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Physicochemical characteristics of well water of Supaul (District) Bihar

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Abstract: Physicochemical characteristics like pH, turbidity, conductivity, total solid, total hardness as $CaCO_3$, sulphate, nitrate, chloride, fluoride, magnesium, calcium, iron and arsenic of well-water of Supaul district, Bihar state have been studied for pre- and post-monsoon seasons and the data were analyzed and discussed with respect to different standards and health hazards. Most of the samples were found to be of slightly alkaline nature and a few samples were found to be of acidic nature and having well within the permissible/allowable limits prescribed by WHO/ USPH except the value of iron which was slightly higher in some of the samples.

(Keywords : Groundwater, well-water, physico-chemical parameters)

Introduction

The physicochemical parameter of water is of prime importance to assess its quality for different purposes. Chemical analysis of the samples of well water was made with a view to examine the ionic environment in groundwater and evaluating their nutritive value as well as effects if any as health hazards. Chemical quality of water in aquifer is a function of mineral composition of the rocks through which the water percolates in the recharge area and where in the flow system of the water occurs. The quality of groundwater is the resultant of all the processes and reactions that have acted on the water from the moment it condenses in the atmosphere to the time it is discharged by a well.

The geochemistry of groundwater describes the nature and amount of dissolved mineral matter in groundwater. The geological and chemical changes influence the kinds and amounts of substance carried in solution. They also influence the chemical relationships between dissolved mineral matters in water and minerals that make up the rocks in which the water occurs.

Rain water contains very little amount of dissolved mineral matters which is almost negligible. As soon as rain water touches the earth, it starts to react with the minerals of soils and rocks coming in its contact. The amount and character of the mineral matters dissolved by water depend on the physical structure and chemical composition of the rocks and soils with which they have been in contact, the pressure, the temperature, the duration of contact and the chemical matters already present in the solution. The solvent action of water is improved by the presence of carbon dioxide derived from atmosphere and the soils through which it runs.

Among the liquids, water is the most universal solvent. It has the highest surface tension, the highest dielectric constant and the greatest heat of vaporization. The effectiveness of water in rock weathering is increased by the ability of this cohesive liquid to wet mineral surfaces and penetrate into small openings.

Variations of temperature, pressure, hydrogen ion concentrations (pH), redox potential (E) and the relative concentrations of other substances in solution control the solubility of a given element in water. All the minerals have surfaces having unbalanced electrical charges and these surfaces attract water because it is a polar compound.

The availability of safe and reliable source of water is an essential pre-requisite for the establishment of a stable community. To meet these requirements, the concept of water quality criteria was evolved which is based on the acceptable levels of concentration of various constituents which indicate physical, chemical and biological characteristics of water and form the basis for judgment in several environmental protection Agency and State programs that are associated with water quality considerations. In order to achieve the level of satisfaction for the desired water quality for different uses, various agencies have developed standards/criteria viz. European Community Standards (EC standard), WHO standards. Water Quality, Institute of Hydrological Sciences and Water Resources (WQIHSWR) Tehran applicable in their countries. In India, desirable limit for concentration of various water quality parameters are given in the Indian Standard Specification for Drinking Water IS – 10500 – 1983[1]. Central Pollution Control Board (CPCB) has also developed the standards for Inland Surface Water (CPCB Standards 16:229, 1982)[2].

Materials and methods:

Quality of materials used in chemical analysis and the methods and techniques employed as well as the sampling season and the sampling procedure are the most important part of the studies on water quality assessment. Reliability and correct interpretation of data are completely dependent on the field methods and also on the accuracy of the laboratory techniques. Proper sampling is very important in all such cases where chemical variations are to be traced out.

Chemicals used in analysis : All the Chemicals used were of Anal R grade. Double distilled water was used. All the glass wares used in analysis were of Pyrex, Corning and Borrosil.

Groundwater sampling: For the laboratory analytical investigations, ground water samples were collected in one liter polythene bottles. The bottle was properly cleaned and dried completely before being carried to the site of collection. At the time of water sample collection first, the bottle was rinsed by water sample and then collected sample, stored in cool place and protected from sunlight before being transported to the laboratory for analysis.

Due care has been taken to collect the water samples only from those wells which are regularly used. The water sample has been collected from the mid-length of the water column so as to avoid the collection of floating foreign matters and the bottom materials. With each sample, a record has been made of well site number, depth to water level and date and time of collection.

Samples were collected in pre-monsoon (May-June) and post-monsoon (October-November) seasons in the year 2021. Eleven sampling sites were selected for well water sampling and from each sites two samples, one for pre-monsoon and one for post-monsoon seasons were collected. Thus in all, twenty one samples were collected for analysis. In Marauna Community Development Block there was no any well and hence the sample from well was not collected from this site.

Laboratory Techniques for Chemical Analysis:

It is difficult to use all samples collected in the field for analysis work. To avoid the unnecessary duplication of samples of similar area and of similar horizon, the representative samples were selected from different geological horizons and different areas.

The procedures for the chemical analysis are based on (a) the Techniques of water resources investigation of U. S. G. S. Book 5, Al[3] (b) Indian Standard Methods of Sampling and Test (Physical and Chemical) for water[4], and (c) Standard Methods for Examination of the Water and Wastewater, prepared by American Public Health Association[5].

For analytical work, mainly three standard analytical procedures have been adopted. They are Titrimetry, Colorimetric Spectrophotometry and Atomic Absorption Spectrophtometry.

Experimental

Aerial temperature, water temperature and the pH of the sample were recorded as soon as water was collected in the bottle. The pH was determined both by what man - BDH pH paper and by portable Philips pH meter (model PP-9040). Turbidity, conductivity, total solid and total hardness were determined in the laboratory. The fluoride, chloride, sulphate, nitrate, magnesium, calcium, iron and arsenic were determined at Madhepura in the PHED Laboratory.

Results and Discussion

Analytical results of physicochemical parameters like pH, turbidity, conductivity, total solid, total hardness as $CaCO_3$, sulphate, nitrate, chloride, fluoride, magnesium, calcium, iron and arsenic of well-water of Supaul district, Bihar in the groundwater of the study area have been tabulated in the Table-1to3.

Physicochemical characteristics of water

Following fifteen parameters have been studied for the water samples.

(i) Arial temperature
(ii) Water temperature
(iii) pH
(iv) Turbidity
(v) Conductivity
(vi) Total solid
(vii) Total hardness as $CaCO_3$
(viii) Chloride
(ix) Sulphate
(x) Nitrate
(xi) Fluoride
(xii) Magnesium
(xiii) Calcium
(xiv) Iron and
(xv) Arsenic.

Aerial temperature

Aerial temperature was recorded at different sampling sites whose values were found to be 36^0C to 39^0C for pre-monsoon (May-June) season and from 28^0C to 32^0C for post-monsoon (October-November).

Water temperature

Water temperature was also recorded at the sampling site for all the samples and it ranges between 33^oC to 36^0C for the samples collected in pre-monsoon season and 25^0C to 28^0C for the samples collected in post-monsoon season. The average minimum and maximum water temperature was 30^0C to 31.5^0C. The ambient and water temperature show a close proximity at all sampling stations. Seasonal variations, however, had a profound effect on water temperature. The water temperature is 3^0C to 7^0C lesser than the air temperature in pre-monsoon and 3^0C to 8^0C lesser in post-monsoon.Water temperature governs the composition and activities of biological species to a large extent. It has an effect on most chemical reactions that occur in natural water system and has pronounced effect on the solubility of gases.

Potenza of hydrogen (pH)

The pH values are in between 6.9 to 7.2 for pre-monsoon and 7.0 to 7.08 for post-monsoon seasons. The values of pH for two samples of well water (W_7 & W_{10}) for pre-monsoon were found to be 6.9 for both samples i.e. these two samples were found to be acidic in nature. The average minimum and maximum pH for pre- and post-monsoon seasons were found to be 6.95 to 7.5. Thus, from the result of pH values it appears that most of the samples are slightly alkaline in nature and some of the samples are slightly acidic in nature. Almost similar reports have been made by Ray *et al.*[6], Pahwa and Mehrotra[7] and Singh[8] in river water. Olanna *et. al.*[9] reported highly alkaline underground water in Jaipur and Andhra Pradesh respectively. CGWB has also reported the higher pH values (above 8.0) for the groundwater of Arariya district. Recently , Similar report have been made by A.K Yadav et.al.[10].

The acceptable value of pH as prescribed by USPH is 6.5 to 8.5. The minimum and maximum limit of pH for drinking water, prescribed by both USPH and WHO, are 6.5 and 9.2 respectively. Thus the pH values of all the water samples are within the acceptable limits. The pH plays an important role in water related environment. High pH values of 8.2 have been reported by Sharma and Ghosh[11] to kill cholera causing bacteria. Lehr[12] proposed that the normal range of pH of groundwater can vary slightly less than 6 to 8.5. The pH is one of the important factors in water quality management[13]. It is a vital aquatic parameter which provides an important means to understand the chemical condition prevailing in natural water. It gives an idea of the concentration of ionized hydrogen which in turn yields indirect information of free carbon dioxide content, alkalinity, dissolved oxygen, dissolved solids and this may serve as a test of several environmental conditions[14].

The lower the pH, the higher is the metal pollution in water because of the formation of ions on dissolution. Toxicity is greater in acidic water than in alkaline sample. The pH is influenced by biological activities besides the addition of chemical substances. The presence of organic matter in huge quantity may lower the pH due to release of CO_2 and SO_2.

Biological processes can give rise to cyclic fluctuation in pH. During summer stagnation, the vertical distribution of CO_2 and HCO_3^-often varies as the inverse of oxygen profile. This imbalances with respect to photosynthetic and respiratory cycle hints that additional bicarbonate may be finding its way into the water from anaerobic process in the underlying bottom muds, possible as ammonium carbonate and as bicarbonates of iron, manganese, calcium and magnesium.

Silica is one of the factors of water which determine the pH of natural waters.[15] Silica is primarily in the form of undissolved orthosilicate, with perhaps some colloidal SiO_2 and complex aluminosilicate ions such as $A1(OH)(HSiO_3)^+$or $A1(HSiO_3)^{2+}$.

Temperature had an influence on the pH because it affects the dissociation coefficient of acids and the solubility of CO_2 in water. Values of pH ranged within the range reported by Warren.

Though being slightly acidic or alkaline in nature, the pH values of samples are within the acceptable limits and hence the water of the study area is nearly fit for different purposes from the pH point of view.

Turbidity

Turbidity is the state of water in which the suspended particles make the water turbid and opaque. It depends upon the amount of suspended particles, soil particles, discharged effluents, decomposed organic matter, total dissolved solids as well as microscopic organisms which interfere with the penetration of light. Besides other impacts, the turbidity has a marked effect on microbial population. The number of bacteria and fungi increases with the rise in turbidity while plankton population shows a fall. It was measured in N.T.U. (Nephelo-Turbidity-Unit).

The values of turbidity for well water were found to be between 3 to 11 and 4 to 10 for pre- and post-monsoon seasons respectively. The average minimum and maximum are 3.5 and 10. The maximum allowable limit as prescribed by WHO is 25. Thus all the values are under the prescribed allowable limit.

Conductivity

Distilled water is almost non-conductor, but the natural waters, in which dissolved salts are present, have a property of conductivity. The conductivity of water is defined as “the reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specified temperature”. The unit of conductivity is micro mhos/cm.

The presence of charged ionic components in solution is responsible for the electrical conductivity of natural water, greater the ionic concentration, higher is the conductance of the water. The conductivity, therefore, serves as an index to the degree of mineralization of natural waters. Generally the ionic concentration (i.e. total dissolved solids in ppm) bears a ratio of 0.55-0.75 with the conductivity.

The conductivity values of well water were found in between 296 to 632 and 256 to 586 for pre- and post-monsoon seasons respectively. The average minimum and maximum are 276 and 609. All these values are in micro mho cm^{-1} unit.

Total solid

It is the sum of dissolved solids and suspended solids in water. As per WHO standard, the maximum allowable limit of total solid is 1500 ppm. For the present study its values for well water were found from 206 to 994 and 184 to 849 for pre- and post-monsoon seasons respectively. The average minimum and maximum are 195 and 921.

Total Hardness

Hardness is primarily due to the presence of calcium and magnesium salts in the form of hydrogen carbonate, chloride and sulphate in the water. Some other polyvalent cations like Fe, Mn, Cu, Sr, Al and Zn have also been reported to impart hardness but it is significantly much less as compared to the presence of Ca^{++} and Mg^{++}ions. Hardness is expressed as ppm of $CaCO_3$. Hard water does not give lather with soap. Water free from soluble salts of calcium and magnesium is called soft water. It gives lather with soap easily. Hard water froms scum/precipitate with soap.

The value of hardness in the well water of study area ranged from 142 ppm to 295 ppm and 123 ppm to 198 ppm for pre- and post-monsoon seasons respectively. The average minimum and maximum are 132.5 ppm to 239.5 ppm. The variation in the hardness values show that the ground water of the study area fall in the range of moderately hard to hard water.

Although excess of hardness causes no health hazards but it increases soap consumption and higher fuel consumption in cooling towers. Higher consumption of soap and detergents again impart the pollution to surface and groundwater as it finally reaches to that enough surface runoff. Some time it also show laxative properties to unaccustomed person and makes skin rough after bathing with soap. Its beneficial effects have also been studied. It is believed that hardness save life by lowering the risk of cardio vascular disease.

Chloride

Chloride is present in most natural water as a major dissolved constituent. Sodalite and apatite are the most common chlorine bearing minerals. Chlorine is also found in micas, hornblende and natural glass in little amount. Liquid inclusion and residual water contained in rock and mineral structures, have also been quoted to incorporate some chloride.

There are many opinions about the possible sources for concentration of chloride in the groundwater. They are:

(a) Connate or entrapped sea water in marine sedimentary evaporate sequences.
(b) Concentration by evaporation of chloride transported from the sea and precipitated on land by rain or snow.
(c) Dissociation of halite and related minerals of evaporate series, etc.

Chloride in natural water is derived largely form the cyclic salts, which are carried to land by clouds and precipitated on the land surface as rain or show. Chloride is relatively free from effects of exchange of ion, absorption, and biological activities. It is very difficult to remove the dissolved chloride from the water on account of its high solubility. Hence the chloride concentration in natural water continues to rise, particularly in arid regions, because carbonates and sulphates precipitate out depending upon their saturation points and intensity of evaporation. The concentration of chloride in

natural water is therefore, highly variable over wide range. Practically, all natural water contains chloride varying concentration. Their presence can be expressed from their origin as pure sodium chloride crystals in natural deposits of igneous and sedimentary rocks. Chloride can also show an increase if there are chances of domestic waste water pollution specially caused by release of NaCl taken in food around 10g/day when there is a corresponding rise in the nitrate content as well. Considering non bio-degradable nature of chloride, this has also been considered as an important parameter. The recommended maximum concentration for chloride in drinking water is 250 g/L primarily for reasons of taste.

In the present study, the values of chloride in the well water were found to be 42 ppm to 94 ppm and 38 ppm to 89 ppm for pre-monsoon and post-monsoon seasons respectively. The average value is 40 ppm to 91 ppm. All these values are within the permissible limit.

Sulphate

Sulphur is the minor constituent to the earth's crust. In water and sedimentary rocks, it occurs in the form of sulphate and also in reduces form as metallic sulphides, both in igneous as well as sedimentary rocks. Sulphate ion is chemically stable in aerated water where salts of low solubility are formed. Due to recycling of salts, the concentration of sulphate ions increases in ground water. It has been commonly observed that sulphate content in rain water increases landwards for which a number of theories have been put forwards 103-119. In the area of low rainfall the solutes, which are brought by rainfall remain in the soil and are not fully leached. The water either of surface or of sub-surface area are likely to have comparatively high dissolved salts of which sulphate may, at places, become the dominant anion. Pyrite in sedimentary rocks also happens to be a source of ferrous iron and sulphate in ground water, sulphate also comes into the groundwater from the minerals of feldspathoid group.

The acceptable limit of sulphate is 200 ppm and maximum allowable limit is 400ppm. The concentration of sulphate in the well water is 10 ppm to 12 ppm and 8 ppm to 10 ppm for pre-monsoon and post-monsoon seasons respectively. The average value is 9 ppm to 11 ppm. As obvious from the values of sulphate given in the tables, all the values are well within the acceptable limit of 200 ppm.

Nitrate nitrogen (NO_3/N)

The principal source of nitrate is the rainwater itself. It also occurs naturally in some groundwater and enters the mammalian body through drinking water. Although its presence in drinking water is not known to be harmful to children and adults, but it can be hazardous in case of babies up to the age of six months. If baby is fed with milk made from water containing more than 10 mg/l of nitrate nitrogen the possibility of methaemoglobinaemia exists since nitrate absorbed in the blood prevents oxygen transport. Nitrate content of aquatic system are important because they have a great bearing on the growth of living bodies in the system, for example, higher amount of this ions is responsible for eutrophication of aquatic body. Atmospheric nitrogen plays an important role in causing the nitrate concentration by pouring this ion through rainfall. Higher denitrifying bacterial activities at increased temperature and utilization of nitrate by dense algal population are considered by earlier worker[16].

Nitrogen like oxygen, dissolves from the atmosphere in equilibrium with water at the surface. But unlike oxygen nitrogen gas itself is quite inert chemically. Nevertheless nitrogen may exist in a number of different valence states in the natural environment depending on the prevailing redox condition.

Disturbance of the ecology of the watershed alter their nitrogen content. When a watershed is deforested, summer vegetation fails to take up nitrate-nitrogen nutrient and the highly

leachable forms of nitrogen are carried away by the waters and lost to the ecosystem. In well water the value of nitrate were found to be 0 to 14 ppm for pre-monsoon and 0 to 12 ppm for post-monsoon. The average is 0 to 13 ppm.

The value of nitrate is well within the permissible limit. The maximum allowable limit of nitrate prescribed by USPH and WHO is 45ppm. Thus all the values are much less than the limit.

Calcium & Magnesium

Calcium is the most common cation in natural water, while magnesium is commonly present in amounts much less than calcium. Both the elements found in water are derived from the decomposition of contacted minerals. In closed system of arid zones, evaporation may changes the concentration substantially so that the less soluble salts like sulphate and carbonate of calcium are precipitated and enrich the water with magnesium and calcium salts.

In sedimentary rocks, calcium is found in the form of calcite, dolomite, gypsum, fluorite, etc. In sandstones, calcium carbonate is generally present as a cementing material. There are so many minerals of igneous rocks which contain calcium as an essential constituent e.g. minerals of the pyroxene group, amphibole group and feldspar group. In the metamorphic rocks, it occurs in the silicate minerals.

The ionic size of magnesium is smaller than that of the sodium or calcium, that's why magnesium has stronger charge density, and greater attraction for the water molecules. The presence of carbon dioxide controls the solubility of magnesium. The magnesium carbonate is much more soluble than calcium carbonate and due to this magnesium carbonate is not precipitated under ordinary temperature and pressure.

Magnesium

In well water the value of magnesium were found between 8 ppm to 14 ppm for pre-monson and 6 ppm to 12 ppm for post-monsoon respectively. The average values are from 7 ppm to 8 ppm. The acceptable limit prescribed by USPH is 30 ppm and maximum limit prescribed by USPH and WHO is 150 ppm. Thus almost all the values are well within the maximum limits and mostly around the acceptable limit of 30ppm.

Calcium

In well water the value of Ca was found to be 19 ppm to 24 ppm for pre-monsoon and 17 ppm to 22 ppm for post-monsoon seasons. The average is 17.5 ppm to 24 ppm.

The acceptable limit of Ca is 75 ppm as prescribed by USPH. The maximum allowable limit is 200 ppm as prescribed by USPH and WHO. Thus all the values are well within the acceptable range of 75 ppm.

IRON (Fe):

The well-water value of iron was between 0.4 ppm to 1.9 ppm and 0.328 ppm to 1.833 ppm for pre– and post- monsoon respectively. The average is between 0.364 ppm to 1.866 ppm.

As per U.S. public health service (USPH) Standard for drinking water is acceptable, concentration of iron is 0.100 ppm and water having 1.30 ppm iron is the cause of rejection. As per the internal standard for drinking water prescribed by WHO, the maximum allowable limit of iron is 1.000 ppm.

Thus, the value of Iron in some pockets of study area is more than the allowable and acceptable value prescribed by WHO and USPH.

Fluoride (F):

The well water value of fluoride was found between 0.3 ppm to 0.7 ppm and 0.3 ppm to 0.6 ppm for pre – monsoon and post – monsoon respectively. The average value comes between 0.3 ppm to 0.65 ppm. The value of fluoride in the study area is well within the permissible and allowable limits.

Table - 1
Physicochemical characteristics of ground water (well water) of Supaul district (Bihar) for pre-monsoon season (May-June 2021)

SL.NO	SAMPLING SITE	SAMPLE NO	AERIAL temp in °C	WATER TEMP °C	PH	TURBIDITY	CONDUCTIVITY mhos/Cm	TOTAL SOLID ppm	TOTAL HARDNESS AS $CaCO_3$ ppm	Fe in ppm	SO_4 in ppm	NO^3 in ppm	Mg in ppm	Ca in ppm	Cl in ppm	F in ppm	As in ppm
1	Pipra	W_1	37	34	7.0	3	296	632	142	0.4	12	nil	8	20	42	0.4	BDL
2	Tribeniganj	W_2	39	36	7.0	6	402	798	148	0.5	10	nil	14	34	47	0.6	BDL
3	chhatapur	W_3	38	35	7.1	6	524	903	160	0.4	11	nil	9	19	91	0.5	BDL
4	Pratapganj	W_4	37	34	7.1	9	496	994	172	1.6	11	nil	9	24	88	0.5	BDL
5	Basantpur	W_5	38	35	7.2	11	424	206	202	1.7	12	nil	8	26	89	0.4	BDL
6	Raghopur	W_6	37	34	7.1	8	468	212	205	1.9	12	nil	9	22	68	0.5	BDL
7	Supaul	W_7	39	36	6.9	6	486	226	200	1.7	11	nil	8	22	98	0.6	BDL
8	Kishanpur	W_8	37	34	7.2	6	632	268	214	1.5	11	3	9	23	82	0.7	BDL
9	Bhaptiyahi	W_9	38	35	7.1	4	405	290	190	1.4	1 2	3	8	24	74	0.6	BDL
10	Nirmalli	W_{10}	37	34	6.9	3	412	286	295	1.6	12	14	8	23	94	0.7	BDL
11	Marauna	W_{11}	-	-	-	-	-	-	-	-		-	-	-	-		-

Table -2
Physicochemical characteristics of ground water (well water) of supaul district (Bihar) for post-mansoon season (October-November,2021)

SL.NO	SAMPLING SITE	SAMPLE NO	AERIAL TEMP. IN ^{0}C	WATER TEMP ^{0}C	PH	TURBIDITY	CONDUCTIVITY mhos/Cm	TOTAL SOLID ppm	TOTAL HARDNESS AS $CaCO_3$ppm	Fe IN ppm	SO_4 ppm	NO_3 IN ppm	Mg IN ppm	Ca IN ppm	Cl in ppm	F in ppm	As in ppm
1	Pipra	W1	30	28	7.1	4	256	589	123	0.328	8	nill	6	17	38	0.3	BDL
2	Triveniganj	W2	31	27	7.5	6	366	749	139	0.436	8	nill	12	30	43	0.5	BDL
3	Chhatapur	W3	30	27	7.6	6	496	825	139	0.468	8	nill	7	16	86	0.4	BDL
4	Pratapganj	W4	31	26	7.3	8	456	849	156	1.566	9	nill	7	20	68	0.4	BDL
5	Basantpur	W5	30	27	7.4	9	368	184	181	1.642	9	nill	7	22	83	0.3	BDL
6	Raghopur	W6	32	26	7.8	10	398	186	169	1.833	10	nill	7	20	58	0.4	BDL
7	Supaul	W7	30	26	7.2	5	456	188	168	1.646	10	nill	7	20	89	0.5	BDL
8	Kishanpur	W8	32	28	7.3	7	586	190	198	1.538	10	3	7	20	57	0.6	BDL
9	Bhaptiyahi	W9	28	25	7.3	4	368	192	183	1.452	9	10	7	22	61	0.6	BDL
10	Nirmali	W10	31	28	7.0	4	456	194	184	1.646	10	5	7	20	88	0.5	BDL
11	marauna	W11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table -3
Average value of Physicochemical characteristics of ground water (well water) of supaul district (Bihar) for pre-mansoon season (2021

MPLING SITE	SAMPLE NO	AERIAL TEMP. IN ^{0}C	WATER TEMP ^{0}C	PH	TURBIDITY	CONDUCTIVITY mhos/Cm	TOTAL SOLIDppm	TOTAL HARDNESS AS $CaCO_3$	Fe IN ppm	SO_4 ppm	NO_3 IN ppm	Mg IN ppm	Ca IN ppm	Cl inppm	F inppm	As in ppm
Pipra	W1	33.5	31	7.5	3.5	276	560	132.5	0.364	10	nil	7	18.5	40	0.35	BDL
veniganj	W2	35	31.5	7.25	6	384	273	143.5	0.468	9	nil	13	32	45	0.55	BDL
ıhatapur	W3	34	31	7.35	6	510	864	149.5	0.434	9.5	nil	8	17.5	88.5	0.45	BDL
ıtapganj	W4	34	30	7.2	8.5	476	921	164	1.583	10	nil	8	22	78	0.45	BDL
ısantpur	W5	34	31	7.3	10	396	195	191.5	1.671	10.5	nil	7.5	23	86	0.35	BDL
ıghopur	W6	34.5	30	7.5	9	433	199	187	1.866	11	nil	8	24	63	0.45	BDL
Supaul	W7	34.5	31	7.5	5.5	471	207	184	1.673	10.5	nil	7.5	21	93.5	0.55	BDL
shanpur	W8	34.5	31	7.25	5.5	609	224	206	1.519	10.5	3	8	21.5	68.5	0.65	BDL
aptiyahi	W9	33	30	7.2	4	386.5	241	186.5	1.426	10.5	6.5	7.5	23	67.5	0.6	BDL
Nirmali	W10	34	31	6.95	3.5	434	240	239.5	1.623	11	9.5	7.5	21.5	91	0.6	BDL
ıarauna	W11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Arsenic (As):

The acceptable and the maximum allowable limit of arsenic is 0.01 ppm. The level of arsenic in well water and tube well water in both pre– monsoon and post– monsoon were below detection limit (BDL) in the study area.

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