. Sci.*, **1 (6)**, 62-65 **(2012)**

6. Nwajei G.E., Obi-Iyeke G.E. and Okwagi P., Distribution of selected trace metal in fish parts from the river Nigeria, *Res. J. Rec. Sci.*, **1 (1)**, 81-84 **(2012)**

7. Mumtazuddin S., Azad A.K., Kumar M. and Gautam A.K., Determination of physico-chemical parameters in some ground water samples at Muzaffarpur town, *Asian Journal of Chemical and Environmental Research*, **2(1-2)**, 18-20 **(2009)**

8. Mumtazuddin S., Azad A.K. and Kumar M., Assessment of Water Quality of Budhi Gandak River at Muzaffarpur, Bihar, India, *Int. J. Chem. Sci.*, **7(4)**, 2429-2433 **(2009)**

9. Mumtazuddin S., Azad A. K. and Prabhat Bharti, Assessment of physico- chemical parameters and heavy metals in some groundwater samples at Muzaffarpur Town during pre-monsoon, *Biospectra*, **6 (2)**, 129-135 **(2011)**

10. Mumtazuddin S., Azad A.K., Kaushal Kabir, Kanhaiya Jee and Amjad Ali, Water quality assessment of Oxbow lake of Sikanderpur at Muzaffarpur town in Bihar state in the month of September, 2011, *J. Chemtracks*, **13(2)**, 379-384 **(2011)**

11. APHA, Standard Methods of Examination of Water and Wastewater, 19th ed., American Public Health Association, Washington DC **(1996)**

12. De A.K., Environmental Chemistry. 7th ed., New Age International Publishers, N. Delhi **(2010)**

13. EPA, Quality Criteria for Water, Environmental Protection Agency, Washington DC, USA **(1976)**

14. Definitions of pH scales, standard reference values, measurement of pH, and related terminology, *Pure Appl. Chem.*, **57pp**, 531–542 **(1985)**

15. Ramadevi P. et al, The study of water quality of Ponnamaravathy in Pudukkottai district, Tamil Nadu, *Nature, Environment, and Pollution, Technology*, **8 (1)**, 91-94 **(2009)**

16. Davies S.N. and De Wiest R.J.M., Hydrogeology, John Wiley and Sons, Inc, New York **(1996)**

17. Shrivastava A.K., A review on copper pollution and its removal from water bodies by Pollution Control Technology, *IJEP*, **29 (6)**, 552-560 **(2009)**

18. Abbasi S.A., Abbasi Naseema and Soni Rajendra, Heavy Metals in the Environment, Mittal Publication **(1998)**

19. Adak M.D. and Purohit K.M., Assessment of the water quality in Rajgangpur Industrial Complex – II: Metallic parameters, *Pollution research*, **20 (4)**, 575 **(2001)**

20. Korte N.E., and Fernando Q., A review of arsenic(III) in groundwater, *Critical Reviews in Environmental Control*, **21(1)**, 1-39 **(1991)**

21. Khan H.R., Management of groundwater resources for irrigation in Bangladesh, *FAO*, **(1994)**

22. Bhattacharya P. and Mukherjee A.B., Management of arsenic contaminated groundwater in the Bengal Delta Plain. In conference on Management of Water Resources (eds Chatterji, M., Arlosoroff, S. and Guha, G.), Ashgate Publishing, UK, pp 308–348 **(2002)**

23. Singh A.K., Arsenic contamination in groundwater of North Eastern India. In Proceedings of 11th National Symposium on Hydrology with Focal Theme on Water Quality, National Institute of Hydrology, Roorkee, pp. 255–262 **(2004)**

24. Singh A.K., Approaches for removal of arsenic from groundwater of northeastern India, *CURRENT SCIENCE*, **92 (11)**, 1506-1515 **(2007)**

25. Nickson R.T., McArthur J.M., Burgess W.G., Ahmed K.M., Ravenscroft P. and Rahaman M., Arsenic poisoning of Bangladesh groundwater, *Nature*, 395–338 **(1998)**

26. Manimaran D., Groundwater geochemistry study using GIS in and around Vallanadu hills, Tamil Nadu, India, *Res. J. Rec. Sci.*, **1 (7)**, 5-9 **(2012)**

Table1
Methods used for physico-chemical analysis of water samples

Parameters used	Methods employed
pH	pH meter
Electrical Conductivity (EC)	Conductivity/ TDS meter
Total Dissolved Solids (TDS)	Conductivity/ TDS meter
Dissolved Oxygen (DO)	DO meter
Total hardness(TH)	EDTA Titration.
Total Alkalinity (TA)	Neutralising with standard HCl (Titration)
Calcium	EDTA Titration
Magnesium	By Calculation.
Sodium	Flame photometer
Potassium	Flame photometer
Chloride	Titration by $AgNO_3$
Copper	UV- Visible Spectrophotometer
Zinc	UV- Visible Spectrophotometer
Iron	UV- Visible Spectrophotometer
Arsenic	UV- Visible Spectrophotometer

Table 2
GPS locations of sampling sites

Sampling sites	Sample no.	GPS locations
Kanti, near Chhinnmastika temple	S_1	$26^0$12 N $85^0$17 E
Bathnaha Sri Ram	S_2	$26^0$13 N $85^0$16 E
Kharika	S_3	$26^0$14 N $85^0$15 E
Panapur	S_4	$26^0$14 N $85^0$14 E
Nariyar Navada	S_5	$26^0$14 N $85^0$13 N
Pansalva	S_6	$26^0$15 N $85^0$12 E
Motipur, Indian Institute of sugarcane research regional centre	S_7	$26^0$15 N $85^0$10 E
Motipur Chowk	S_8	$26^0$15 N $85^0$10 E
Motipur, infront of Motipur block	S_9	$26^0$16 N $85^0$03 E

Vol. **1(1),** 7-11, August **(2012)**

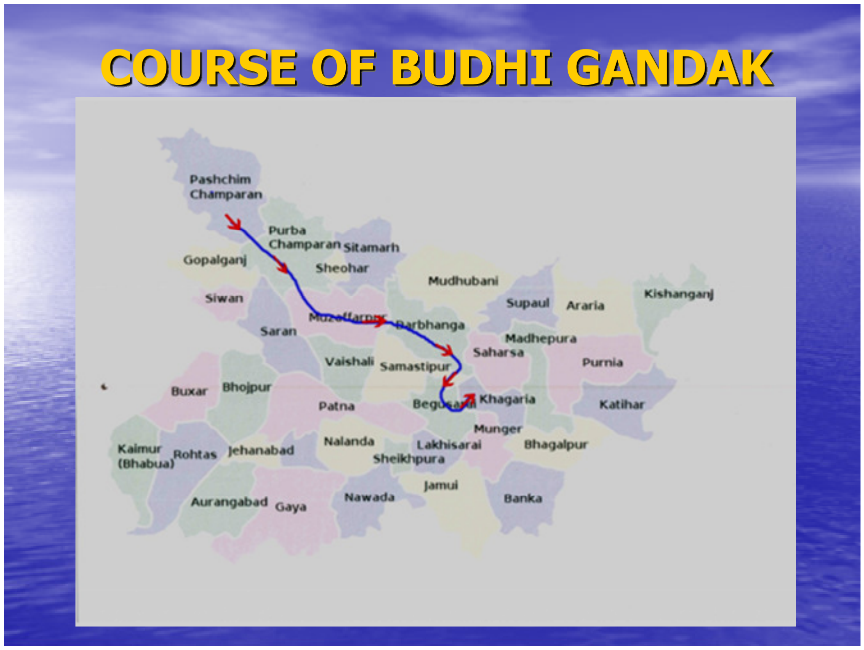

Figure-1
Map of the state of Bihar, India showing the course of the river, Budhi Gandak with arrowed line

Table 3
Physico-chemical parameters and heavy metals of ground water samples

Sample no.	pH	EC	TDS	TH	DO	TA	Ca	Mg	Na	K	Cl^-	Cu	Zn	Fe	As
S_1	7.40	671	435	165	4.7	170	46	25.5	11.02	6.89	135.2	0.025	0.26	1.15	Nil
S_2	7.35	540	355	142	4.1	155	55	21.2	8.60	6.76	67.5	0.022	0.33	1.00	Nil
S_3	7.50	850	502	225	3.8	190	80	30.5	24.57	6.91	58.4	0.045	0.56	0.83	15
S_4	7.30	951	567	237	4.6	142	82	35.6	14.16	10.78	110.7	0.038	0.62	1.15	Nil
S_5	7.54	737	423	170	4.0	210	45	30.3	9.89	11.57	122.5	0.054	0.33	0.83	Nil
S_6	7.42	860	572	240	4.4	185	87	37.2	16.26	6.66	78.3	0.078	0.75	1.80	50
S_7	7.65	586	388	130	3.8	275	38	22.3	41.63	4.68	85.7	0.040	0.65	0.43	Nil
S_8	7.52	874	512	210	4.6	220	78	30.5	19.07	5.48	124.7	0.025	0.55	0.50	Nil
S_9	7.33	698	462	180	4.5	174	60	28.2	29.83	4.05	65.4	0.063	0.27	0.35	Nil
US EPA	6.5-8.2	-	500	-	4-6	-	100	30	<60	10 (EU)	250	1	5	-	-
WHO	6.5-9.2	300	500	500	-	200	75	50	200	-	250	1	5	0.30	10
BIS	6.5-8.5	-	500-1000	300-600	3	200-600	75-200	30-100	250	-	250-1000	0.05-1.5	5-15	0.3-1.0	50
ICMR	6.5-9.2	-	500-1500	300	-	-	75	50	-	-	200	0.05	0.1	0.1	-

*All parameters are expressed in mg/L except pH, EC (in μScm^{-1}) and Arsenic (in ppb)