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Physico-Chemical and Heavy Metal Investigation of Underground Water at Commercial Areas of Agra District (U.P.), India

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ABSTRACT

Today, it is a known fact that the groundwater quality is degrading day by day which is a serious concern nowadays, as water with poor quality pose threats to human health and hygiene. Good quality of water is of utmost importance for survival of man and animals, and as we know because the groundwater aquifers are the largest source of fresh water, their contamination will prove to be havoc. Present work deals with the physico-chemical and heavy metal investigation of ground water samples from submersible pumps at different sites of commercial areas of Agra district during 2020-2021. Total twelve water samples were collected and investigated with respect to parameters such as pH, conductivity, TDS, total hardness, total alkalinity, chloride and fluoride as well as heavy metals such as Cu, Zn, Fe and As. TDS of most of the water samples exceeded the maximum permissible limit set by WHO and ICMR. Significantly, iron was found much above the maximum permissible limit of WHO in almost all the samples, whereas arsenic contamination was also noted at many sites. The results reveals that the water quality of most of the sites of commercial areas of Agra district is not suitable for drinking purpose which recommends the use of indigenous technologies, to make water fit for drinking purpose.

Keywords: Agra, Drinking water, Fluoride, Ground water, Hardness, TDS.

INTRODUCTION

It is well known that no straightforward reasons can be given for deterioration of water quality, as it depends on several water quality parameters. There are strong correlations among different parameters and a cumulative effect of their mutual relationship affects the water quality. Correlation analysis is a useful statistical tool to determine the extent to which changes in the value of a parameter are associated with the changes in another parameter. Therefore, a systematic statistical study of correlation among the various quality parameters not only helps to assess the overall water quality but also indicates relative concentrations of various pollutants in water. This in turn provides vital information for implementation of rapid water quality management programmes. A large number of workers have undertaken statistical analysis and assessed the ground water quality in different parts of the India.

Water is an important component for life on Earth, which contains minerals extremely important in human nutrition. Groundwater contamination is a serious global issue today. Continuously

increasing level of contamination with a variety of toxic substances and lowering down of the groundwater table due to over-exploitation to meet globally increasing water demand followed by the declining annual recharge have brought them under severe constrains worldwide. Interferences altering the natural water balance have further influenced the redox chemistry of the aquifers resulting in mobilization of several chemical constituents present in the solid matrices. The problem of excessive fluoride in ground water in India was first reported in 1937 in the state of Andhra Pradesh [**1**]. In India, approximately 62 million people including 6 million children suffer from fluorosis because of consumption of water with high fluoride concentrations [**2**]. Quality of water is a measure of its physical and chemical properties along with the biological and aesthetic characteristics. It refers to the efficiency of water to meet the basic requirements for the progressive survival of human beings as well as several other species. There are a certain set of standards which are referred to as a reference for the assessment of water quality. Since last few years, continuously growing population, fast pace of industrialization and the simultaneous techniques of waste disposal have been responsible for the discharge of pollutants into the water bodies, resulting in rapid contamination of water. Moreover, the rate of contamination of water is much faster than the processes of its purification [**3**]. The analysis of the physicochemical properties of water, assist in analyzing the structure and functions of water bodies [**4**]. The physical, chemical and biological characteristics of water are the decisive factor for defining the suitability or non-suitability of water for consumption, irrigation or industrial uses [**5, 6**]. Considerable number of researches have been made in this direction, which focus on how anthropogenic activities, mainly agricultural and industrial processes, result into the contamination of groundwater [**7, 8**]. It is observed that human activities are a major factor determining the quality of the surface and groundwater through atmospheric pollution, wastewater discharges, use of agricultural chemicals, eroded soils, and land use [**9, 10**].

Groundwater is a significant water resource in India and around the world for domestic, irrigation, and industrial needs. Most of the states like Andhra Pradesh, Rajasthan, Punjab, Uttar Pradesh, West Bengal, Bihar and Jharkhand are affected by fluoride and Arsenic [**11, 12**]. Subba Rao (2009) [**13**] has suggested that the main source of groundwater fluoride in granitic rocks is the dissolution and anion exchange with micaceous minerals and their clay products. Fluoride is found in all natural waters at some concentrations. Fluoride is one of the very few chemicals that have been shown to cause significant effects in people through drinking water. Fluoride has beneficial effects on teeth at low concentrations in drinking water, but excessive exposure to fluoride in drinking water, or in combination with exposure to fluoride from other sources, can give rise to a number of adverse effects. These range from mild dental fluorosis to crippling skeletal fluorosis as the level and period of exposure increases [**14, 15**].

MATERIALS AND METHODS

Study Area: Agra city is selected for the study as it is known to be hotspot of drinking water supply because of the presence of major problems such as inadequate water supply, declining groundwater level and poor water quality. The major source of drinking water in city is groundwater with most of the drinking water supply depending on it. The 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. On the North it is bounded by Mathura District, On the South it is bounded by Dhaulpur District, On the East it is bounded by Firozabad District and On the West it is bounded by Bharatpur. Agra is situated on the bank of Yamuna River.

Map of Agra District: Most parts of city are known to having high fluoride content in ground water. The recommended level for tropical countries like India, where the maximum temperature goes above 45°C during summer season, should be in the range of 0.6–0.7 mg L^{-1}. In Agra Maximum Temperature in summer reaches above 45°C.

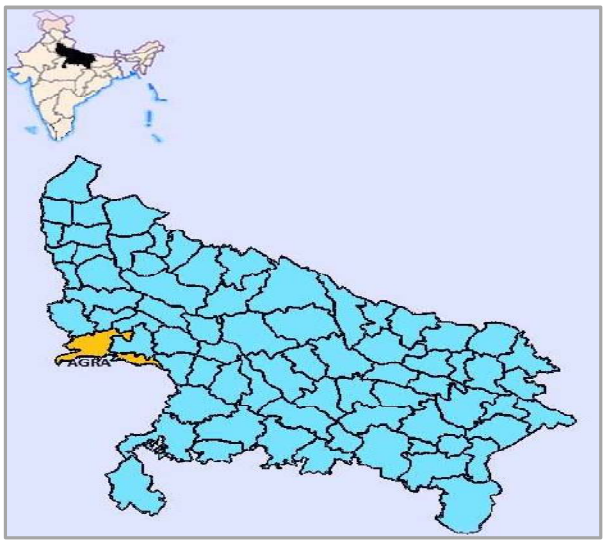

Figure 1. Map of Agra District.

The water samples were collected from various submersible pumps located in commercial areas of Agra district, in plastic bottles having capacity of 1 liter. Necessary precautions were taken while sampling and then the samples were carefully sealed, labelled and taken for analysis of physico-chemical parameters such as pH, conductivity, TDS, total hardness, total alkalinity, chloride and fluoride as well as heavy metals such as Cu, Zn, Fe and As. Water samples were diluted with equal quantities of TISAB (Total Ionic Strength Adjustment Buffer) and the fluoride ion concentration was determined using a colorimetric method (alizarin dye). Other parameters were determined as per standard methods [**16**].

Twelve ground water samples were taken from submersible pumps of various sites of commercial areas of Agra district.

Table 1. Physico-Chemical and Heavy Metal Investigation of Underground Water of Different Sites of Commercial Areas of Agra District

S.No.	Sites↓	WQPs→	pH	EC	TDS	TH	TA	Chloride	Fluoride	Copper (Cu)	Zinc (Zn)	Iron (Fe)	Arsenic (As)
1	Shahganj	Site – 1A	7.5	1968	1059	420	256	658	1.0	0.04	0.01	0.48	0.02
		Site – 1B	7.4	1980	1680	362	290	682	1.9	0.04	0.04	0.57	0.01
		Site – 1C	7.3	2010	1650	360	242	670	1.9	0.03	0.03	0.51	0.01
2	Kinari Bazar	Site – 2A	6.9	1872	1080	412	208	310	1.5	0.03	0.004	0.32	0.02
		Site – 2B	6.8	1910	1275	395	206	420	1.6	0.02	0.002	0.49	0.02
		Site – 2C	7.1	1920	1150	410	212	408	1.5	0.01	0.003	0.33	0.03
3	Sadar Bazaar	Site – 3A	7.8	3280	2890	650	462	710	3.7	0.08	0.004	0.61	0.02
		Site – 3B	8.3	3260	2750	770	390	690	3.1	0.06	0.001	0.57	0.01
		Site – 3C	8.1	3190	2990	890	460	675	2.9	0.04	0.003	0.52	0.02
4	Pratap Pura	Site – 4A	7.8	2575	1875	930	286	716	1.8	0.04	0.003	1.0	0.01
		Site – 4B	7.5	2591	2215	890	240	732	2.1	0.06	0.002	1.1	0.02
		Site – 4C	7.9	2570	2300	860	270	728	2.2	0.01	0.001	1.0	0.01

It is well known that no straightforward reasons can be given for deterioration of water quality, as it depends on several water quality parameters. There are strong correlations among different parameters and a cumulative effect of their mutual relationship affects the water quality. Correlation analysis is a useful statistical tool to determine the extent to which changes in the value of a parameter are associated with the changes in another parameter. Therefore, a systematic statistical study of

correlation among the various quality parameters not only helps to assess the overall water quality but also indicates relative concentrations of various pollutants in water. This in turn provides vital information for implementation of rapid water quality management programmes. A large number of workers have undertaken statistical analysis and assessed the ground water quality in different parts of the India [17]

Table 2. Descriptive Statistics

Parameter	pH	EC	TDS	TH	TA	Chloride	Fluoride	Copper (Cu)	Zinc (Zn)	Iron (Fe)	Arsenic (As)
Mean	7.533333	2427.167	1909.5	612.4167	293.5	616.5833	2.1	0.038333	0.008583	0.625	0.016667
Standard Error	0.134465	162.594	205.8459	69.32373	26.76738	42.47467	0.222928	0.006009	0.003677	0.075714	0.00188
Median	7.5	2290	1777.5	535	263	678.5	1.9	0.04	0.003	0.545	0.02
Mode	7.5	#N/A	#N/A	890	#N/A	#N/A	1.9	0.04	0.003	0.57	0.02
Standard Deviation	0.4658	563.242	713.071	240.1444	92.72491	147.1366	0.772246	0.020817	0.012738	0.26228	0.006513
Sample Variance	0.21697	317241.6	508470.3	57669.36	8597.909	21649.17	0.596364	0.000433	0.000162	0.068791	4.24E-05
Range	1.5	1408	1931	570	256	422	2.7	0.07	0.039	0.78	0.02
Minimum	6.8	1872	1059	360	206	310	1	0.01	0.001	0.32	0.01
Maximum	8.3	3280	2990	930	462	732	3.7	0.08	0.04	1.1	0.03
Sum	90.4	29126	22914	7349	3522	7399	25.2	0.46	0.103	7.5	0.2
Count	12	12	12	12	12	12	12	12	12	12	12

Table 3. Correlation Matrix

Parameter	pH	EC	TDS	TH	TA	Chloride	Fluoride	Copper (Cu)	Zinc(Zn)	Iron(Fe)	Arsenic (As)
pH	1										
EC	0.868845	1									
TDS	0.843325	**0.95891**	1								
TH	0.75349	0.762727	0.734912	1							
TA	0.782566	0.891523	0.873577	0.483604	1						
Chloride	0.774596	0.594553	0.662955	0.59449	0.525692	1					
Fluoride	**0.687418**	**0.909485**	**0.928974**	**0.505844**	**0.882856**	**0.471245**	**1**				
Copper (Cu)	0.475028	0.659389	0.592781	0.322397	0.653245	0.501358	**0.661647**	1			
Zinc(Zn)	-0.20428	-0.40956	-0.23453	-0.54862	-0.13119	0.177083	**-0.19592**	-0.03714	1		
Iron(Fe)	0.427868	0.35448	0.40477	0.759638	0.041605	0.678785	**0.171904**	0.204803	-0.20285	1	
Arsenic(As)	-0.43947	-0.1899	-0.28714	-0.24546	-0.13848	-0.58022	**-0.18074**	-0.11175	-0.41271	-0.43636	1

RESULTS AND DISCUSSION

The groundwater samples were collected from different commercial areas of Agra district. The values of Physico-chemical parameters and heavy metals of drinking water samples from twelve different sites of Agra district are shown in the tables. These results were compared with WHO (2006) and BIS (1991) drinking water standard [18, 19] and then discussed.

pH is used to determine the acidity or alkalinity of water and the concentration of hydrogen ions in the water. The pH value of all groundwater samples is found to be in the range of 6.8 to 8.3. The highest value of 8.3 is observed at Sadar Bazaar area whereas the lowest value of 6.8 is observed at Kinari Bazaar area. In terms of pH value, the groundwater samples are well within the acceptable limit of WHO. There is no anomalous change in the groundwater samples. Long term exposure to pH beyond the permissible limit affects the mucous membrane of cells10 (Table 1).

The conductivity was ranged between 1872-3280 µmhos cm^{-1}. The lowest value was recorded at kinari bazaar area and highest value was recorded at sadar bazaar area. At all four sites the value of conductivity was found highest guide level (400) EC(1981).

The total dissolved solids are composed mainly of calcium, potassium, sodium, manganese, magnesium, carbonate and bicarbonate and other particulate matter. In present assessment the groundwater samples show variation between1059 and 2990 mg L^{-1}, in terms of TDS. For domestic uses, the maximum permissible limit of total dissolve solids is 1500 mg L^{-1} (prescribed by WHO). The maximum value of 2990 mg L^{-1} is recorded at sadar bazaar area and minimum value of 1059 mg L^{-1} is recorded at Shahganj area. Hence all the groundwater samples are excessive saline. In the present assessment, the total dissolved solids are found above the permissible limit of 1500mg L^{-1}.

Most of the samples have total hardness value above permissible limit. On leaving for some time ground water leave white crust on pots. Fluoride content is found to be surprisingly high in most cases. Fluoride content in higher quantities is very dangerous and causes fluorosis. Fluoride is released into the ground water through weathering of primary silicate and associated accessory minerals. Most of samples have fluoride values near or above WHO permissible limit.

The chloride values for most of the samples were found above. The maximum value 732 mg L^{-1} is recorded at pratappura area and the minimum value of 310 mg L^{-1} l is recorded at kinari bazaar area. Chlorides when reaches concentration above 250 mg L^{-1}; imparts an unacceptable salty taste to waters although no adverse effect have been observed on human beings regularly consuming water with much higher concentrations of chloride [**20, 21**] (Table 2 and 3).

Heavy metals such as arsenic and zinc concentration were found under the limit at all sites of commercial areas of agra district during the study period but iron was found above the desirable limit for drinking water. The average value of copper content was found under the desirable limit at all areas except sadar bazaar area.

APPLICATION

There results bring awareness in Public to know what type of water they are drinking.

CONCLUSION

Water quality standards WHO (2006) and BIS (1991) shows water quality of none of the samples is not suitable for domestic purposes without prior treatment. Most of the samples are not potable for drinking purpose. These contain high amount of Cl^-, TH and F- values as given in table 1. In the light of correlation study, we can clearly observe that all the parameters are more or less correlated with each other. As seen in correlation table Conductivity shows strong correlation with TDS and fluoride. It suggests that if any one increases the other also show increasing trend.

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