VARIABILITY IN PHYSICO-CHEMICAL PARAMETERS OF GROUND WATER OF NORTH-EAST ZONE OF THE BHIWADI INDUSTRIAL AREA (ALWAR)

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ABSTRACT

Ground water quality parameters of North–East zone of Bhiwadi industrial area (Alwar) Rajasthan were assessed in this study. Ground water samples were collected from different location of North–East zone and analysis of parameters such as pH, TDS, BOD, COD, DO, Fluoride, Nitrate, Sulphate, TH, TA, and heavy metals were carried. Finding parameters were compared with the WHO water quality parameters. It was found that some of the location under the study fall in polluted zone. The results shown that the areas which near to industries have polluted than the others.

INTRODUCTION

Pollution of ground water is an important aspect of environmental pollution with the fast industrialization and urbanization in the world. The principal sources of contaminants of ground water are mines, petroleum processing units, steel, smelter plants, pulp paper, textile and agriculture industries etc. When the waste water of an industry is dumped into streams, it gets into natural sources and causes change in physio-chemical composition of ground water which ultimately becomes unsuitable for use. Many different chemicals and various synthetic products we use today are usually the main causes of ground water pollution[1-5].

A lot of effluents and wastes discharged by the industries over the years have contaminated the groundwater resources. Bhiwadi is a highly polluted city due to too much industrialization. Many industries leave out his effluents without treatment. This untreated effluent spared on land surface and it enter into aquifer and contaminated the groundwater. This contaminated groundwater cause of many disorders in human being and crops[6,7].

This paper highlights the various physico-chemical parameters of ground water from various sources of North-East zone of Bhiwadi industrial area, which will helps us to formulate the strategy for mitigating the harmful effects of ions present above the prescribed levels.

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EXPERIMENTAL

Material and method

Bhiwadi is located at the East end of Rajasthan in Tijara tehsil of Alwar district. It is within the national capital region, just 55 Kms away from Delhi, 200 Kms from state capital Jaipur and 90 Kms from the district head quarter Alwar. Spread over 3347 acres of land and 3000 acres area proposed for extension, Bhiwadi has about 1455 tiny, small, medium and large industries including MNC industrial units manufacturing various types of products. They include all types of industries like steel, furnance, electronics, engineering, textiles, pharmaceuticals, printing, packaging, cables, rolling mills, food processing, herbal care etc.

Bhiwadi already boasts of big multinational companies, namely, Pepsi, Honda Siel (manufacturers of Honda cars), Orient Craft, Asahi, Jaquar, and Hero Honda, Bausch & Lomb, United Breweries, Ray Ban, Saint Gobain, Federal Moghul, Gillette, Sakata Ink and Ocap Chasis. Other major industries in the city include Relaxo Footwear, Lakhani Footwear, Jacquar Ltd., Harvest Foods Limited, Kajaria Ceramic Ltd, and SEZ of Mahindra and Mahindra. These companies have acquired huge acres of land in Bhiwadi, made crores of investment and employed thousands of people. Bhiwadi serves as a gateway to Rajasthan.

The present study was planned by selecting ten locations located in North-East Zone of Bhiwadi industrial area and ground water samples were collected from selected locations as per standard procedure. The literature survey showed that no ground water studies were made in these localities so far. Hence the present study was undertaken by authors.

Collection and analysis of ground water samples

The ground water samples were collected in pre cleaned one- liter plastic bottles from borewells, handpumps and open wells located in North-East zone of Bhiwadi industrial area. The ground water samples which collected from different sources, analyzed as per standard procedures to know the chemical status of ground water[8-10]. These groundwater samples were taken two times- pre monsoon and post monsoon. The analyzed data were compared with the water standards given in the Table 1[4,5,9]. Results of ground water samples of North-East zone are summarized in the Table 2, 3, 4 and 5.

RESULTS AND DISCUSSION

pH

The pH value of a water source is a measure of its acidity or alkalinity. The pH level is a measurement of the activity of the hydrogen atom, because the hydrogen activity is a good representation of the acidity or alkalinity of the water.

The range of pH of ground water samples was found to vary 6.3 to 8.9 for pre monsoon samples and 6.1 to 8.4 for post monsoon samples. The pH value varies from 6.1 to 8.9 for both sessions. Maximum pH values of both session are found within range according to ISI standards but some pH value of pre monsoon samples like that of village Rampur and community centre have higher values than permissible limits and subzi mandi area have lower values than the desirable limit. Industrial effluents are logged around the Rampur village area. Community centre is located between the many industries. Hence the pH value was found greater than the others areas in this zone.

Table 1: Standards of drinking water according to various agencies.

Parameter	International standard (APHA 1993)		Indian standard (BIS, 1993)		Ministry of Urban development		W.H.O. (1971)		I.C.M.R. (1975)	
	Max. acceptable conc.	Max. allowable conc.	Max. acceptable conc.	Max. allowable conc.	Max. acceptable conc.	Max. allowable conc.	Max. acceptable conc.	Max. allowable conc.	Max. acceptable conc.	Max. allowable conc.
Colour	5 Unites	25 Unites	5 Unites	25 Unites	5 Unites	25 Unites	5 Unites	25 Unites	5 Unites	25 Unites
Odour	Unobjectable	-	Unobjectable	-	Unobjectable	-	Unobjectable	-	Unobjectable	-
Taste	Agreeable	-	Agreeable	-	Agreeable	-	Agreeable	-	Agreeable	-
Turbidity	2.5NTU	10NTU	5 NTU	10 NTU	2.5 NTU	10 NTU	2.5 NTU	10 NTU	2.5 NTU	10 NTU
pH	7.0 to 8.5	6.5to 9.2	6.5 to 8.5		7.5 to 8.5	6.5 to 9.2	7.0 to 8.0	6.5 to 9.2	7.0 to 8.6	6.5to 9.2
TH	100	500	300	600	200	600	100	500	360	600
TDS	500	1500	500	2000	500	1500	500	1500	550	1500
Iron	0.1	1.0	0.3	1.0	0.1	1.0	0.1	1.0	0.1	1.0
Calcium	75	200	75	200	75	200	75	200	75	200
Magnesium	30	150	30	150	30	150	80	150	50	100
Chloride	200	600	250	1000	200	1000	200	600	200	1000
Sulphate	200	400	200	400	200	400	200	400	200	400
Nitrate	45	100	45	100	45	100	45	-	20	-
Fluoride	0.7	1.5	0.7	1.5	1.0	1.5	0.9	1.7	1.0	2.0
Zinc	5	1.5	5	1.5	5	1.5	5	1.5	-	-
Copper	0.05	1.5	0.05	1.5	0.05	1.5	0.05	1.5	0.05	1.5
Arsenic	0.05	NR	0.05	NR	0.05	0.05	-	-	-	-
Cadmium	0.01	NR	0.01	NR	0.01	1.0	-	0.01	0.01	-
Cyanide	0.05	NR	0.05	NR	0.05	0.55	-	-	-	-
Lead	0.1	NR	0.1	NR	0.1	0.1	-	0.1	0.1	-
Mercury	0.001	NR	0.001	NR	0.1	0.001	-	-	-	-
Selenium	0.01	NR	0.01	NR	0.01	0.01	-	-	-	-
RC	0.2	0.2	-	-	-	-	-	-	-	-
Coliform	-	4	-	4	-	10	-	-	-	-

NR = No relaxation; RC = Residual chlorine; THTotalhardne

Table 2: Physical and Biological Parameters of North- East zone: Pre-monsoon samples

Location / Source	pH	Color	Odour	Turbidity	Taste	Conductivity	BOD	COD	DO	Total coliform
Ghatal (HP)	7.2	Colorless	Unobjectionable	< 0.1	Agreeable	678	1.2	15.21	1.1	< 3
Govt. School (BW)	7.8	Clear	Unobjectionable	1.7	Agreeable	789	0.9	10.9	0.8	2
Phool Bagh Chowk (BW)	6.5	Clear	Unobjectionable	2.9	Agreeable	1090	3.8	44	1.9	4
Hanuman Plaza (BW)	6.9	Clear	Unobjectionable	1.5	Agreeable	690	2.3	38	1.04	0.0
Rampur (OP)	8.6	Slightly brown	Unobjectionable	12.9	Agreeable	1580	12.5	64.4	2.8	5
Subzi Mandi (HP)	6.3	Clear	Unobjectionable	0.6	Agreeable	580	0.6	10.8	4.2	1
Community Centre(OP)	8.9	Reddish	Unobjectionable	10.2	Agreeable	1700	15.8	66	1.2	6
Police Thana(BW)	7.5	Clear	Unobjectionable	1.2	Agreeable	490	0.5	8.4	1.9	2
I.T.I.(HP)	7.2	Clear	Unobjectionable	2.6	Agreeable	600	0.0	5.4	0.7	2
BMA(HP)	7.0	Clear	Unobjectionable	1.0	Agreeable	400	0.8	10.2	0.4	1

HP = Handpump   BW = Bore well   OP = Open well

Table 3: Chemical Parameters of North-East zone: Pre-monsoon samples

Location / Source	Cl^-	NO_3^-	TDS	PO_4^{-3}	SO_4^{-2}	Al^{+3}	F	Cd	Hg	Cu	As	Pb	Cr	Fe	Zn	Hard-ness	Ca-Hardness	Mg-Hardness	Alkalinity	Oil & Grease
Ghatal (HP)	236	45	790	0.005	24.5	0.03	0.52	ND	ND	0.01	ND	ND	0.04	0.1	2.8	450	165	89	580	ND
Govt. School (BW)	400	16.6	1100	0.07	ND	0.2	1.4	ND	ND	0.05	ND	ND	ND	ND	5.0	970	289	110	409	ND
Phool Bagh Chowk (BW)	270	124	550	0.0	110	0.01	0.9	ND	ND	ND	0.002	ND	ND	0.17	ND	630	150	95	240	ND
Hanuman Plaza (BW)	117	56	950	ND	170	ND	1.2	ND	ND	0.08	ND	ND	ND	0.3	ND	290	110	65	350	ND
Rampur (OP)	890	87	2200	1.2	756	0.9	2.5	0.01	ND	ND	0.05	0.05	ND	5.6	14.9	1170	430	190	560	1.09
Subzi Mandi (HP)	350	45	780	0.4	345	0.07	1.1	ND	ND	0.01	ND	0.001	0.05	1.1	ND	230	75	45	160	ND
Community Centre (BW)	185	39	366	0.001	175	0.0	1.0	ND	ND	ND	0.001	ND	ND	0.03	ND	590	178	85	290	ND
Police Thana (OP)	650	49	1545	0.0	390	1.3	1.5	0.02	0.001	0.6	0.004	ND	0.001	1.5	1.6	745	230	125	180	0.7
I.T.I. (HP)	440	34	876	ND	198	0.3	1.9	ND	ND	0.05	ND	ND	ND	0.6	0.08	670	345	78	278	ND
BMA (HP)	195	22	1480	ND	378	0.2	1.3	ND	0.001	0.02	ND	0.04	ND	0.09	ND	1520	650	220	610	0.3

Table 4: Physical and biological parameters of North-East zone: Post-monsoon samples

Location / Source	pH	Color	Odour	Turbidity	Taste	Conductivity	BOD	COD	DO	Total coliform
Ghatal (HP)	7.0	Colorless	Unobjectionable	2.9	Agreeable	765	ND	12.21	2.1	< 4
Govt. School (BW)	6.6	Clear	Unobjectionable	3.7	Agreeable	740	1.9	7.9	1.3	ND
Phool Bagh Chowk (BW)	6.5	Clear	Unobjectionable	2.9	Agreeable	460	0.8	24	0.5	1
Hanuman Plaza (BW)	7.6	Clear	Unobjectionable	0.5	Agreeable	987	4.3	37	1.6	0.0
Rampur (OP)	7.8	Slightly brown	Unobjectionable	3.9	Agreeable	1480	16.5	77.4	0.8	8
Subzi Mandi (HP)	8.4	Clear	Unobjectionable	1.6	Agreeable	580	8.9	39.8	1.5	4
Community Centre (OP)	7.9	Reddish	Unobjectionable	6.8	Agreeable	1560	13.8	98	2.4	3
Police Thana (BW)	7.1	Clear	Unobjectionable	1.2	Agreeable	745	0.0	29	1.8	9
I.T.I. (HP)	6.8	Clear	Unobjectionable	0.1	Agreeable	510	0.9	9.4	0.9	18
BMA (HP)	7.6	Clear	Unobjectionable	2.6	Agreeable	390	1.2	22.9	2.2	3

HP = Handpump BW = Bore well OP = Open well

Table 5: Chemical parameters of North-East zone: Post-monsoon samples

Location / Source	Cl^-	NO_3^-	TDS	PO_4^{-3}	SO_4^{-2}	Al^{-3}	F^-	Cd	Hg	Cu	As	Pb	Cr	Fe	Zn	Hard-ness	Ca-Hardness	Mg-Hardness	Alkalinity	Oil & Grease
Ghatal (HP)	355	22	1780	0.0	290	ND	1.1	ND	ND	ND	ND	ND	0.02	0.9	ND	680	279	98	390	ND
Govt. School (BW)	125	105	680	0.02	ND	ND	1.0	ND	ND	0.02	ND	0.02	ND	1.1	2.9	480	180	80	589	ND
Phool Bagh Chowk (BW)	650	34	1455	ND	110	0.02	4.2	0.001	ND	ND	ND	ND	0.01	0.4	ND	746	210	103	495	ND
Hanuman Plaza (BW)	290	49	819	ND	170	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.8	340	110	99	480	ND
Rampur (OP)	980	134	1900	0.9	890	1.02	6.3	0.01	ND	0.8	ND	ND	ND	7.3	16.3	1922	398	178	640	2
Subzi Mandi (HP)	390	18	560	0.002	675	0.02	1.3	ND	ND	0.01	ND	0.01	ND	0.009	4.3	389	115	45	395	ND
Community Centre (BW)	220	43	790	ND	175	ND	0.9	ND	ND	ND	ND	ND	ND	0.4	ND	579	222	70	510	ND
Police Thana (OP)	1050	34	3256	1.02	390	0.7	3.2	0.02	ND	0.06	0.05	ND	0.001	2.1	0.9	1380	278	134	605	1.08
I.T.I. (HP)	340	48	2120	0.003	198	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND	780	190	87	448.8	ND
BMA (HP)	255	54	1970	ND	410	0.2	1.1	ND	ND	0.4	ND	ND	0.05	1.0	ND	980	569	149	579	ND

ND= Not detectable

Color

The color of ground water samples of pre monsoon and post monsoon are not found same. This is indicative of large amounts of organic chemicals and inadequate treatment. There may be little health concerns to the color availability in the groundwater. However, it is aesthetically unpleasing.

Odour

Certain odours are indicative of organic or non-organic contaminants that originate from municipal or industrial waste discharges or from natural sources in the ground water samples.

Taste

It can be evaluated by a taste test. In the North East zone ground water samples which are unaffected by industries have agreeable taste.

Turbidity

It is the cloudiness or haziness of a fluid caused by suspended solids that are generally invisible to the naked eye. The measurement of turbidity is a key test of water quality. Fluids can contain suspended solid materials consisting of particles of many different sizes. While some suspended materials will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand. Very small particles settle very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid.

Turbidity of the North–East zone was found within the range 0.1 to 12.9. The pre monsoon samples of village Rampur and community centre have higher values of turbidity than the permissible limits.

Electrical conductivity

It is the ability of a substance to conduct electricity. The conductivity of water is a more-or-less linear function of the concentration of dissolved ions. Conductivity itself is not a human or aquatic health concern, but because it is easily measured, it can serve as an indicator of other water quality problems. Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems.

Electrical conductivity of this zone was found between range 400 to 1700 microsiemens/cm. The Tables 2 and 4 reveal that Rampur village and community centre have high conductivity than other sources. This is due to pollution of ground water by percolating industrial effluents in the soil.

Biological Oxygen Demand (BOD)

Biological oxygen demand is a test of great value in the analysis of sewage industrial effluents and polluted water. It provides an indirect measure of total amount of unstable organic matter contained in a waste. The test is a basis for assessing the effect of the discharge of the waste water on the oxygen balance of natural water receiving it. BOD refers to the quantity of oxygen required by bacteria and other micro organisms in the biochemical degradation and transformation of organic matter under aerobic conditions.

The BOD values vary for the pre monsoon samples from 0.5 to 15.8 mg/L range and for the post monsoon from 0.8 to 16.5 mg/L range. The range for both session is 0.5 mg/L to 16.5 mg/L. The higher values of BOD indicate that the industrial effluents contain large amount of organic matter. That is why the distillery, beverages, oil and food processing industrial units operative in the industrial area. The Table 2 and 4 show that Rampur and Police thana area sample have higher value of BOD than other samples. These two

areas are Rampur and Police thana are located near the industries. Perhaps, this is due to industrial effluents percolating the in these areas.

Chemical Oxygen Demand (COD)

This test is highly useful to find out the pollution strength of industrial effluents and sewage. Chemical oxygen demand as the name implies is the oxygen requirement of a sample for oxidation of organic and inorganic matter. As the oxidisable inorganic matter is usually negligible in comparison with the quantity of organic matter, COD is generally considered as the oxygen equivalent of the amount of the organic matter oxidisable by potassium dichromate.

The range of COD found for pre monsoon samples varies from 5.4 to 66 mg/L and for post monsoon from 9.4 to 98 mg/L. The range is 5.4 to 98 mg/L for both sessions. The water with high BOD and COD is totally unsuitable for drinking, irrigation, domestic, industrial and other purposes.

Dissolved oxygen

Oxygen is dissolved in most of the water in varying concentration. Solubility of oxygen depends on temperature, pressure and salinity of water. In industrial water, dissolved oxygen is a nuisance as it induces corrosion reactions.

The DO values of the North–East region for pre monsoon sample was found in the range from 0.4mg/L to 2.8 mg/L and for the post monsoon session from 0.5 to 2.4 mg/L. It indicates that the water is contaminated and it is difficult to survive any aquatic species in this water.

Total coliform

These occur naturally in the environment from soils and plants and in the intestines of humans and other warm-blooded animals. Used as an indicator for the presence of pathogenic bacteria, viruses, and parasites from domestic sewage, animal wastes, plant or soil material. Bacteria, viruses, and parasites can cause polio, cholera, typhoid fever, dysentery, and infectious hepatitis.

The total coliforms range from 1MPN/100 to 18MPN/100 for both sessions, which show the presence of coliform and water is bacteriological contaminated. All the ground water samples except Subzi Mandi, BMA and Phool bagh chowk have more Total coliform than the desirable limit as per described in IS : 10500-1991.

Total hardness

Water hardness is an aesthetic quality of water and is caused mostly by the minerals calcium and magnesium but is classified or measured based on the level of concentration of calcium.

The Table 3 and 5 reveal that the values of total hardness vary from 230 to 1520 mg/L for the pre-monsoon samples and Ca and Mg Hardness varies from 75 to 650 mg/L and 45 to 220 mg/L, respectively. For the post-monsoon samples range of TH was found 389 to 1922 mg/L and Ca, Mg hardness range, 110 to 569 mg/L and 45 to 178 mg/L, respectively. All sample have higher value in the both sessions than the desirable limit as compared to IS-10500-1991 parameters.

Sulphate

Sulphate in groundwater is caused by natural deposits of magnesium sulfate, calcium sulfate or sodium sulfate. Higher concentrations are undesirable because of their laxative effects. People not used to drinking water with high levels of sulfate can experience dehydration and diarrhea.

Sulphate values were found in the range from 24.5 to 756 mg/L and 110 to 890 mg/L for pre and post-monsoon samples, respectively. Village Rampur, subzimandi area and BMA area have higher sulphate values in the both session than the permissible limits due to industrial effluents percolating in the ground water.

Chloride

Chlorides in groundwater can be naturally occurring in deep aquifers or caused by pollution from industrial or domestic wastes.

The chloride contents in the all ground water samples were found in the range from 117 to 890 mg/L and 125 to 1050 mg/L for the pre and post session, respectively. Police thana area have 1050 mg/L chloride value for the post-monsoon session higher than the permissible limits.

Total dissolve solid

The total dissolved solids test measures the total amount of dissolved minerals in water. The solids can be iron, chlorides, sulfates, calcium or other minerals found on the earth's surface.

The Tables 3 and 5 show the ranges of the total dissolved solids the pre monsoon samples which was found between 366 to 2200 mg/L. The Table 5 indicates that village Rampur has higher values than the permissible limits. TDS values of the post monsoon sample ranged in 560 to 3256 mg/L and police thana and ITI area have higher TDS value than the permissible limits. It may be concluded that all water sources except community centre (TDS 366 mg/L) have more TDS value than the desirable limit.

Alkalinity

Alkalinity is a measure of the presence of bicarbonate, carbonate or hydroxide constituents. Concentrations less than 100 ppm are desirable for domestic water supplies. The recommended range for drinking water is 30 to 400 ppm.

The range of alkalinity of the pre monsoon sample was found 160 to 610 mg/L and maximum alkalinity was found in BMA area source. The value of TA of the post monsoon samples were found in the ranges 390 to 640 mg/L and village Rampur has maximum alkalinity value. The Tables 3 and 5 show that the all sources (except subzi mandi & police thana) have higher alkalinity than the desirable limit.

Nitrate

The Table 3 and 5 reveal the values of nitrate of the pre monsoon samples from 16.6 mg/L to 124 mg/L range and of post-monsoon sample, 22 mg/L to 134 mg/L range. All ground water samples have higher value of nitrate than the permissible limits. This may be due to less rainfall and excessive use of fertilizers and higher concentration of nitrates in industrial effluents discharged by different industries.

Aluminium

Aluminium is widely used in water treatment as flocculants. An associated link between the Alzheimer disease and aluminium in drinking water has lately been suspected.

The observed values of aluminium in North-East zone ground water samples of the pre-monsoon sample and post-monsoon sample are shown in the Table 3 and 5, respectively. Rampur and police thana water sources have higher value of aluminium ion than permissible limits only pre-monsoon samples.

Table 6: Ground water quality status in North-East Zone

Location / Source	Samples collected			
	Pre-monsoon	Remarks	Post-monsoon	Remarks
Ghatal (HP)	Good		Doubtful	TH, TDS Iron higher
Govt. School (BW)	Good	Only TH higher	Excellent	
Phool Bagh Chowk (BW)	Good	Only TH higher	Doubtful	Fluoride & TH higher
Hanuman Plaza (BW)	Excellent		Excellent	
Rampur (OP)	Unsuitable	Not fit for drinking	Unsaitable	Not fit for drinking
Subzi Mandi (HP)	Good	Sulphate and iron higher	Good	EC & Nitrate higher
Community Centre (OP)	Doubtful	pH, Turbidity, TH EC higher	Good	Sulphate, TDS & TA higher
Police Thana (BW)	Good	TH, TDS higher	Unsuitable	Cl⁻, TDS, TH, F⁻, Fe, TA& EC higher
I.T.I. (HP)	Good	TH higher	Doubtful	TDS, TA & TH Higher
BMA (HP)	Good	TA & TH higher	Doubtful	TDS, TA, Sulphate higher

Fluoride

The Tables 3 and 5 reveale the range of fluoride in this zone for the pre monsoon sample range from 0.52 to 2.5 mg/L. It can be seen from table that ITI, village Rampur and police thana have higher fluoride values then the permissible limits. The fluoride range of the post monsoon samples was found 0.9 to 6.3 mg/L. Police thana, Rampur and phoolbagh chowk samples have higher fluoride values than the permissible limits[11-14].

Iron

The range of iron of the pre monsoon sample varies from 0.03 to 5.6 mg/L and Rampur, police thana area, and subzi mandi sources have higher values than the permissible limits. Iron values for the post monsoon sample varies from 0.09 to 7.3 mg/L. The Table 5 shows that in post monsoon samples Govt. School, Rampur and police thana samples have higher values than the permissible limits.

Lead

The Tables 3 and 5 reveal that the range of lead varies from 0.01 to 0.05 mg/L for both type samples. Desirable limit for lead is 0.05 mg/L. Hence, the data obtained indicate the low degree pollution due to this element.

Mercury

The range of mercury in the ground water samples of North-East zone for pre and post-monsoon session is not detectable but only police thana and BMA have 0.001 mg/L values of Hg. The results has shown in the Table 3 and 5.

Arsenic

The heavy metal arsenic is not detectable in ground water samples for post-monsoon session except police thana. The range of arsenic of pre-monsoon samples varies from 0.001 to 0.005 mg/L.

Cadmium

The range of Cd occurrence varies for pre and post-monsoon samples was found from 0.001 to 0.02 mg/L, which is in the permissible limit.

Chromium

Chromium is widely distributed in the Earth's crust. In water, chromium (III) is a positive ion that forms hydroxides and complexes, and is adsorbed at relatively high pH values. The ratio of chromium (III) to chromium (VI) varies widely in surface water. In general, chromium (VI) salts are more soluble than those of chromium (III), making chromium (VI) relatively mobile. The average concentration of chromium in rainwater is approximately 0.2-1 µg/L. The chromium concentration in groundwater is generally low (< 1 µg/L). In general, the chromium content of surface water reflects the extent of industrial activity.

The concentration of chromium was found to vary for the pre-monsoon samples from 0.01 to 0.04 mg/L and for post-monsoon 0.001 to 0.05 mg/L range. All values are found within the range as compared to the recommended standard values.

Copper

This heavy metal concentration of the pre-monsoon sample varies from 0.01 to 0.6 mg/L and for the post-monsoon samples varies from is 0.01 to 0.8 mg/L. The concentration variation of Cu are found within the range for both session as compared to the recommended standards given in the Table 1.

Zinc

The concentration of Zn of the pre-monsoon sample was found between 0.08 to 14.9 mg/L and the range of post monsoon samples varies from 0.8 to 16.3 mg/L. All values of pre-monsoon samples are within ranges but village Rampur has higher values than the permissible limits.

CONCLUSION

Considering all the investigated problematic chemical constituents collectively, suitability of water for drinking purpose have been decided by authors as given below.

(i)   Excellent to good – All chemical constituents below desirable limit.

(ii)   Good to permissible - All chemical constituents between desirable and permissible limit. 1 to 5 constituents may be below desirable limit.

(iii)   Doubtful to unsuitable - If all constituents except any one of pH. Chloride, T.D.S. and T.H. are below permissible limit.

(iv)   Unsuitable - If any one of direct health affecting constituent (nitrate and fluoride) or 2 to 6 constituents are above permissible limit.

REFERENCES

1.   A. A. Ammann, E. Hoehn and S. Koch, Ground Water Pollution by Roof Runoff Infiltration Evidenced with Multi-Tracer Experiments, Water Research, **37(5)**, 1143-1154 (2003).

2.   WBCSD Water Faacts Trends, http://www.wbcsd.org/includes/getTarget.asp, Retrieved 2010-07-25.

3.   Smith, D. Jared, D. Cappa Christopher, R. Kevin, R. Wilson and C. Ronald, (2005). Unified Description of Temperature-Dependent Hydrogen Bond Rearrangements in Liquid Water, Proc. Natl. Acad. Sci., **102(40)**, 14171-14174 (2005).

4.   WHO, Guidelines for Drinking-Water Quality, **Vol. 2**, Health Criteria and Other Supporting Information, World Health Organization, Geneva (1984).

5.   Guidelines for Drinking Water Quality, **Vol. 3**, Surveillance and Control of Community Supply, Geneva, W.H.O. (1997).

6.   Central Ground Water Board (July 1999), High Incidence of Arsenic in Ground Water in West Bengal, World Health Organization, Safe Water and Global Health, WHO.Int.2008-06-25.

7.   http://www.who.int/features/qa/70/en/.Retrieved 2010-07-25.

8.   W. H. Bruvold, Consumer Attitudes Towards Mineral Taste in Domestic Water, Publ. J. American Water Works Asso., **59** (1967).

9.   India Standards (IS): 10500, Drinking Water Specifications, (First Revision), BIS, India (1991).

10.   R. N. Yadav, Hydrofluorosis Problem in and Around Ramgarh Town, Indian. J. Environ. Sci., **6(2)**, 103-104 (2002).

11.   R. N. Yadav and Rajdeep, Assessment of Fluoride Content, pH and T.D.S. in Potable Water of Alwar City (Raj), Res. J. Chem. and Environ., 929-935 (2008).

12.   R. N. Yadav and Rajdeep, Defluoridation of the Potable Water by Aluminum Sulphate, International J. Chem. Sci., 760-774 (2009).

13.   R. N. Yadav and Rajdeep, Study of the Aluminum Ammonium Sulphate as Defluoridated Agent in Drinking Water Earthenware, Archives of Applied Science Research, **11** (2010).

14.   R. N. Yadav and Rajdeep, Aluminum Nitrate (Al $(NO_3)_3$) as Defluoridating Agent in Drinking Water Soil Pots (Vessels of Earthenware), NEERI (2011).