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Original Research Paper

Assessment of Some Physico-Chemical Characteristics and Heavy Metals in Some Groundwater Samples Along the Budhi Gandak Belt of Muzaffarpur District During Monsoon Season

S. Mumtazuddin, A. K. Azad and Manoj Kumar
University Department of Chemistry, B.R.A. Bihar University, Muzaffarpur-842 001, Bihar, India

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ABSTRACT

This paper presents quality of water samples from bored tube wells at different sites along the Budhi Gandak belt from Akharaghat to Musahari in Muzaffarpur district of Bihar state during monsoon season of 2011. The 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 almost all samples exceeded the maximum permissible limit of WHO. Iron was also found much above the maximum permissible limit in nearly all the samples. The water samples along Budhi Gandak belt under study have arsenic contamination in some samples which even much exceeded the maximum permissible limit at certain sites. The arsenic contamination in the groundwater of this area is serious concern for human health.

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 comprises 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. Water is not only one of the most essential commodities of our day-to-day life, but the development of this natural resource also plays a crucial role in economic and social development processes. Groundwater is an invisible natural resource and is present in the dark pores and fissures of sands and rocks of the upper portion of the earth's crust (Kumar et al. 2010). 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 (Trivedi & Gurdeep 1992). 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. 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. An estimated 700 million Indians have no access to a proper toilet, 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 (Mumtazuddin et al. 2009, 2009, 2011), we have, in the present work, studied quality of water samples from bored tube wells at different stations along the Budhi Gandak belt from Akharaghat to Musahari in Muzaffarpur district of Bihar state during monsoon season in 2011 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.

MATERIALS AND METHODS

Water samples of bored tube wells were collected from 21 different sites of different regions along the Budhi Gandak belt from Akharaghat to Musahari in Muzaffarpur district during monsoon season in 2011. The samples were collected in precleaned polythene bottles with necessary precautions (APHA 1996). 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 (APHA 1996, De 2010).

RESULTS AND DISCUSSION

pH: The pH of water is an important indication of its quality and provides significant information in many types of geochemical equilibrium solubility calculations (Hem 1975). The pH of the groundwater in the study area varied from 7.10 to 7.71. 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.

Electrical conductivity (EC): Electrical conductivity is directly related to the concentration of ionized substance in water and may also be related to problems of excessive hardness and mineral contamination which is measure of salinity that affects the taste of potable water. It depends upon temperature, concentration and types of ions present as studied earlier in our research work. The EC varied from 565 to 1230 µS/cm. All the samples were above the permissible limit of WHO.

Total dissolved solids (TDS): As groundwater moves and stays for a longer time in its flow path, increase in total dissolved concentrations of major ions normally occur (Norris et al. 1992). Higher TDS show longer residence period of water (Davies et al. 1996). The principal ions contributing to TDS are bicarbonate, carbonate, chloride, sulphate, nitrate, sodium, calcium and magnesium (EPA 1976). The TDS of the groundwater in the study area varied from 305 to 710 mg/L. Out of 21 samples, 8 samples were found to be above the maximum permissible limit of WHO.

Total hardness: Calcium and magnesium along with their carbonates, sulphates and chlorides make the water hard in groundwater. The water hardness is primarily due to the result of interaction between water and geological formations. Total hardness in the study area varied from 145 mg/L to 330 mg/L in the groundwater.

Dissolved oxygen: DO is an important parameter for water purity. DO content varied from 3.4 mg/L to 5.8 mg/L. The fluctuations in DO values indicate its dependence on temperature besides the influence of sources due to different chemical and biological processes taking place.

Total alkalinity: The presence of carbonates, bicarbonates and hydroxides is the main cause of alkalinity in natural waters. Bicarbonates represent the major factor since they are formed in considerable amount from the action of carbonates upon the basic materials in the soil. The alkalinity value in the groundwater varied from 165 mg/L to 310 mg/L.

Calcium: The calcium content of water samples fluctuated in the range of 39 mg/L to 110 mg/L. The results show that nearly 33% of the samples exceeded the limit of WHO. The presence of calcium is due to interaction of minerals like felspar as well as due to the weathering process.

Table 1: Methods used for physico-chemical analysis of water samples.

Parameters	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

Magnesium: The magnesium concentration varied from 6.2 mg/L to 26.1 mg/L. All the samples were within the permissible limit of WHO.

Sodium: The sodium concentration varied from 21.56 mg/L to 95.62 mg/L in the study area. All the samples fall within the permissible limit of WHO.

Potassium: Potassium is an essential element for humans, plants and animals and is derived in food chain mainly from vegetation and soil. The main sources of potassium in groundwater 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 2.86 mg/L to 22.12 mg/L in the groundwater samples. When compared with European Union (EU) standards, the concentration of potassium exceeded in one sample location. The potassium concentration in water is low because of high degree of stability of potassium bearing minerals.

Chloride: The concentration of chloride in the study area ranged from 22.8 mg/L to 235.6 mg/L 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. A limit of 250 mg/L chloride has been recommended as desirable limit and 1000 mg/L as the permissible limit for drinking water (BIS 1991, WHO 1996). However, no adverse health effects on humans have been reported from intake of waters containing even higher content of chloride (Shrivastava & Nemade 1997).

Copper: Copper in drinking water arises from corrosive action of water and leaching of Cu from copper pipes (Adak

Table 2: Physico-chemical parameters and heavy metals in groundwater samples.

Sampling sites	Sample No.	pH	EC	TDS	TH	DO	TA	Ca	Mg	Na	K	Cl^-	Cu	Zn	Fe	As
Akharaghat, Near Gaytri temple	S_1	7.15	860	452	181	4.4	185	51	6.2	40.62	4.12	95.5	0.022	0.43	0.20	65
Akharaghat, Karpuri Nagar	S_2	7.21	1221	625	235	3.7	190	48	19.1	29.23	2.90	65.7	0.030	0.59	0.25	Nil
Akharaghat, near Shamshanghat	S_3	7.20	595	325	292	4.7	178	77	17.8	41.66	4.50	112.2	0.025	0.54	0.21	Nil
Sikanderpur, Srighat	S_4	7.15	855	456	280	4.8	170	79	14.1	59.27	6.25	185.6	0.045	0.75	1.25	10
Chandwara, Kamra	S_5	7.29	722	390	260	3.4	205	50	21.2	39.31	3.12	105.3	0.039	0.55	0.37	Nil
Awantipur	S_6	7.35	565	305	207	4.7	215	55	8.6	69.12	7.23	210.4	0.029	0.54	1.07	35
Bhagwatipur	S_7	7.71	948	510	330	4.5	310	110	13.1	42.54	4.95	162.1	0.049	1.49	0.94	57
Balughat, Raj Narayan Singh College	S_8	7.41	1105	595	249	5.1	235	78	10.2	21.56	7.45	22.8	0.046	1.12	0.55	22
Dr. Jagannath Mishra College	S_9	7.25	907	505	225	3.6	210	51	18.2	48.42	3.12	178.5	0.031	0.69	0.33	Nil
Kanhauli, Sahdullahpur	S_{10}	7.40	715	378	330	3.7	227	95	8.3	30.20	4.13	72.3	0.032	1.78	1.02	38
Kanhauli (west), Bisnudatta tola	S_{11}	7.26	880	470	232	4.7	195	39	26.1	51.66	2.86	145.8	0.024	0.30	2.67	12
Kanhauli (East), Bisnudatta tola	S_{12}	7.12	595	335	251	4.9	187	71	14.6	76.21	3.05	218.2	0.060	0.21	0.47	25
Kanhauli, Leprosy Mission	S_{13}	7.10	855	465	294	5.8	165	80	19.2	50.64	4.25	165.4	0.048	1.12	0.55	17
Kanhauli, Bawan Bigha	S_{14}	7.40	1017	535	145	3.9	212	45	7.7	91.21	6.71	225.3	0.075	0.85	1.07	Nil
Punas	S_{15}	7.12	930	507	183	4.7	178	50	10.1	60.73	2.91	186.2	0.040	2.51	2.57	44
Kothiyan Chowk	S_{16}	7.30	860	485	197	4.8	207	66	6.6	53.03	7.54	180.2	0.031	0.56	0.67	50
Kothiyan	S_{17}	7.29	1230	610	238	4.4	210	60	13.8	92.56	4.24	216.4	0.021	0.85	0.42	87
Rehua Chowk	S_{18}	7.51	937	458	215	4.1	245	75	7.5	95.62	22.12	235.6	0.042	1.90	0.37	20
Musahari	S_{19}	7.10	1180	710	180	5.2	171	53	8.7	79.25	5.75	207.2	0.022	2.26	0.34	Nil
Musahari Police Station	S_{20}	7.41	660	375	177	3.9	247	48	10.4	38.32	4.28	95.6	0.039	0.47	0.30	Nil
Gaushala Chowk, Badi Imambada	S_{21}	7.18	842	447	220	5.5	191	60	13.2	51.18	4.10	140.2	0.050	0.74	0.21	Nil
U.S. EPA standards	-	6.5-8.2	-	500	-	4-6	-	100	30	<60	10(EU)	250	1	5	-	-
WHO standards	-	6.5-9.2	300	500	500	-	200	75	50	200	-	250	1	5	0.30	10
BIS standards	-	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 standards	-	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 (μScm^{-1}) and arsenic (ppb).

& Purohit 2001). The copper content in water samples under study ranged from 0.021 mg/L to 0.075 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: Zinc enters in the drinking water from the deterioration of galvanized iron. Accumulation of zinc in human body causes vomiting, renal damage, cramps, etc. (Alur & Patil 2008). The Zn content in water samples varied from 0.21 mg/L to 2.51 mg/L and hence, water samples are free from zinc contamination.

Iron: 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 discolouration of cloths, plumbing fixtures and porcelain wares besides imparting bitter taste. In drinking water, iron (Pande 2001) 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 0.20 mg/L to 2.67 mg/L. About 76% of the samples in the study area exceeded the permissible limit of WHO. This indicates high content of iron in groundwater of the study area.

Arsenic: In typical groundwater 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 (Korte & Fernando 1991). 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 (Khan 1994, Bhattacharya & Mukherjee 2002, Singh 2004). A recent study on cancer risks from arsenic in drinking water indicates that it could cause liver, lung, kidney and bladder cancers besides skin cancer (Smith et al. 1992). Twelve out of 21 (i.e., 57%) groundwater samples in the study area were found to have arsenic contamination and exceeded the maximum permissible limit of 10 ppb set by WHO.

CONCLUSION

The physico-chemical properties studied revealed that the groundwater in Muzaffarpur town has marked electrical conductivity values that indicates the presence of high ionic concentrations in the groundwater during monsoon season. Besides, some samples also showed high content of TDS which may have aesthetic problems or cause nuisance. Few samples showed high values of calcium as well. However, other physico-chemical parameters were well within the respective maximum permissible limits. As far as heavy metals are concerned, 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 57% of the 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.

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