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Physico-chemical analysis of selected ground water samples of Agra city, India

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Abstract
The aim of present study was carried out to assess the status of the groundwater in Agra city .The range of physicochemical parameters like pH (7.2-7.7), EC (1580-5200 mmhos), TDS (1020-4950 mg/l), Turbidity (1.1-31.4 NTU), Total Alkalinity (330-525 mg/l), Total hardness 240-1425 mg/l), Chloride (295-1140 mg/l), Calcium (72-436 mg/l), Magnesium 14.6-151.2 mg/l), Sodium (126.5-1254.9 mg/l) and Potassium (1.9-60.6 mg/l) were found to be higher than the natural background level of groundwater. This indicates the groundwater pollution in selected water samples from 12 sampling sites from Feb. to May 2011 of Agra city. The results considered that the groundwater of the study area in general cannot be considered as good quality.
Keywords: Groundwater, Physicochemical Parameters, Agra.

INTRODUCTION

Water plays vital role in human life. It is extremely essential for survival of all living organisms. Groundwater is ultimate, most suitable fresh water resource with nearly balanced concentration of the salts for human consumption. Over burden by means of population pressure, unplanned urbanization, unrestricted exploration policies and dumping of the polluted water at inappropriate place enhance, the infiltration of harmful compounds to the groundwater (Pandey et al., 2008). The quality of water is of vital concern for the mankind since it is directly linked with human welfare. There are several states in India where more than 90% populations are dependent on groundwater for drinking and other purpose (Ramachandraiah, 2004; Tank and Singh, 2010). The uncontrolled disposal of industrial and urban wastes and the use of chemical substances in agriculture (fertilizers, herbicides and pesticides) are the primary causes of groundwater contamination (Ullah et al., 2009). During last decade, this is observed that groundwater get polluted drastically because of increased human activities. Consequently, number of cases of water borne diseases has been seen that is a cause of health hazards.

Agra is the most populous district in Uttar Pradesh and had population of 4380793 as per 2011 census. In terms of urbanization level, Agra district ranks 8th place among the other district in Uttar Pradesh. The status of the groundwater depends on a large number of individual physicochemical parameter and heavy metals. Pollutants are added to the ground water system through anthropogenic activities and natural processes. The uncontrolled disposal of industrial and urban waste and use of chemical substances (fertilizers, pesticides, herbicides) are the primary cause of the ground water contamination. Agra city is surrounded by many leather tanneries and small scale dying industries and their effluents are discharged in to the Yamuna River causing impact on the quality of the underground water. Solid waste from industries is being dumped near the factories and subjected to reaction with percolating rain water and reaches the ground water level. The percolating water picks up a large amount of dissolved constituents and reaches the aquifer system and thus it contaminates the ground water.

The specific objectives of the study were however to assess physical and chemical properties of groundwater in the study area.

METHODOLOGY

Study Area

The Agra City in Agra district is situated in western U.P. between 27.11' degree Latitude North and 78.0' degree to 78.2' degree Longitude East. Its Altitude is 169 meters above sea level. Agra is bounded by Mathura District in North, Dhaulpur district in south, Firozabad district in East and Bharatpur district in West. Agra is situated on the bank of Yamuna River.

Sample Collection

Water Samples from the twelve selected sites namely (Sikandra (S1), Khandari (S2), Dyalbagh (S3), Langre Ki Chaouki (S4), Balkeshwar (S5), Rambagh (S6), Balenganj (S7), Daresi (S8), Shahganj (S9), Agra Cant (S10), Balluganj (S11) and Tajganj (S12) were collected during Feb. to May 2011 and taken in pre-cleaned polyethylene bottles. Samples were analyzed immediately for parameters, which need to be determined instantly and rest of samples were refrigerated at 40° C to be analyzed later

Physico-Chemical Analysis

The collected samples were analysed for major physical and chemical water quality parameter like pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Alkalinity (TA), Total Hardness (TH), Chloride (Cl^-), Calcium (Ca^{++}), Magnesium (Mg^{++}), Sodium (Na^+) and Potassium (K^+) were carried out referring the 'standard methods 2002.

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Statistical Analysis

The simple linear correlation analysis has been carried out to find out correlation between two tested parameters.

RESULT AND DISCUSSION

The average results of the physicochemical parameters for water samples are presented in Table 1 and matrix of correlation among different parameters are shown in table 2.

The quality of water resources depends on the management of the water sources. This would include anthropogenic discharge as well as the natural physicochemical properties of the area.

pH

pH is considered as an important ecological factor and provides an important piece factor and piece of information in many type of geochemical equilibrium or solubility calculation (Shyamala et al., 2008). The maximum pH was recorded as 7.7 at sampling location S4 and S12 and minimum was 7.2 at S2, S7 and S10. When composed with the standard values of WHO and IS 10500-91, the samples are found to be in the permissible limit as prescribed.

EC

Electrical Conductivity is a useful tool to evaluate the purity of water (Acharya et al., 2008). EC values were in the range of 1580 micromhos/cm (S6) to 5200 micromhos/cm (S5). EC values for all the investigated samples were found to be greater than the limit prescribed by WHO. High EC values indicate the presence of high amount of dissolved inorganic substances in ionized form.

TDS

Total Dissolved Solids usually related to conductivity. Water containing more than 500 mg/l of TDS is not considered desirable for drinking water supplies, though more highly mineralized water may be used where better quality water is not available (Jain, 2002). The maximum value of TDS during the study period was found as 4950mg/l at sampling location S5 and minimum was1020 mg/l at 12. The TDS values of all the water samples of the selected places are greater than the limit prescribed by IS-10500-91.

Turbidity

In most waters, turbidity is due to colloidal and extremely fine dispersions. The turbidity values varied between 1.1 NTU (S8) to 31.4 NTU (S10). Of the total investigated samples, 50% water samples shows greater value than the limit prescribed by WHO.

Total Alkalinity

Alkalinity value in water provides an idea of natural salts present in water. The cause of alkalinity is the minerals which dissolve in water from soil. The various ionic species that contribute to alkalinity includes bicarbonate, hydroxide, phosphate, borate and organic acids. These factors are characteristics of the source of water and natural processes taking place at any given time (Sharma, 2004). The maximum value of alkalinity was found as 525 mg/l at sampling location S11 and minimum 330 mg/l at S10 and found greater than the limit prescribed by WHO.

Total Hardness

Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water (Patil and Patil, 2010). Total Hardness was found in the sample water ranges from 240 mg/l (S4) to 1425 mg/l (S5), which shows the values higher than the permissible limit prescribed by WHO. According to some classifications, water having hardness upto 75 mg/l us classified as soft, 76-150 mg/l is moderately soft, 151-300 mg/l as hard and more than 300 mg/l as very hard (Saravanakumar and Ranjith Kumar, 2011). On this basis, the results show that all the samples were very hard except Sample S4.

Chloride

Chloride usually occurs as NaCl, CaCl2 and MgCl in widely varying concentration, in all natural waters. They enter water by solvent action of water on salts present in the soil, from polluting material like sewage and trade wastes (Shaikh and Mandre, 2009). The maximum value of chloride was recorded as 1140 mg/l at sampling location S5 and minimum was 295 mg/l (S6).

Calcium and Magnesium

The source of calcium and magnesium in natural water are various types of rocks, industrial waste and sewage (Trivedy and Goel, 1984). The values of calcium varied from 72 mg/l (S4) to 436 mg/l (S10) and the values of magnesium ranged from 14.6 mg/l (S4) to 151.2 mg/l (S5).

Sodium

Sodium concentration was found in between 126.5 (S12) mg/l to 1254.9 mg/l (S7). All the samples were found greater than the permissible limit of WHO except the sampling point S2, S3, S4 and S12.

Potassium

The major source of potassium in natural fresh water is weathering of rocks but the quantities increase in the polluted water due to disposal of waste water (Trivedy and Goel, 1984). It was varied between 1.9 mg/l (S4) to 60.6 mg/l (S7).

Statistical analysis

Interrelationship studies between different variables are very helpful tools in promoting research and opening new frontiers of knowledge. The study of correlation reduces the range of uncertainty associated with decision making. The correlation co-efficient 'r' was calculated using the equation (Patil and Patil, 2010).

$$r = \frac{N\sum(XY) - (\sum X).(\sum Y)}{\sqrt{[N\sum X2 - (\sum X)2][N\sum Y2 - (\sum Y)2]}}$$

Where, X and Y represents two different parameters, N= Number of total observation

Correlation among physical and chemical water quality parameters

The high positively correlated values were found between TDS and EC (0.973), Chloride and EC (0.905), Chloride and TDS (0.871), Calcium and Total Hardness (0.847), Magnesium and Total Hardness (0.948), Sodium and Total Hardness (0.940) and Potassium and Sodium (0.881) While the negatively correlated values were found between TDS and pH (-0.052), Magnesium and pH (-0.076) and Sodium and Magnesium (-0.082). pH is negatively correlated with most of the parameters. However, Total Alkalinity is negatively correlated with all parameters.

Table 1. Average results of the physicochemical parameters

S. No	Parameter	Sampling Points												WHO (1993)	IS (10500-91)
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12		
1.	pH	7.3	7.2	7.6	7.7	7.4	7.3	7.2	7.5	7.5	7.2	7.4	7.7	-	6.5-8.5
2.	EC	2100	2300	2100	3200	5200	1580	2650	3450	4350	4200	2600	1735	250	-
3.	TDS	1335	1235	1315	2070	4950	1065	1435	2780	3270	3635	1540	1020	-	500
4.	Turbidity	6.5	10.8	2.8	7.8	4.7	4.1	3.4	1.1	9.0	31.4	2.0	17.9	< 5	10
5.	TA	365	512	450	455	395	340	385	380	390	330	525	345	-	200
6.	TH	593	674	700	240	1425	460	535	1250	955	1160	840	675	150-500	300
7.	Cl^-	365	305	425	1050	1140	295	429	1070	1060	980	535	300	250	250
8.	Ca^{2+}	123.6	148	174	72	322	134	172	294	168	436	186	137	-	75
9.	Mg^{2+}	69.2	74.1	64.6	14.6	151.2	30.5	25.6	125.6	130.5	139	95.1	81.1	-	30
10.	Na^+	313	162	140	153.5	715	1030	1254.9	520	614.9	484.9	439.9	126.5	200	200
11.	K^+	9.6	8.4	5.1	1.9	7.5	47.5	60.6	10.2	9.6	21.5	10.6	3.9	-	-

All parameters are in mg/l except pH, EC and Turbidity. ECin micromhos/cm, Turbidity in NTU

Table 2. Matrix of correlation among water quality parameters

Parameter	pH	EC	TDS	Turb.	TA	TH
pH	1					
EC	0.047	1				
TDS	-0.052	0.973*	1			
Turbidity	0.060	0.188	0.214	1		
TA	0.074	-0.104	-0.221	-0.393	1	
TH	-0.176	0.729	0.799	0.155	-0.179	1
Cl^-	0.354	0.905*	0.871*	0.109	-0.106	0.581
Ca^{2+}	-0.348	0.654	0.729	0.457	-0.350	0.847*
Mg^{2+}	-0.076	0.716	0.768	0.302	-0.156	0.948*
Na^+	-0.498	0.165	0.170	-0.252	-0.382	0.940*
K^+	-0.510	-0.206	-0.208	-0.102	-0.355	-0.238

Parameter	TH	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
TH	1					
Cl^-	0.581	1				
Ca^{2+}	0.847*	0.525	1			
Mg^{2+}	0.948*	0.570	0.767	1		
Na^+	0.940*	0.035	0.182	-0.082	1	
K^+	-0.238	-0.307	0.019	-0.401	0.881*	1

CONCLUSION

Analysis of water samples collected from various locations of Agra City revealed that all water samples do not comply with WHO standards and Indian Standards- 10500-91. Groundwater in Agra region requires precautionary measures before drinking so as to prevent adverse health effects on human beings.

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