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Research article

QUALITY ASSESSMENT OF DRINKING WATER: A CASE STUDY OF MOHANPUR VILLAGE OF DISTRICT SAMASTIPUR, BIHAR, INDIA

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ABSTRACT: Assessment of quality of drinking water is very crucial for public health. A study was conducted to evaluate the quality of groundwater in a village Mohanpur situated at the boarder of Samastipur town of North Bihar. Water samples were randomly collected from 20 tube wells situated near the pit latrines at the radius of 10-15 feet. The samples were analyzed for physico-chemical parameters like pH, electrical conductivity, total hardness, total dissolved solids; chemical parameters like total alkalinity, calcium, magnesium, chloride, nitrate, sulphide, and microbiological parameter total coliform (MPN)**.** In most of the water samples the values of one or more physicochemical parameters of drinking water were higher than the BIS permissible level. In pre-monsoon season 13 water samples and in post-monsoon season 15 water samples showed MPN above the recommended permissible level. Introduction of sewage and animal waste into the drinking water might be the reason for the contamination of water samples.
Key words: Physico-chemical, bacterial, total coliform, MPN, groundwater, Mohanpur village

INTRODUCTION

Pollution of surface and groundwater is a global concern of the day. Majority of the people in this locality depend on fresh water supplies from ground water. It is the only source of water for domestic use. In this part of the country groundwater is being exploited at large scale for both domestic and agricultural uses. This resulted in lowering of water table to such an extent that during summer season many tube wells become dry. The improper management of water systems may cause serious problems in availability and quality of water in near future. The deterioration of ground water quality is more severe in densely populated villages. Lack of proper amenities and sewage disposal practices in most of the villages has rendered the water unsafe for drinking as well as for domestic purpose. Due to lack of proper drainage system in the villages the sewage water gets accumulated in the form of stagnant water in small ditches. In monsoon season the agricultural run off water also accumulate in these ditches and remains there for longer duration. Some part of the accumulated water from these ditches may percolate into the soil and reach to shallow aquifers. Domestic sewage and agricultural run-off can overload groundwater with chemical wastes and nutrients. This results in deterioration of groundwater quality due to contamination with harmful chemicals and different bacteria including pathogens. During the past decade, widespread reports of ground water contamination have increased public concern about drinking water quality. The water quality characteristics is assessed in terms of physical parameters like pH, total dissolved solid (TDS), electrical conductivity (EC) etc., chemical parameters like total alkalinity, total hardness, Ca, Mg, Cl, Fe, NO_3, SO_4, PO_4 etc. and microbiological characteristics such as colony forming unit (CFU/100 mL), total coliform (TC/100 mL), faecal coliform (FC/100 mL), faecal streptococci (FS/100 mL) etc. A number of papers dealing with contamination of groundwater were published recently [1-7]. In the present study we have selected Mohanpur village located in the out skirt of Samastipur town as our experimental site and monitored the quality of water during pre- and post-monsoon seasons of 2013. To the best of our knowledge, no report is available on the physico-chemical and bacterial analysis of groundwater from this area.

MATERIALS AND METHODS

Samastipur is located on 19.57’ north latitude and 79.18’ east longitudes in the northern Bihar, and situated at 189.90 meter above form the mean sea level. The district is situated on the Budhi Gandak river basin. The climate of Samastipur is tropical with hot and humid summer months and cold winter season.

In the present study Mohanpur village situated at the boarder of Samastipur town was selected for monitoring of groundwater quality. In this village the only source of drinking water is groundwater drawn from tube wells with a hand pump. The depth of these tube wells varies from 60-100 ft. Water samples were collected from 20 tube wells from different parts of this village in between March to May (pre-monsoon season) and October to December (post-monsoon season), 2013. Samples were collected in pre-cleaned polypropylene bottles with necessary precautions between 8.00 to 9.30 AM. After collection the samples were immediately transported to laboratory for the analysis. The physico-chemical parameters selected were pH, electricalconductivity (EC), total dissolved solid (TDS), total hardness (TH), total alkalinity (TA), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Chloride (Cl^-), Nitrate (NO_3^-) Sulphate (SO_4^{2-}) and Iron (Fe) as per standard procedures [8]. The quality of ground water has been assessed by comparing each parameter with the standard desirable limit of that parameter in drinking water as prescribed by ISI 10500-91.

Bacteriological analysis was carried out the day on which the samples were collected. Samples from each site were assessed for total coliform (TC) count. The analysis was carried out using the multiple–tube fermentation technique [9]. This was done in three steps; the presumptive, the confirmed and completed tests. Most Probable Number (MPN) of total coliform was determined by referring to standard probability table for estimation of total coliform.

RESULTS AND DISCUSSION

The average value of different water quality parameters, their desirable limits and permissible limit in the absence of alternate source as per Drinking Water Specification First Revision -ISI:10500:1991, Edition 2.2 (2003-09), are summarised in Table 1 and 2. The pH values of water samples varied from 6.7 to 8.4 in both pre- and post-monsoon seasons. The water samples analysed were either slightly acidic or slightly alkaline but were well within the limit prescribed by ISI (6.5-8.5). In the pre-monsoon season EC values were in the range of 402.7 to 654.5 micromhos cm^{-1} and in the post-monsoon season in the range of 423.0 to 676.4 micromhos cm^{-1}. The WHO permissible limit of EC in water is 600 mhos cm^{-1}. In the present study 6 water samples showed higher EC values than the permissible limit. Electrical conductivity is a measure of water capacity to convey electric current and is an indicator of the amount of total dissolved salts. The variations in the EC of water samples of the same area indicates that their exist variation in the amount of dissolved inorganic substances in ionized form in the water samples. The desirable level of TDS of drinking water as prescribed by BIS is 500 mg/L but in unavoidable cases 2000 mg/L is also allowed. In the water samples the TDS values in pre-monsoon season varied from 241.6 to 688.7 mg/L whereas in post-monsoon season it ranged from 301.7 mg/L to 735 mg/L. In the pre-monsoon season 8 samples showed higher TDS values where as in post-monsoon season 10 samples showed higher TDS values than the desirable limit given by ISI 10500-91. Water with high dissolved solids generally is inferior quality. In the water samples collected during pre-monsoon season, the total hardness values ranged from 229.7 mg/L to 499.5 mg/L. On the other hand, in the post-monsoon season higher values were found for all the samples and it ranged from 232.1 mg/L to 506.3 mg/L. Out of 20 samples analysed in the present study 15 sample in the pre-monsoon season and 16 samples in the post monsoon season showed higher TH values than the desired level but lower than permissible limit. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. All the samples showing higher TH values also showed either higher level of Ca^{2+} or Mg^{2+} or both. Calcium concentration in the water samples in the pre-monsoon season ranged between 46.37 to 90.35 mg/L while in post-monsoon season it ranged from 31.90 to 99.70 mg/L. Out of 20 samples Ca^{2+} concentration was higher than desirable level (75 mg/L) in 5 samples only. Magnesium concentration in the investigated water samples ranged from 12.45 to 61.45 mg/L in pre-monsoon season and 16.0 to 62.80 mg/L in post-monsoon season. Out of the 20 samples analysed, 11 samples showed presence of magnesium above the desirable level (30 mg/L). Chloride is one of the major inorganic anion of water. High concentration of chloride indicates pollution due to organic waste. In the present analysis, chloride (Cl^-) concentration in the water samples was found in the range of 15.3 to 97.6 mg/L in pre-monsoon season and 22.4 to 88.7 mg/L in post-monsoon season. In all the water samples the value was within the desirable limit (250 mg/L). Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium. Total alkalinity values of all the water samples analysed were found to be higher than the desirable limit (300 mg/L) but within the permissible limit (600 mg/L) in the absence of alternate source (ISI 10500-91). The nitrate (NO_3^-) content in the water samples varied in the range 0.19 mg/L to 0.75 mg/L and found much below the desirable limit (45 mg/L). Similarly the sulphate (SO_4^-) concentration varied between 16.8 mg/L to 25.7 mg/L in pre-monsoon season and 22.7 to 43.3 mg/L in post-monsoon season. These values were much lower than the desirable limit (200 mg/L). Iron is an important element for human and other organisms, as it is partially responsible for transporting oxygen through the bloodstream. Iron easily gets dissolved in water and found in naturally occurring water bodies. Iron is an essential element for human nutrition and metabolism.

But in large quantities it produces toxic effect. Accumulation of iron causes haemochromoitosis in tissues. Iron content of different sites in sampling village was found to be in the range of 0.11 to 0.72 mg/L in pre-monsoon season and 0.12 to 0.88 mg/L in post-monsoon season. Out of 20 samples analysed 14 contained iron concentrations above the desirable limit (0.3 mg/L) hence it can affect the health of local public. The bacteriological analysis of water in the present study revealed that some of the water samples contain coliform indicating higher level of contaminated. Among all the samples, 15 (75%) samples showed high density of faecal coliforms compared to rest of the samples. These samples contained total coliform population in the range of 1.1-12 MPN/100 mL. Presence of faecal coliforms in drinking water serves as a potential indicator of harmful bacteriological contamination. A comparison of data of revealed that there was a two to threefold increase in concentrations of indicator organisms during post-monsoon season as compared to pre-monsoon season Higher densities of indicator organisms during post-monsoon season might be due to more percolation as well as seepage of domestic sewage through the soil. On the contrary depletion in the ground water level and evaporation of domestic sewage due to intense heat of summer are two main factors contributing to very low number of indicator organisms in the samples collected in pre-monsoon season. The present study revealed that most of the groundwater samples have failed to meet the water quality parameters. Out of 20 samples analysed in the present study, 6 samples are not fit for drinking so far as physico-chemical characteristics of drinking water is concerned. On the other hand, 15 samples showed presence of coliform bacteria thus showing faecal contamination. The maximum bacterial contamination was observed in the samples collected in monsoon season.

Table-1: Physico-Chemical and bacteriological characteristics of tube well water samples collected from Village Mohanpur during pre-monsoon season (March-May, 2013)

Sample Number	Physico - Chemical characteristics											Bacteriology
	pH	EC	TDS	TH	Ca	Mg	Cl	Alka.	Fe	NO_3	SO_4	T.Coliform
1	6.7	432.4	351.7	288.4	52.4	16.4	17.7	329.5	0.11	0.36	16.82	5.1
2	6.8	465.7	412.8	310.5	64.3	24.7	22.8	345.2	0.23	0.19	18.59	<1.1
3	6.9	544.4	534.6	368.3	68.3	33.2	46.4	418.6	0.43	0.32	21.38	<1.1
4	6.9	654.5	548.5	434.6	88.0	42.1	75.1	432.8	0.58	0.36	22.46	5.1
5	7.2	632.6	688.7	499.5	90.3	61.4	97.6	498.9	0.72	0.42	27.45	<1.1
6	7.0	618.9	675.7	488.9	88.1	53.9	95.2	467.7	0.66	0.30	25.75	<1.1
7	7.5	402.7	241.6	229.7	46.3	12.4	13.6	231.8	0.09	0.19	12.83	<1.1
8	8.4	506.3	418.6	319.8	64.7	24.7	31.2	365.0	0.32	0.24	19.65	1.1
9	7.0	646.8	612.8	441.7	88.1	47.7	86.7	451.9	0.63	0.22	25.35	5.1
10	6.8	448.9	425.6	321.7	68.3	31.3	38.4	386.9	0.36	0.75	19.67	2.2
11	6.8	476.4	403.6	304.5	62.1	24.4	21.5	345.2	0.21	0.46	18.10	<1.1
12	6.9	522.7	451.9	343.4	68.3	31.9	43.3	402.6	0.42	0.19	20.15	1.1
13	6.6	404.6	345.7	286.4	49.6	13.9	16.5	248.7	0.09	0.22	15.48	6.9
14	7.6	405.8	335.6	265.4	47.7	12.9	15.3	248.7	0.09	0.24	14.54	3.2
15	6.9	590.7	546.7	412.5	71.8	35.8	63.4	424.9	0.56	0.36	21.38	10.2
16	6.9	622.6	546.8	433.6	79.6	37.4	72.5	429.7	0.57	0.48	22.10	5.1
17	7.0	444.7	369.3	289.9	59.6	22.0	18.4	341.2	0.12	0.39	16.82	<1.1
18	8.2	535.8	542.5	395.6	68.3	35.6	50.6	422.9	0.43	0.56	21.38	6.9
19	6.8	499.6	423.8	320.6	66.0	26.3	32.6	375.6	0.56	0.35	19.65	6.9
20	6.9	521.8	440.5	322.5	68.3	31.4	65.4	390.5	0.65	0.48	19.68	5.1
Desirable Limit*	6.5-8.5	–	500	300	75	30	250	200	0.3	45	200	–
Permissible Limit in absence of Ialternate source **	NR	–	2000	600	200	100	1000	600	1.0	NR	400	**

, * Drinking Water Specification First Revision -IS:10500:1991,Edition 2.2(2003-09)(Reaffirmed1993), NR = No Relaxation,

*** Throughout any year, 95% of the samples should not contain coliform organisms in 100ml of sample

Table 2: Physico-chemical and bacteriological characteristics of tube well water samples collected from Village Mohanpur during post-monsoon season (October - January, 2013)

Sample Number	Physico - Chemical characteristics											Bactr ology
	pH	EC	TDS	TH	Ca	Mg	Cl	Alka.	Fe	NO_3	SO_4	T.Col iform
1	7.4	451.7	377.5	322.7	42.80	21.50	22.4	344.6	0.23	0.41	26.90	6.9
2	7.9	505.8	422.8	310.5	66.70	18.60	24.80	334.4	0.48	0.22	22.70	<1.1
3	7.8	578.9	555.6	368.3	54.60	22.40	34.90	406.3	0.27	0.35	43.30	2.2
4	7.6	645.6	569.7	412.8	76.40	32.60	64.80	466.7	0.65	0.46	29.00	6.9
5	8.4	676.4	710.6	456.2	99.70	44.5	84.30	532.6	0.45	0.55	40.40	<1.1
6	7.0	654.9	735.8	506.3	67.50	62.80	88.70	521.9	0.88	0.34	32.7	<1.1
7	7.6	423	301.7	242.7	31.90	16.60	24.80	301.7	0.19	0.26	21.90	3.2
8	6.8	522.5	442.4	329.4	55.70	32.40	44.90	332.4	0.45	0.33	20.50	3.2
9	7.0	649.9	632.7	445.7	64.70	56.80	76.40	478.6	0.76	0.38	32.60	12.0
10	7.5	534.2	465.8	301.6	78.90	24.70	48.90	389.9	0.44	0.75	22.30	6.9
11	7.8	488.9	412.9	276.8	66.50	44.60	34.70	322.8	0.38	0.55	34.70	1.1
12	6.9	558.9	471.7	366.5	72.30	52.40	31.80	444.7	0.56	0.49	16.20	1.1
13	7.9	448.5	365.9	296.9	65.40	26.80	22.60	298.9	0.22	0.44	17.40	6.9
14	7.2	435.8	342.6	232.1	57.60	18.30	35.3	265.7	0.12	0.32	12.10	3.2
15	7.6	622.7	566.7	424.7	56.90	44.70	76.40	432.8	0.65	0.56	17.50	12.0
16	6.9	638.9	578.9	442.8	86.40	31.30	66.50	389.7	0.88	0.44	32.90	6.9
17	7.4	460.6	380.7	305.7	55.40	29.90	28.90	322.6	0.19	0.19	28.70	3.2
18	7.4	589.3	556.8	354.8	58.20	34.70	46.40	414.9	0.27	0.26	30.60	10.2
19	7.8	525.3	542.7	365.4	72.10	21.80	38.90	356.8	0.18	0.27	22.50	6.9
20	7.9	554.2	468.2	342.7	66.40	32.90	54.30	412.7	0.77	0.33	16.50	6.9
Desirable Limit*	6.5-8.5	–	500	300	75	30	250	200	0.3	45	200	–
Permissible Limit in absence of Ialternate source **	NR	–	2000	600	200	100	1000	600	1.0	NR	400	**
, * Drinking Water Specification First Revision -IS:10500:1991,Edition 2.2(2003-09)(Reaffirmed1993), NR = No Relaxation												
*** Throughout any year, 95% of the samples should not contain coliform organisms in 100ml of sample												

CONCLUSION AND RECOMMENDATION

The study showed that contamination of water was more prominent where poor hygienic conditions are prevalent. Most of the tube wells were situated outside the house. Lack of adequate sanitation facilities and hygiene practices makes the situation more critical. Sewage disposal practices like soak pit system and disposal of animal excreta near the tube wells are mostly contributing to contamination of water. Due to lack of knowledge and low affordability the tube wells are mostly shallow in nature and hence there is high risk of faecal contamination. So, water, must be boiled and filtered before use for drinking purpose in these areas. Public should be made aware of the water quality importance before use and it is necessary to implement remedial measures.

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