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RESEARCH ARTICLE

Assessment of chemical and microbial contamination of groundwater around pit-latrines – A case study in Dharampur and Dadpur villages of Samastipur District of Bihar

Priyanka, Surendra Prasad and Anand Mohan Jha
Department of Botany, R. N. A. R. College, Samastipur-848 101, Bihar, India

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***Corresponding Author**

Priyanka

Abstract

In the present study an Investigation was carried out to assess the extent of chemical and microbial contamination of drinking water in two villages viz. Dharampur and Dadpur of Samastipur. This study was carried out in the pre- and post-monsoon seasons of year 2011, 2012 and 2013.Water samples were randomly collected from 20 tube wells situated near the pit-latrines at the radius of 10-20 ft. Water samples were analyzed for some inorganic pollutants i.e. nitrates (NO_3^-), nitrite (NO_2^-) and ammonium (NH_4^+) and bacteriological population. In all the samples of water the level of nitrate, nitrite and ammonium was below the Maximum Acceptable Limit (MAL). With regards to bacteriological parameters, most of the samples tested positive to coliform indicating microbial contamination of water in these localities.

Introduction

Ground water is an essential and vital component of life support system on this earth. The ground water resources are being over exploited for drinking, irrigation and industrial purposes all over the world. Rapid growth of population, urbanization, industrialization and agriculture activities in recent past, not only put our ground water resources under stress, but also caused deterioration of ground water quality. Ground water contains a wide variety of dissolved inorganic chemical constituents in various concentrations, resulting from chemical and biochemical interactions between water and the geological materials. Inorganic contaminants including salinity, chloride, fluoride, nitrate, nitrite, iron and arsenic are important in determining the suitability of ground water for drinking purposes. Groundwater is an important source of drinking water and its quality is currently threatened by the combination of chemical pollution and microbiological contamination. The World Health Organization (WHO, 1992) reported that nearly half of the population in developing countries suffers from health problems associated with consumption of contaminated drinking water. Microbial contamination of drinking water is a major concern for human health. Poor microbial quality of drinking water is linked to various health conditions. Surveillance of water quality to ensure microbiological and chemical safety is a vital public health function especially in rural areas in developing countries. Pit-latrine is often promoted as sustainable, affordable and hygienic solution to sanitation issue in rural areas of the developing countries. Pit-latrines are one of the major causes of pollution of shallow aquifers because it contains the excreted pathogens and certain chemical constituents like nitrate, nitrite and ammonium ions. The pit latrines generally lack a physical barrier, such as concrete, between stored excreta and soil and/or groundwater (vanRyneveld and Fourie 1997). Accordingly, contaminants from pit-latrine excreta may potentially leach into groundwater, thereby threatening human health through water contamination (Graham and Polizzotto, 2013). The presence of poorly designed pit latrines as well as poor and inadequate groundwater protection may lead to contamination of groundwater. Groundwater contamination by nitrate, nitrite and ammonium ions is a global problem and nitrate is a wide-spread contaminant of ground and surface water worldwide. Numerous sources in the environment contribute to the total nitrate content of natural waters mainly by agriculture, human and animal wastes etc.

Bihar is the third largest state of Republic India having population over 86 million. 89% of its population resides in rural area. Recent findings of the water quality mapping of the whole state (226145 samples were tested during November 2007-February 2008, covering all the 38 districts) indicates that the drinking water sources in rural areas are not safe in most of the area and the health of the rural population is at risk (Mishra, 2009). Apart from chemical impurities fecal contamination of water is prevalent in many water sources (Envirotech Report PHED, 2008). This study was carried out in Dharampur and Dadpur village of Samastipur district of Bihar. As is the case with most rural communities in the country, the people of these two villages mainly use shallow tube wells as a source of domestic water. Pit latrines are one of the most common human excreta disposal systems for low income group of people and their use is on the rise. High densities of pit-latrines and lack of the construction of improved pit-latrines may lead to chemical and microbial contamination of groundwater in this locality. Further, in most cases water from these sources is used directly without treatment. In the present study we have monitored the chemical and microbial quality of drinking water during pre- and post-monsoon season of the year 2011, 2012 & 2013. To the best of our knowledge, no report is available on the nitrate, nitrite, ammonia and bacterial analysis of groundwater from this area.

Materials and Methods

Two villages (Dharampur and Dadpur) situated at the western boarder of Samastipur a District of State of Bihar were selected for the study. This area was chosen because people of these villages drink untreated groundwater drawn from tube wells with a hand pump. The depth of these tube wells varies from 20-40 meters. These tube wells were situated at a distance of 3-4 m from the pit latrines. Water samples from the 20 tube wells were collected in the pre-monsoon (between March to May) and post-monsoon seasons (between October to December) in the year 2011, 2012 and 2013. Sampling was done in the morning and the water samples were collected in 1 L polyethylene bottles and 1 mL of 10 ppm $HgCl_2$ solution (preservative) was added to each sample. Until analysis, the samples were kept in a refrigerator. Each water sample was analyzed for nitrate (NO_3^-), nitrite (NO_2^-) and ammonium (NH_4^+) as per standard procedures [APHA, 1998, 2005]. 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 in IS 10500; 2004.

Bacteriological analysis

Water samples were collected in 200 ml capacity sterilized containers from the selected tube wells using standard water collection techniques. These water samples were transported to laboratory within two hours of collection. In the laboratory, all the samples were subjected to the bacteriological analysis like colony forming unit (CFU), total coliform count (TCC) and fecal coliform count (FCC). All the collected water samples were analysed within 24 hr.

For CFU count the water samples were serially diluted 5 times (10^{-1}- 10^{-5}). The total colony forming unit was done by pour plate technique on plate count agar (PCA) and counting the colonies developed after the incubation at 37°C for 24 hours (APHA, 1998).

Total coliform and fecal coliform count was done by multiple tube fermentation method for determination of most probable number (MPN) of coliforms and fecal coliforms. The test was performed according to standard procedure. Aseptically, 10 ml volume of water was added in 10 tubes each containing 10 ml of double strength Lauryl tryptose Broth Medium (Himedia, Mumbai, India). All the tubes contained inverted Durham tubes and were pre-sterilized in autoclave. All the tubes were incubated at 37◦C for 48 hours. The tubes which showed acid and gas production were considered positive for coliforms. From the distribution of these positive tubes Most Probable Number (MPN) of total coliform was determined by referring to standard probability table for estimation of Total Coliforms.

All the tubes, positive for total coliform were sub-cultured into 10 ml of brilliant green lactose bile broth (BGLB) with inverted Durham tubes to determine presence of fecal coliforms. These tubes were incubated at 44˚C for 24 hours. The tubes showing acid and gas production were taken as positive for fecal coliform. From the number of these positive tubes, MPN of fecal coliform was calculated by referring to the table as for total coliform.

The samples with MPN of one or more were considered as contaminated while samples with zero MPN were considered free from bacterial contamination according to WHO standard for drinking water.

Results and Discussion

Nitrate and nitrite occur naturally in the environment as a component of the nitrogen cycle. In the ground water as well as surface water the level of nitrate is normally low but its level may increase if there is leaching or runoff from agricultural fertilizers or contamination from human and animal faeces. Dissolved Nitrogen in the form of Nitrate is the most common contaminant of ground water. The contamination of ground water by Nitrate (NO_3^-) is generally from non-point sources such as runoff from fertilizer use, leaching from septic tanks, sewage, erosion of natural deposits etc. Though, nitrate is considered relatively non-toxic, its high concentration in drinking water is an environmental health concern. If the specified limit exceed, the water is considered to be unfit for human consumption.

The mean concentration of nitrate, nitrite and ammonium ions in the water samples of village Dharampur and Dadpur collected in the pre-monsoon and post-monsoon seasons of 2011, 2012 and 2013 are presented in Tables 1- 2.

The Nitrate (NO_3^-) concentration in the water samples collected from village Dharampur varied in the range 4.58±0.318 mg/L to 15.40±1.656 mg/L and in the water samples of village Dadpur was in the range of 4.68±0.384 mg/L to 19.80±3.376 mg/L. As per the BIS Standard for drinking water the maximum desirable limit of nitrate ion in ground water is 45 mg/L with no relaxation. All the water samples collected from these two villages contained nitrate ion much below the maximum permissible limit (MPL) set by BIS.

Table 1: Concentration of Nitrate (NO_3^-), Nitrite (NO_2^-) and Ammonium (NH_4^+) ions in the water samples obtained from tube wells of village Dharampur

Sample No.	Nitrate (NO_3^-) Mean ± SEM*	Nitrite (NO_2^-) Mean ± SEM*	Ammonium (NH_4^+) Mean ± SEM*
S 1	15.40±1.656	0.013±0.007	1.218±0.444
S 2	6.51±0.836	0.011±0.007	0.700±0.121
S 3	5.33±0.231	0.027±0.005	0.623±0.133
S 4	6.63±0.296	0.010±0.007	0.807±0.104
S 5	5.36±0.332	0.014±0.009	1.180±0.258
S 6	5.28±0.472	0.009±0.008	0.730±0.081
S 7	4.58±0.318	0.009±0.008	0.808±0.048
S 8	8.36±0.433	0.014±0.009	1.092±0.562
S 9	7.66±0.384	0.012±0.007	0.865±0.395
S 10	4.63±0.517	0.036±0.004	0.973±0.281
S 11	6.36±0.304	0.020±0.009	0.463±0.157
S 12	5.71±0.329	0.016±0.006	0.555±0.244
S 13	8.71±0.551	0.026±0.005	0.295±0.183
S 14	12.80±1.207	0.019±0.006	0.563±0.244
S 15	9.11±0.596	0.017±0.006	0.542±0.148
S 16	14.78±1.488	0.004±0.001	0.445±0.260
S 17	14.20±1.353	0.007±0.002	0.332±0.178
S 18	7.951±0.441	0.027±0.005	0.273±0.087
S 19	5.75±0.324	0.020±0.006	0.490±0.154
S 20	6.96±0.432	0.022±0.009	0.352±0.275

*values represent the mean concentration of pre- and post-monsoon seasons of 2011, 2012 and 2013.

Nitrite (NO_3^-) is formed as a consequence of microbial activity. The admissible concentration of nitrites in drinking water in the majority of countries controlling these parameters is 0.5 mg/L. The mean nitrite content in the water samples of village Dharampur was in the range of 0.004±0.001 mg/L to 0.036±0.004 mg/L . In the water samples of village Dadpur mean nitrite concentration was in the range of 0.014 ±0.007 mg/L to 0.044 ±0.002 mg/L.

The sources of ammonium ions (NH_4^+) in surface waters are reactions of biochemical decomposition of organic nitrogen compounds, reduction of nitrites and nitrates by hydrogen sulfide, iron, humus substances or other reducing compounds, municipal wastes, industrial wastes and animal farm wastes. Organic nitrogen compounds undergo biochemical decomposition into nitrites and later oxidized to nitrates. During the study period the mean value of ammonium ion in the water samples of village Dharampur was found in the range of 0.273 ±0.087 mg/L to 1.218 ±0.444 mg/L. In the water samples of village Dadpur the mean concentration of ammonium ion ranged from 0.132±0.009 mg/L to 1.082 ±0.767 mg/L. The admissible concentration of ammonium ion expressed in ammonia is 0.5 mg/ L.

Table 2: Concentration of Nitrate (NO_3^-), Nitrite (NO_2^-) and Ammonium (NH_4^+) ions in the water samples obtained from tube wells of village Dadpur

Sample No.	Nitrate (NO_3^-) Mean ± SEM	Nitrite (NO_2^-) Mean ± SEM	Ammonium (NH_4^+) Mean ± SEM
S 1	13.36±1.381	0.023±0.005	0.425±0.165
S 2	5.53±0.738	0.014±0.007	1.082±0.767
S 3	4.68±0.384	0.027±0.005	0.318 ±0.180
S 4	6.45±0.648	0.041±0.003	0.338±0.177
S 5	12.16±1.619	0.037±0.003	0.203±0.198
S 6	19.80±3.376	0.019±0.001	0.397±0.168
S 7	5.45±0.232	0.036±0.003	0.380±0.171
S 8	4.85±0.795	0.028±0.005	0.263±0.188
S 9	5.38±0.739	0.044±0.002	0.577±0.241
S 10	9.68±1.064	0.032±0.005	0.295 ±0.141
S 11	5.73±0.342	0.029±0.004	0.208±0.197
S 12	5.05±0.475	0.030±0.004	0.428±0.163
S 13	15.11±1.798	0.038±0.003	0.333±0.178
S 14	15.00±1.486	0.034±0.004	1.017±0.772
S 15	7.61±0.496	0.037±0.003	0.622±0.33
S 16	5.88±2.010	0.027±0.005	0.515±0.50
S 17	7.80±1.574	0.043±0.003	0.965±0.325
S 18	7.23±0.603	0.023±0.005	0.945±0.284
S 19	6.88±0.401	0.040±0.007	0.298±0.183
S 20	14.60±1.865	0.029±0.004	0.132±0.009

*values represent the mean concentration of pre- and post-monsoon seasons of 2011, 2012 and 2013.

In all the samples analyzed in the present study the nitrate, nitrite and ammonium ion content was very much below the BIS permissible limit. Thus so far as these three chemical pollutants are concerned the water samples do not pose any health risk to the people concerned.

The evaluation of bacterial population in water is used as a water quality parameter and their presence can be taken as an indication of the potential health risks. Bacterial contamination of ground water is the greater concern to human health in most of the developing countries. The main sources of microbial contamination are human and animal excreta, domestic and animal farm wastes, industrial wastes etc. As per the norms of BIS and WHO drinking water should not contain coliform bacteria. The total coliform test is the starting point for determining the biological quality of drinking water. The total coliform and fecal coliform tests have been extensively used as bacterial indicators of fecal contamination. Presence of higher level of indicator bacteria in the drinking water indicates higher level of fecal contamination and greater risk of water-borne diseases.

In the present study in the water samples collected from 20 tube wells of village Dharampur bacterial population (CFU/ 100 mL water) ranged from 6.21±1.24 ($x10^4$/100mL) to 13.66±4.21 ($x10^4$/100mL). In the water samples collected from 20 tube wells of village Dadpur the range of bacterial population was 6.48±1.33 ($x10^4$/100mL) to 16.56±4.50 ($x10^4$/100mL). The mean total coliform (/100 ml sample) in the water samples collected from 20 tube wells of village Dharampur varied from 0.73±0.84 to 4.56±1.73. The mean total coliform (/100 ml sample) in the water samples collected from 20 tube wells of village Dadpur varied from 0.91±0.24 to 6.63±1.50. In both the villages all the samples showed the presence of coliform bacteria (Table 3 and 4).

In the water samples collected from 20 tube wells of village Dharampur fecal coliform were not detected in 8 water samples while in water samples of village Dadpur 6 samples showed negative result for the presence of fecal coliform. In the remaining samples

Table 3: Microbial population the water samples obtained from tube wells of village Dharampur

Sample No.	CFU (X 10^4)	Total Coliform	Fecal Coliform
S 1	8.26±1.42	1.10±0.80	0
S 2	7.78±1.40	2.30±0.75	1.00±0.48
S 3	6.21±1.24	3.76±0.91	1.33±0.85
S 4	6.36±1.17	0.91±0.80	0
S 5	8.78±1.48	4.56±1.73	1.50±0.26
S 6	9.41±2.57	1.28±-.74	0.16±0.09
S 7	10.50±2.75	2.55±0.73	0.66±0.33
S 8	9.71±2.63	0.91±0.80	0
S 9	11.25±1.84	4.27±1.28	1.83±0.91
S 10	11.93±2.96	3.69±0.73	1.50±0.76
S 11	10.26±2.70	1.46±0.73	0
S 12	12.46±2.05	0.73±0.84	0
S 13	7.50±1.30	4.16±0.75	0.83±0.08
S 14	8.20±1.42	2.25±0.65	1.00±0.30
S 15	10.60±1.74	1.10±0.75	0
S 16	11.68±3.93	1.28±0.83	0
S 17	11.91±3.97	0.91±0.80	0
S 18	12.63±4.17	3.15±0.62	1.50±0.79
S 19	13.30±4.15	1.93±0.79	0.33±0.09
S 20	13.66±4.21	2.06±0.70	0.16±0.02

*values represent the mean concentration of pre- and post-monsoon seasons of 2011, 2012 and 2013.

of both the villages its range was 0.16 ±0.01 to 2.50 ±0.74/100 mL of water sample. According to WHO guidelines (2004), water will be considered safe for human consumption only when 100% of the results show a value of 0 CFU/100 ml. The presence of coliform bacteria in water sources indicates that sewage or some type of surface water is entering and contaminating the water supply. Microbial contamination of groundwater is usually attributed to infiltration of water containing human or livestock faeces into the underlying aquifer. However, in areas where hand-pumped tube wells are used to draw water part of the contamination might also be due to microbial attachment to surfaces inside the pump or the well casing, or contamination of the water used for periodic priming of the hand-pumps (Andrew, et al., 2011). The present study revealed that most of the ground water samples collected from both the villages failed to meet the bacteriological quality parameters

Table 4: Microbial population the water samples obtained from tube wells of village Dadpur

Sample No.	CFU (X 10^4)	Total Coliform	Fecal Coliform
S 1	11.57±2.92	1.88±0.73	0.16±0.08
S 2	10.83±2.73	1.10±0.30	0
S 3	11.86±3.90	4.48±1.04	1.83±0.74
S 4	12.50±2.30	1.28±0.79	0
S 5	10.03±1.67	4.81±1.33	1.50±0.43
S 6	8.30±1.43	3.63±1.60	1.16±0.29
S 7	8.81±1.51	1.10±0.30	0.16±0.01
S 8	6.48±1.33	1.70±0.81	0.50±0.02
S 9	7.98±1.37	2.11±0.75	0.50±0.01
S 10	7.46±1.33	4.48±1.84	1.50±0.07

S 11	10.44±3.67	2.36±0.83	0.50±0.08
S 12	10.90±3.82	2.48±0.63	1.16±0.29
S 13	11.20±2.85	0.91±0.24	0
S 14	13.51±3.21	6.63±1.50	2.50±0.74
S 15	14.81±4.42	1.10±0.24	0
S 16	15.20±3.47	2.83±0.67	0
S 17	16.53±4.66	3.51±0.89	1.33±0.21
S 18	16.56±4.50	2.53±0.70	0.66±0.08
S 19	12.68±3.07	2.91±1.07	0.83±0.08
S 20	15.51±4.58	1.46±0.77	0

*values represent the mean concentration of pre- and post-monsoon seasons of 2011, 2012 and 2013.

Throughout the sampling years. Sewage disposal practices like soak pit system and septic tank near the tube wells may be contributing to the bacterial contamination of groundwater. Thus the study reveals that raw ground water is not safe for human consumption. In order to meet the quality of ground water it is recommended that continuous, effective treatment combined with constant monitoring is essential to ensure that it meets the standards of drinking water.

References

Andrew, S. Ferguson, Brian J. Mailloux, Kazi M. Ahmed, Alexander, van Geen, Larry D. McKay and Patricia, J. Culligan. (2011): Hand-pumps as reservoirs for microbial contamination of well water. Journal of Water and Health, 9(4); 708-717.

APHA (1998): Standard Methods for the Examination of Water and Wastewater (19th edn) American Public Health Association, Port city press, Baltimore, Moryland. USA.

APHA (2005): Standard methods for examination of water and waste water. 21st Edn. American Public Health Association, Port city press, Baltimore, Moryland. USA.

Bureau of Indian Standard (2004): Drinking Water- Specification (Second Revision of IS 10500, Bureau of India Standard, New Delhi.

Graham, Jay P. and Polizzotto, Matthew L. (2013+: Pit Latrines and Their Impacts on Groundwater Quality: A Systematic Review. Environment Health Perspective, NIEHS, National Institutes of Health, U.S. Department of Health and Human Services, http://dx.doi.org/10.1289/ehp.1206028, pp.38.

Mishra, D. S. (2009): Safe drinking water status in the state of Bihar, India: Challenges ahead. In: Water, Sanitation and Hygiene: Sustainable Development and Multisectorial Approaches, 34th WEDC International Conference, Addis Ababa, Ethiopia, 2009 Reviewed Paper 202

PHED (2008) Testing and mapping of drinking water quality in the state of Bihar. Public Health Engineering Department, Govt of Bihar, Patna, India.

vanRyneveld, M. B. and Fourie, A. B., (1997): A strategy for evaluating the environmental impact of on-site sanitation systems. Water Sa, 23(4):279-291.

World Health Organisation (WHO) (1992): Our Planet, Our Health, Report of the WHO Commission on Health and Environment. World Health Organization, Geneva, Switzerland.

World Health Organisation (WHO) (2004): Guidelines for Drinking-Water Quality, Vol. 1, third ed. World Health Organisation, Geneva, Switzerland.