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PHYSICO-CHEMICAL AND MICROBIOLOGICAL ANALYSIS OF GROUNDWATER OF SONEPUR SUBDIVISION OF SARAN DISTRICT OF BIHAR, INDIA

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ABSTRACT

The 24 samples of underground water were collected for physico-chemical and microbial analysis from different (24 panchayats) rural locations of four blocks (Sonepur, Dariyapur, Parsa and Dighwara) of Sonepur sub-division of Saran district of Bihar. Analysis of samples for pH, TDS, conductivity, turbidity, odour, nitrate, sulphate, phosphate, dissolved oxygen (DO), hardness, chlorides, fluorides, sodium, potassium Ca, Mg and alkalinity, Free NH_4^+, along with microbial parameters EC and Coliform organisms indicate towards major health concerns of rural living beings. On comparing results with drinking water quality standards laid down by WHO, it was found that most of the water samples were potable for human beings permissible concentration of parameters. Most of the samples have EC, free NH_4^+, and Coliform organism was comparable to the permissible levels set up by WHO. The values of these parameters have very less health implications and did not require adequate time bound remedial measures.

KEY WORDS : Physiochemical, Microbiological, Groundwater, Saran, Sonepur

INTRODUCTION

Water is the most precious and valuable natural resource in which all biological metabolic reactions for the maintenance of life are performed. Water, the source or exalter of life, is vital for socio-economic growth, quality of life and environmental sustainability of a nation. Water resource on earth is under tremendous pressure all over the world due to climate change, population growth and socio-economic development.

Ground water is the sole source of freshwater for domestic, industrial and agricultural uses to human population. While 70% of the Earth is covered by water, groundwater only makes up a fraction (0.6%) of all available water on Earth; however, that 0.6% accounts for 98% of the freshwater available for human consumption (Zaporozec *et al.*, 2002). Ground water constitutes an important source of water for drinking and irrigation purposes especially for the people residing in rural areas. More than three quarters of rural population of Bihar depends on ground water sources for drinking and other domestic requirements. Also around 60% of total irrigation in the country is sustained by ground water resources. The main source of ground water replenishment is rainfall. It contributes 68% water annually to the ground water reserve. The remaining 32% comes from canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures (Status of groundwater quality in India).

The fresh groundwater or drinking water is essential to human beings and other living organisms even though it neither provides calories nor essential organic nutrients. The quality of ground water of a region is largely determined by both natural processes (dissolution and precipitation of minerals, groundwater velocity, quality of recharge water, and interaction with other types of water aquifer, composition of soil, nature of rocks present, residence time, etc) and anthropogenic activities (Water Aid, 2007). Unfortunately, across the globe, groundwater has been significantly degraded by the human population through unsustainable uses and contaminations (Kulkarni *et al.,* 2015). Significant contaminations have been contributed by the disposal of human, animal and hazardous industrial wastes; byproducts of mining, chemical and oil operations; leakages from sanitary sewer lines and septic tanks; and excess use of chemical fertilizers in agriculture farming and other man-made activities (Schwartz *et al.,* 2003).

The knowledge of the physical, chemical and biological parameters of water are very important for determining the type and quality of water. According to WHO, drinking water should be clear, colorless, odorless, tasteless, and free of pathogens or other toxic chemicals (Harter, 2015).

Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from their sources. Water quality of any specific area or specific source can be assessed using physical, chemical and biological parameters. The values of these parameters are harmful for human health if they occurred more than defined limits (Chakraborti, 2010). These pollutants include heavy metals, nitrates, fluoride, sulphates, chlorides etc. The biological contaminants like various pathogenic bacteria, fungi and viruses may also be present in the ground water due to the mixing of ground water with untreated domestic sewage or contamination from landfills and septic tanks. The contamination deteriorates the quality of water making it unsafe to use, leading to adverse health effects. Microbiological examination of the drinking water mainly covers detection of coliforms and total bacterial count. Coliforms are common bacteria that exist in the intestines of humans and mammals, and excreted out in the dejection. If large quantities of coliforms are present in the water, it is a prominent indicator of possible faecal contamination (Postigo *et al.,* 2018).

As contamination of ground water is a serious issue, it is required that efforts should be made to control pollution. Regular monitoring of ground water is required to ensure that water is safe and usable and the quality of water should be acceptable. However, ground water monitoring is not only costly and time taking but also difficult. Therefore, it becomes imperative to monitor the quality of drinking groundwater at regular intervals, because use of contaminated drinking water causes variety of water borne diseases to human population. Literature survey suggests that very little work on this aspect has so far been done in Bihar (Srivastava *et al.,* 2019 and Vishwranjan *et al.,* 2015)

The present case study was, therefore, undertaken to investigate the quality of ground water by determining its various physicochemical and microbiological characteristics of rural areas of different four blocks (Sonepur, Dariapir, Dighwara and Parsa) of Sonepur sub-division of Saran district of Bihar. Extensive surveys carried by our team during 2016-2018 have showed that the use of groundwater systems in the surveyed rural areas for household, irrigation and industrial purposes is the main source of health problems especially diarrhea, skin infections and kidney diseases.

Due to the aforementioned information, the objective of this case study is to evaluate the microbiological and physicochemical characteristics of groundwater of public and personal hand pumps of selected rural areas as well as their impact of contamination on human health.

Study Area

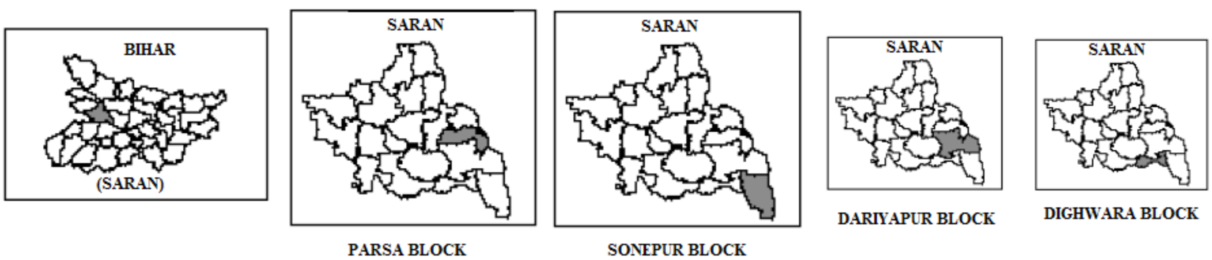
Saran district is located on global map between 25°36' and 26°13' North latitude and 84°24' and 85°15' East longitude. The district is shaped like a triangle with its apex at the confluence of the boundary of Gopalganj district and the Gandak river. The Gandak river along with Muzaffarpur and Vaishali districts forms the eastern side, the Ganges and the Ghaghra along with Bhojpur and Patna districts forms the southern side, whereas the boundaries of Balia district of U.P. and Siwan and Gopalganj districts of Bihar form the western side of the triangular Saran district. Saran contains three Sub-Divisions viz., Chapra Sadar, Marhaura and Sonepur with headquarters at Chapra. The geographical area of the district is 2641 km^2. It comprises of 20 community development blocks, and 1783 villages. The rank of the district in comparison to other districts of Bihar in terms of area is 16^{th}.

This district is a part of the lower Ganga Basin. It falls in the Gandak sub-basin. The area is charactersied by hot and sub-humid climate and is in the subtropical region. The climate is, in general, healthy and is not subjected to sudden variations in temperature. The maximum, average and minimum temperatures are 45 ^oC, 31 ^oC and 7 ^oC respectively. They receive rainfall during the months of July, August, September and October with maximum precipitation in October. The heavy rainfall is limited to a few days in a year due to depressions in Bay of Bengal which leads to flash floods of high discharge. The humidity is lowest in April and highest in August. The average annual rainfall in the district is 840 mm for year 2017 with high spatial and temporal variations. The monsoon rainfall is about 80 % of the annual rainfall.

Even after being rich in water reserves, the summer is water stressed in the studied rural areas and during rainy season flooding causes unsafe drinking water due to fecal contamination causing increase in incidents of diseases like diarrhea, dysentery, typhoid fever, intestinal helminthiasis, jaundice, cholera, kidney diseases, etc. The emergence of chemical contamination in the ground water also posing challenges in providing safe drinking water and irrigation water.

Materials and Methodology

A total of 24 groundwater samples were collected from the hand-pumps representing the entire study area in October-2017 and same locations were again sampled in October-2018. Sampling and analysis were carried out using standard procedures (Ramesh *et al.*, 1996; Trivedy and Goel, 1986; APHA 1995). Groundwater samples were collected in a 1L polyethylene bottles (previously soaked in 10 % nitric acid (HNO_3) for 24 h and rinsed with deionized water) after pumping out the stagnant water for 20 min in hand-pump, in order to get representative samples. All samples were transported to the laboratory and kept at 4 ^oC until used for further analysis. Water temperature, pH, electrical conductivity (EC), total dissolved solids



Saran: 25^{0}37′7.589"N - 26^{0}12′57.497"N; 84^{0}24′10.432"E - 85^{0}12′25.711"E

Sonepur Block: 25^{0}37′22.967"N-25^{0}47′13.402"N; 85^{0}3′49.094"E-85^{0}11′53.802"E

Dariyapur Block: 25^{0}44′50.208"N-25^{0}53′40.418"N 84^{0}55′23.885"E- 85^{0}10′45.248"E

Parsa Block: 25^{0}49′20.529"N-25^{0}56′6.389"N 84^{0}55′7.561"E - 85^{0}7′10.028"E

Dighwara Block: 25^{0}42′7.259"N-25^{0}47′9.399"N 84^{0}54′14.719"E-85^{0}5′27.814"E

Fig. 1. Map of the studied areas with their geographical location

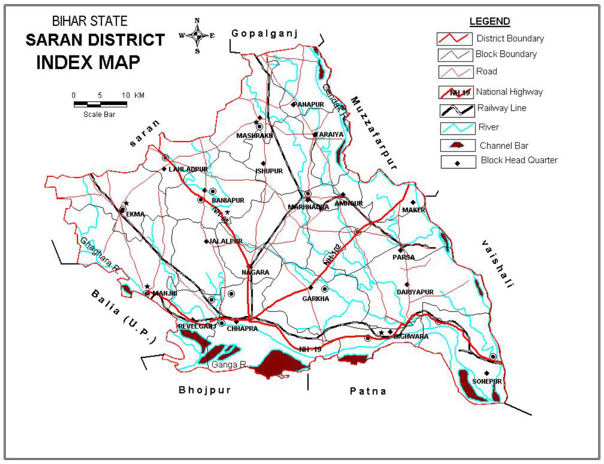


Fig. 2. Index map of Saran District

(TDS) and turbidity were measured in the field using ELICO water quality analyzer PE 138. The samples were analyzed in triplicates for their chemical constituents in accordance to "standard methods for the examination of water and waste water American Public Health Association (APHA 1995)". The results obtained were compared with the drinking water standards as specified by World Health Organisation (WHO) and Bureau of Indian Standards (BIS). The concentration of all the major cations, anions and metals was measured using standard reference solutions of analytical grade. Double distilled water was used for preparing the solutions and blank throughout the analysis.

Multiple tube method recommended by WHO (1985) was used for the detection and estimation of coliform and faecal coliform. This method is based on the incubation of water samples in the laboratory.

The brief details of analytical methods and equipments used in the study are given in the Table 1.

RESULTS AND DISCUSSION

The detailed analytical results of the physico-chemical and microbiological parameters for the collected groundwater samples have been shown in Table 2 and 3, where the groundwater variables were compared with prescribed national and international guidelines for drinking and irrigation water. The physico-chemical and biological parameters of all 24 samples analysed to characterize the groundwater based on BIS standards.

Physiochemical Analysis

The pH value of water is an important indicator of the acidic-basic interaction of organic components of water and a number of minerals. The pH value of groundwater samples indicated their slightly alkaline nature (pH ranged from 6.98 to 7.43 in year-2017 while during year-2018 it varies from 7.08 to 7.81). It also comes within the desirable limits as

Table 1. Analytical methods and equipments used in the study

S.No.	Parameter	Used Method	Used Equipments/Instruments
		Physico-chemical Analysis	
1	Water Temperature	—	Mercury Thermometer
2	pH	Electrometric	pH Meter
3	Electrical conductivity	Electrometric	Conductivity meter
4	TDS	Electrometric	Conductivity/TDS meter
5	Alkalinity	Titration by H_2SO_4	—
6	Hardness	Titration by EDTA	—
7	Chloride	Titration by $AgNO_3$	—
8	Sulphate	Turbidimetric	Turbidity Meter
9	Nitrate	Ultraviolet screening	UV-Vis Spectrophotometer
10	Phosphate	Molybdophosphoric acid	UV-Vis Spectrophotometer
11	Fluoride	Ion selective electron method	Fluoride meter
12	Sodium & Potassium	Flame emission	Flame Photometer
13	Calcium & Magnesium	EDTA Titration	—
14	DO	Winkler method	Titration method
15	BOD	5 days incubation followed by titration	BOD Incubator
16	COD	Digestion followed by titration	COD Digester
		Microbial Analysis	
17	Total Coliform	Multiple tube fermentation technique	Bacteriological Incubator

prescribed by U.S. Environmental Protection Agency (EPA) (2012) (Table 2 & 3).

The electrical conductivity (EC) in water is based on the function of dissolved mineral matter content; if TDS is high then EC will be high as well. The measurable levels of EC with a mean value 1698 in the year 2017 and 1830 in the year 2018 were found.

The higher values of pH and EC of groundwater of the studied area are probably due to additional leaching derived from anthropogenic sources and intense agricultural activities in the area.

The alkalinity of water is the measure of its capacity for neutralization. The bicarbonate represents the measure sources of alkalinity which is within the permissible limits.

The salinity behavior of groundwater was investigated by analyzing the total dissolved solids (TDS), where the water with TDS > 500 mg/l is undesirable but value up to 1500 mg/l is permissible for drinking water supplies (WHO, 2008). The TDS values varied from 295 to 680 mg/l with a mean value of 487 mg/l of all the samples of the studied area, and it is concluded that the values of TDS of the samples of studied areas are within the permissible limits as approved by WHO (2008) and EPA (2012).

The abundance order of major anions in groundwater was $Cl^- > SO_4^{2-} > HCO_3^-$, respectively. The concentration of bicarbonate and carbonate in groundwater was probably due to the dissolution of carbonic acid and carbonate weathering in the aquifers which shows the variation of pH of the studied samples. The chlorides and sulphates were common constituents of all the natural water. The measurable concentrations of Cl^- and SO_4^{2-} were in the range of 129 - 235 (in 2017) and 137 - 244 (in 2018) and 138 - 198 (in 2017) and 126 - 196 (in 2018) mg/L, respectively. All the samples were in the maximum limits as approved by WHO (2008).

As shown in Table 2 & 3, the nitrogen present in groundwater with a mean value greater than the limits established by WHO (2008). The main source of nitrate in the studied area is the application of nitrogenous fertilizers mainly [$(NH_4)_2SO_4$] and the domestic wastes. According to the following reaction, the ammonia is converted into nitrates through nitrification in presence of oxygen:

$$2O_2 + NH_4^+ \rightarrow NO_3^- + 2H_2O$$

The high concentration of nitrate may occur due

Table 2. Summary of Physical and chemical properties of variable hand-pump groundwater samples in October-2017

ID Area	Physico-chemical parameters (October-2017)										
	Temp.	pH	EC	TDS	TH	TA	F^-	Cl^-	Na^+	SO_4^{2-}	NO_3^-	Turbidity
S_1	26.5	7.06	1693	440.6	352	142	0.68	148	125	148	15	4.42
S_2	27.4	7.32	1768	432.2	335	132	0.89	190	162	168	28	4.15
S_3	24.8	7.18	1640	463.4	327	143	0.78	161	158	142	26	4.25
S_4	24.2	7.27	1621	478.2	365	196	0.87	160	161	162	27	3.89
S_5	26.8	7.10	1854	472.5	336	189	0.76	133	186	138	29	4.87
S_6	26.2	7.29	1775	295.3	385	176	0.80	153	198	145	28	4.85
S_7	27.9	7.57	1687	387.9	396	198	0.82	207	189	163	21	4.65
S_8	26.2	7.02	1586	534.9	391	190	0.98	129	165	156	23	3.62
S_9	27.5	7.12	1779	442.6	328	125	0.95	158	187	145	26	4.27
S_{10}	28.3	7.09	1598	364.5	365	198	0.85	149	174	162	27	4.36
S_{11}	25.4	7.23	1866	657.4	332	189	0.67	219	154	176	27	4.56
S_{12}	23.6	7.42	1677	580.6	397	185	0.95	169	195	163	26	4.75
S_{13}	28.8	6.98	1787	572.5	375	168	0.64	204	178	169	28	3.38
S_{14}	27.1	6.99	1776	660.2	356	195	0.69	235	153	187	31	4.29
S_{15}	28.6	7.17	1657	658.7	358	176	0.79	215	124	189	29	4.36
S_{16}	29.1	7.43	1768	362.5	365	134	0.71	235	186	198	27	4.58
S_{17}	27.4	7.16	1651	432.5	371	189	0.62	153	189	159	31	3.69
S_{18}	28.3	7.72	1663	571.8	362	143	0.95	196	185	161	30	4.65
S_{19}	25.1	7.17	1531	598.3	380	136	0.93	128	162	152	29	4.32
S_{20}	26.7	7.05	1743	552.7	335	123	0.91	198	184	162	25	4.35
S_{21}	27.5	7.12	1779	645.6	354	184	0.89	178	174	189	32	4.65
S_{22}	28.3	7.09	1598	610.5	362	189	0.85	171	186	138	31	4.56
S_{23}	27.4	6.99	1651	650.2	358	197	0.65	182	169	159	32	4.68
S_{24}	26.7	7.05	1743	680.4	385	185	0.87	165	176	185	35	3.45

Table 3. Summary of Physical and chemical properties of variable hand-pump groundwater samples in October-2018

ID Area	Physico-chemical parameters (October-2018)										
	Temp.	pH	EC	TDS	TH	TA	F^-	Cl^-	Na^+	SO_4^{2-}	NO_3^-	Turbidity
S_1	26.8	7.26	1963	424.0	329	138	0.65	143	131	152	12	4.80
S_2	27.8	7.38	1845	423.4	368	116	0.90	191	147	185	23	4.04
S_3	26.7	7.28	1754	454.3	308	125	0.95	163	163	124	22	4.24
S_4	27.2	7.37	1763	474.6	350	201	0.90	167	152	162	23	3.68
S_5	27.5	7.18	1854	463.3	327	199	0.58	137	194	142	19	4.84
S_6	27.3	7.31	1798	254.7	397	163	0.79	173	205	138	22	4.74
S_7	27.5	7.62	1757	362.6	349	190	0.72	227	205	154	11	4.72
S_8	27.2	7.32	1768	523.3	387	187	0.97	139	157	149	20	2.54
S_9	27.4	7.22	1789	424.4	302	113	0.90	166	205	147	26	4.52
S_{10}	27.3	7.19	1871	353.8	349	192	0.80	194	147	162	28	4.64
S_{11}	27.4	7.33	1880	653.4	312	203	0.60	249	131	187	17	4.94
S_{12}	27.6	7.48	1705	584.2	373	159	0.86	196	189	153	27	4.54
S_{13}	28.0	7.18	1761	574.1	398	103	0.50	240	168	165	35	3.14
S_{14}	27.4	7.29	1758	652.3	316	209	0.59	241	131	186	36	4.14
S_{15}	28.2	7.32	1725	654.7	340	135	0.75	244	115	196	24	4.74
S_{16}	27.4	7.44	1786	354.6	344	112	0.60	225	173	185	20	4.84
S_{17}	27.6	7.26	1749	423.3	350	196	0.50	162	205	139	31	3. 35
S_{18}	28.0	7.81	1768	563.7	339	128	0.90	226	185	156	29	4.84
S_{19}	27.2	7.37	1698	623.3	345	120	0.90	153	147	148	20	3.24
S_{20}	27.8	7.45	1734	532.0	312	109	0.80	240	215	157	19	4.15
S_{21}	27.6	7.52	1797	654.2	315	170	0.90	168	147	195	45	4.95
S_{22}	28.2	7.29	1859	593.8	345	201	0.80	159	199	126	40	4.76
S_{23}	27.8	7.08	1862	643.3	350	203	0.42	166	205	165	26	4.52
S_{24}	27.3 .	7.25	1835	672.0	405	196	0.71	152	167	175	31	3. 35

Sample code and Sampling locations: S_1= Saidpur (Sonepur); S_2= Shikarpur (Sonepur); S_3= Hasilpur (Sonepur); S_4= Kalyanpur (Sonepur); S_5= Shahpur Diara (Sonepur); S_6= Chaturpur (Sonepur); S_7= Bharpura (Sonepur); S_8= Gangajal (Sonepur); S_9= Kasmaar (Sonepur); S_{10} = Sabalpur west (Sonepur); S_{11} = Trilokchak (Dighwara); S_{12} = Manupur (Dighwara); S_{13} = Rampur Ami (Dighwara); S_{14} = Magarpal (Dariyapur); S_{15} = Barwe (Dariyapur); S_{16} = Sutihar (Dariyapur); S_{17} = Manpur (Dariyapur); S_{18} = Harne (Dariyapur); S_{19} = Shobhepur (Parsa); S_{20} = Anjani (Parsa); S_{21} = Banauta (Parsa); S_{22} = Parsauna (Parsa); S_{23} = Marar (Parsa); S_{24} = Bahar Marar (Parsa);

to leaching of NO_3^- from fertilizers and biocides or anthropogenic activities during the irrigation of agriculture land. The high concentration of nitrate in groundwater of the studied area leads the greater mineralization consequently the lower EC. The excessive levels of nitrate in drinking water may cause serious illness and sometimes death due to shortness of breath and increase in starchy deposits especially to infants causing methaemoglobinaemia, otherwise called infantile cyanosis or blue baby syndrome if consumed.

The concentrations of cations such as Na^+, K^+, Ca^{2+} and Mg^{2+} were within the maximum permissible limits for drinking water. The total hardness values in all the studied area ranged from 327 to 385 mg/L in year 2017 and from 308 to 405 mg/L in the year 2018. The maximum permissible limit of TH for drinking water is 500mg/L and the most desirable limit is 100 mg/L as per the WHO international standards. The Table 2 and 3 show that the majority of the groundwater samples in the studied are very hard.

The concentration of fluoride in the groundwater of the studied area varied from 0.62 to 0.95 mg/l in year 2017 and 0.42 to 0.97 mg/l in the year 2018 which are within the most desirable limit (1.0 to 1.5mg/l).

The samples of groundwater of the studied area have turbidity varies from 3.38 to 4.85 mg/l (2017) and 2.54 to 4.95 mg/l (2018) respectively which is within the permissible limit acceptable for drinking purposes.

The dissolved oxygen (DO) plays an important role in the assessment of water quality as it is an essential ingredient for the sustainability of aquatic life. It reflects the quality of water and used in determining the quality of water which receives the pollutants from the wastes. The reduced

Table 4. Drinking Water Standards

WQPs	USPHA	WHO	EPA	ICMR	BIS	Maximum Permissible
pH	-	7.0-8.5	-	7.0-8.5	6.5-8.5	6.5-9.5
TDS	500	500	-	500	500	1500
TH	600	100	-	300	300	500
Cl^-	250	200	350	250	250	600
SO_4^{2-}	230	200	250	200	200	400
NO_3^-	-	50	-	50	50	50
CO_3^{2-}	-	-	-	-	-	-
HCO_3^-	-	200	-	230	200	300
Ca^{2+}	-	75	-	75	75	200
Mg^{2+}	-	100	-	100	100	150
TA	-	-	-	200	200	600
EC	-	-	-	-	750-2250	2500
Na^+	-	200	150	-	200	200
K^+	-	12	-	-	10	15
DO	-	2-5	-	5.0	4.0	5.0
F^-	-	1.5	-	1.0	1.0	1.5
Turbidity	-	5	-	5	5	6

Concentrations are in mg/l except EC in µS/cm and pH (no unit)
WQPs = Water Quality Parameters; USPHA = US Public Health Association; WHO = World Health Organisation; EPA = Environmental Protection Agency; ICMR = Indian Council of Medical Research; BIS = Bureau of Indian Standards

Table 5. Summary of Biological properties of variable hand-pump (45-85 feet depth) groundwater samples in October-2017 & 2018

ID Area	Coliform (MPM/100ml)		Faecal Coliform (MPM/100ml)		WHO
	2017	2018	2017	2018	
S_1	840	920	95	105	0
S_2	720	800	70	80	0
S_3	870	950	105	125	0
S_4	240	300	45	65	0
S_5	530	600	90	105	0
S_6	150	200	60	75	0
S_7	300	340	55	70	0
S_8	290	320	75	85	0
S_9	520	560	80	90	0
S_{10}	250	280	70	85	0
S_{11}	155	180	60	75	0
S_{12}	250	300	65	80	0
S_{13}	120	150	45	50	0
S_{14}	75	90	25	35	0
S_{15}	170	200	45	55	0
S_{16}	520	560	80	95	0
S_{17}	20	30	20	35	0
S_{18}	850	890	95	110	0
S_{19}	40	75	30	45	0
S_{20}	650	680	85	90	0
S_{21}	180	210	50	65	0
S_{22}	500	520	70	85	0
S_{23}	20	35	45	55	0
S_{24}	320	345	80	105	0

Table 6. Summary of Biological properties of variable hand-pump (150-300 feet depth) groundwater samples in October-2017 & 2018

ID Area	Coliform (MPM/100 ml)		Faecal Coliform (MPM/100 ml)		WHO
	2017	2018	2017	2018	
S_1	15	15	3	3	0
S_2	12	15	3	3	0
S_3	10	10	3	3	0
S_4	5	5	0	0	0
S_5	8	8	2	1	0
S_6	5	5	0	0	0
S_7	10	10	3	2	0
S_8	7	8	2	2	0
S_9	6	7	0	0	0
S_{10}	2	3	0	0	0
S_{11}	7	7	1	1	0
S_{12}	9	8	3	2	0
S_{13}	8	9	2	1	0
S_{14}	5	5	0	0	0
S_{15}	7	6	2	1	0
S_{16}	6	9	2	0	0
S_{17}	5	5	0	0	0
S_{18}	6	7	1	0	0
S_{19}	5	5	0	0	0
S_{20}	8	7	1	0	0
S_{21}	6	5	0	0	0
S_{22}	7	8	1	1	0
S_{23}	3	3	0	0	0
S_{24}	8	8	1	1	0

concentration of DO reflects the degree of organic pollution in water. The samples of groundwater of the studied area have DO values within the permissible limit and is acceptable for drinking purposes.

Biological Analysis

Water quality can be assessed according to chemical, physical and microbiological characteristics. As chemical and physical parameters characterize the physicochemical water quality, microbial water quality involves the measurement of microorganisms as e.g. bacteria, algae, protozoa and other organisms in water. The assessment of microbial water quality can be done in function of the microorganism´s abundance, viability, activity, and/or composition and structure of the microbial community (Prest *et al.,* 2016a). The microbiological parameters of water are determined by bacteriological and parasitological analyzes. The existence of water-borne diseases has been recognized as a pathogenic, microbial agent that is often enteric (i.e. linked to the intestines) and transported by water. The disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausèa, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems (USEPA, 2011).

The results of estimation of coliform and faecal coliform from deep aquifer of groundwater (45 – 85 feet) are shown in Table 5. The range of coliform estimated from various hand-pumps sampled from the study area is 900^+ to 20 MPN per 100 ml. The results of water samples collected from deep aquifer layers (150-300 feet) are presented in Table 6. The range of coliform bacteria is 00 to 20 MPN in 100 ml. Most of the hand-pumps where only deep aquifer layers are penetrated have no faecal coliform which indicate that the deep aquifers are still safe from faecal coliform contamination in the study area.

CONCLUSION AND RECOMENDATIONS

This study provides a comprehensive understanding of groundwater quality and its hydro chemical analysis. In drinking water context the physiochemical parameters are affected by anthropogenic activities, which is supported by the high nitrate values. The problem in the groundwater arises due to the infestation with faecal coliform bacteria. Bacterial contamination arises from the unhygienic practices. The groundwater of investigated area can be considered for portable usage if the bacterial contamination is curbed and the nitrate levels are maintained within the desirable limit. Health hazard due to coliform contamination could be minimized by maintaining better hygiene with good sanitation facilities and practices such as like chlorination, boiling and filtration of drinking water prior to use, and constructing the septic tanks away from the drinking water source (well). The periodical of drinking water quality of hand-pumps, checking for leakage from drinking water and septic tank pipelines will ensures the safe drinking water. The deep aquifer layers are still safe from faecal coliform contamination. It is suggested that pumping from less deep aquifer in bank of river area through hand-pumps should be stopped forth-with and periodic monitoring of all the deep groundwater hand-pump is also recommended. Government, non-governmental organisations, and local institutions can come forward to give free analysis for some important water quality parameters to provide health and hygienic condition. And also conducting awareness programs to maintain hygiene condition around the drinking water source by the concerned government, non-government organizations, and local institutions would lead to a safer drinking water forever.

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Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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