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Drinking Water Quality Status of Some Selected Industrial Areas of Agra City (U.P.), India

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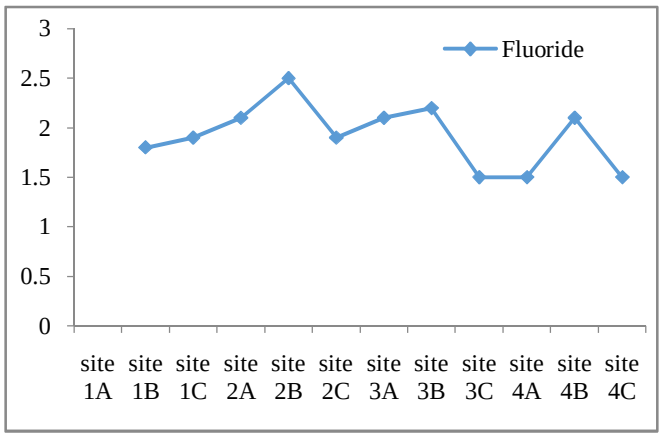
ABSTRACT

Water is a vital resource for human survival. Safe drinking water is a basic need for good health, and it is also a basic right of humans. Due to its outstanding significance to the consumer its parameters must follow the permissible limits set by international water regulating agencies. The present study was therefore undertaken to assess the quality of drinking water of some selected industrial areas of Agra city. 12 water samples were collected from 4 sampling sites and analyzed for physico-chemical parameters such as pH, conductivity, total dissolved solids, 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 industrial areas of Agra city is not suitable for drinking purpose which recommends the use of indigenous technologies, to make water fit for drinking purpose.

Graphical Abstract:



Fluoride in drinking water of selected industrial areas of Agra City

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. 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**].

Drinking water quality is paramount for public health. Despite improvements in recent decades, access to good quality drinking water remains a critical issue. The World Health Organization estimates that almost 10% of the population in the world do not have access to improved drinking water sources [**2**], and one of the United Nations Sustainable Development Goals is to ensure universal access to water and sanitation by 2030 [**3**]. In India, approximately 62 million people including 6 million children suffer from fluorosis because of consumption of water with high fluoride concentrations [**4**]. Although drinking water quality is regulated and monitored in many countries, increasing knowledge leads to the need for reviewing standards and guidelines on a nearly permanent basis, both for regulated and newly identified contaminants. Drinking water standards are mostly based on animal toxicity data, and more robust epidemiologic studies with an accurate exposure assessment are rare. The current risk assessment paradigm dealing mostly with one-by-one chemicals dismisses potential synergisms or interactions from exposures to mixtures of contaminants, particularly at the low-exposure range. Thus, evidence is needed on exposure and health effects of mixtures of contaminants in drinking water [**5**].

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 [**6, 7**]. 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 [**8, 9**]. 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 [**10**].

Various organizations like WHO, BIS 12500:2012, APHA etc [**11-14**] have prescribed drinking water quality parameters according to physicochemical parameters to compare with the value of actual water samples. it is assessed the suitability of groundwater for portability and other consumption purposes by the selection of seven different Physico-Chemical parameters to calculate the Water Quality Index (WQI) [**15**], and also assessed the groundwater quality index of Ganeshwar and Chala villages of Neemkathana block in Sikar District of Rajasthan state [**16**]. Lal *et al.*,. stated about many benefits of alkaline water for drinking purposes [**17**]. Water pollution has increased as a result of various man-made activities such as excessive pesticide and fertilizer use, improper drainage systems, sewerage line leakage, domestic waste, excessive construction work, and so on. In this literature review, some water analysis reports from India and various regional constituents are reviewed along with their human health impacts along with their physicochemical regimes.

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 city 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 City: Most parts of city are known to having high fluoride and TDS 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.

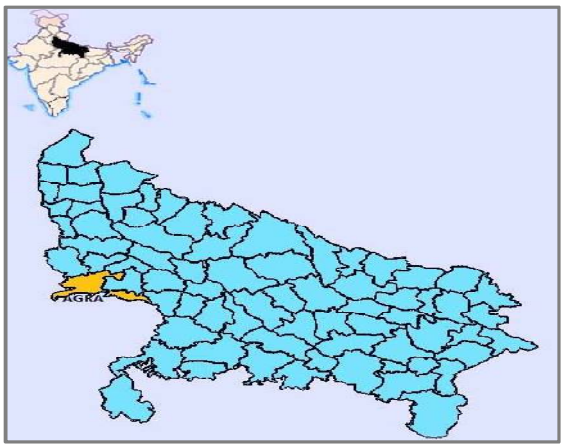


Figure 1. Map of Agra City.

The water samples were collected from various submersible pumps located in industrial areas of Agra city, in plastic bottles having capacity of 1 liter. Necessary precautions were taken while sampling and

Table 1. Water Quality Parameters and Methods of Determination

Water Quality Parameters	Methods of Determination
pH	pH Meter
EC	Conductivity Meter (SYS-308)
TDS	Potentiometric Method
TH	EDTA Method
TA	Titration Method
Chloride	Argentometric Method (APHA)
Fluoride	U V Spectrophotometric Method
Cu	AAS
Zn	AAS
Fe	AAS
As	AAS

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) and finally by UV Spectrophotometric method. Other parameters were determined as per standard methods [**18**].

Twelve ground water samples were taken from submersible pumps of various selected sites of industrial areas of Agra city.

Table 2. Physico-chemical and heavy metal investigation of underground water of different selected sites of industrial areas of Agra city

S.No.	SITES↓	WQPs→	pH	EC	TDS	TH	TA	Chloride	Fluoride	Copper (Cu)	Zinc (Zn)	Iron (Fe)	Arsenic (As)
1	Sikandra	Site – 1A	7.7	1580	1540	580	256	350	2.1	0.02	0.01	1.2	0.001
		Site – 1B	7.6	2020	1720	670	310	370	1.8	0.01	0.01	1.1	0.001
		Site – 1C	7.5	1870	1580	655	250	310	1.9	0.01	0.01	1.4	0.001
2	Foundari Nagar	Site – 2A	8.8	1790	2630	510	323	415	2.1	0.02	0.02	1.3	0.02
		Site – 2B	8.6	2165	2810	520	335	570	2.5	0.02	0.05	1.6	0.01
		Site – 2C	8.9	2235	2900	595	410	422	1.9	0.01	0.03	1.9	0.01
3	Nunhai	Site – 3A	7.6	3290	3763	890	430	541	2.1	0.05	0.05	1.7	0.02
		Site – 3B	7.7	3510	4200	880	320	535	2.2	0.04	0.03	1.2	0.02
		Site – 3C	7.8	3160	3850	890	355	550	1.5	0.04	0.09	1.5	0.01
4	Tehribagia	Site – 4A	8.1	7240	3750	660	580	341	1.5	0.08	0.10	1.8	0.01
		Site – 4B	8.4	5098	4055	715	653	388	2.1	0.09	0.14	1.5	0.01
		Site – 4C	8.2	6800	3880	590	595	410	1.5	0.07	0.13	1.4	0.01

RESULTS AND DISCUSSION

The groundwater samples were collected from different industrial areas of Agra city. The values of Physico-chemical parameters and heavy metals of drinking water samples from twelve different sites of Agra city are shown in the table 2. These results were compared with WHO (2006) and BIS (1991) drinking water standard [**19, 20**] 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 7.5 to 8.9. The highest value of 8.9 is observed at Foundari Nagar (site-c) area whereas the lowest value of 7.5 is observed at Sikandra (site-c) area. In terms of pH value, the groundwater samples are well within the acceptable limit of WHO except Foundari Nagar area. Long term exposure to pH beyond the permissible limit affects the mucous membrane of cells.

The conductivity was ranged between 1580-7240 µmhos cm^{-1}. The lowest value was recorded at Sikandra area and highest value was recorded at Tehribagia 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 between 1540 to 4200 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 4200 mg L^{-1} is recorded at Nunhai area and minimum value of 1540 mg L^{-1} is recorded at Sikandra area. Hence all the groundwater samples are excessive saline. In the present assessment, the total dissolved solids are found above the permissible limit of 1500 mg L^{-1}

Table 3. Classification of water on the basis of Total Hardness

Total Hardness (mg L^{-1})	Nature of Water
0 – 60	Soft
61 – 120	Moderate
121 – 180	Hard
>180	Very Hard

All of the samples have total hardness and total alkalinity values were found above the permissible limit set by WHO. On leaving for some time ground water leave white crust on pots. Fluoride content is found to be surprisingly high in all 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. All of the water samples have fluoride values above the WHO permissible limit.

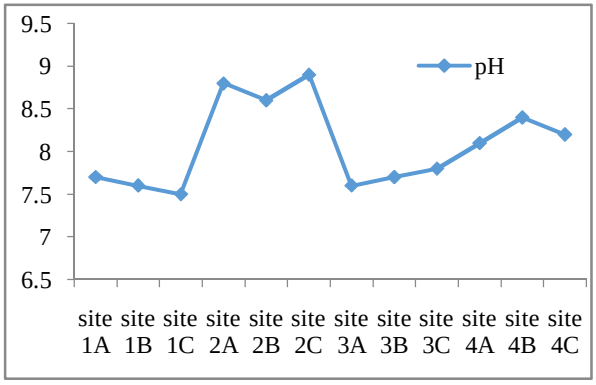


Figure 2. pH in drinking water of selected industrial areas of Agra City.

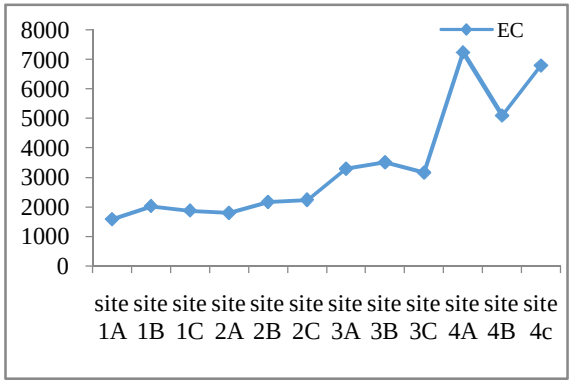


Figure 3. Conductivity in drinking water of selected industrial areas of Agra City.

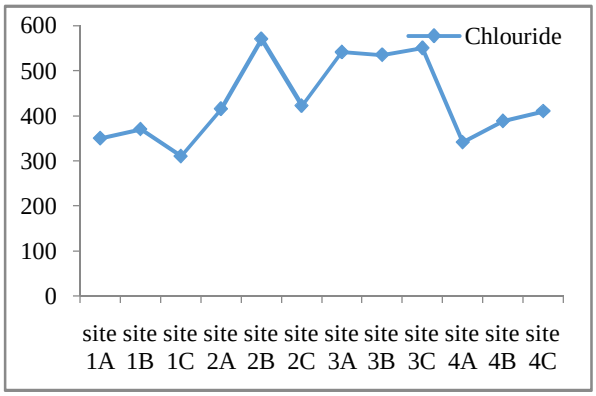


Figure 4. Chloride in drinking water of selected industrial areas of Agra City.

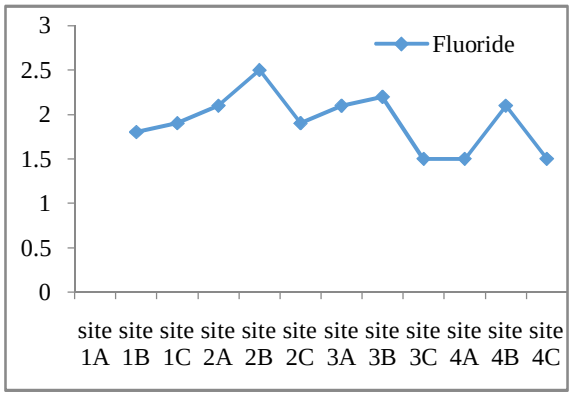


Figure 5. Fluoride in drinking water of selected industrial areas og Agra City.

The chloride values for all samples were found above. The maximum value 570 mg L^{-1} is recorded at Foundary Nagar area and the minimum value of 310 mg L^{-1} is recorded at Sikandra 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 [21, 22]

Heavy metals such as arsenic and zinc concentration were found under the limit at all sites of commercial areas of Agra city during the study period but iron was found well above the desirable limit for drinking water. The value of copper content was found under the desirable limit at all selected study areas except Tehribagia area.

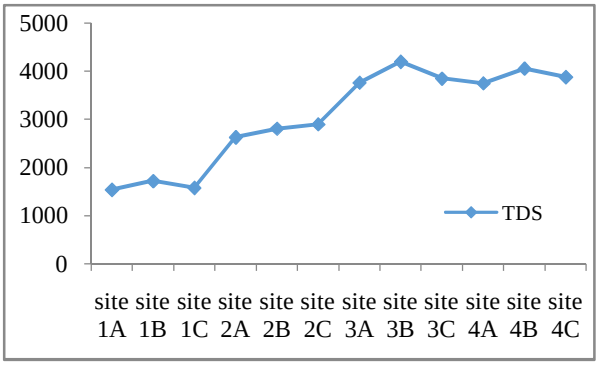


Figure 6. Total Dissolve Solids in drinking water of selected industrial areas of Agra City.

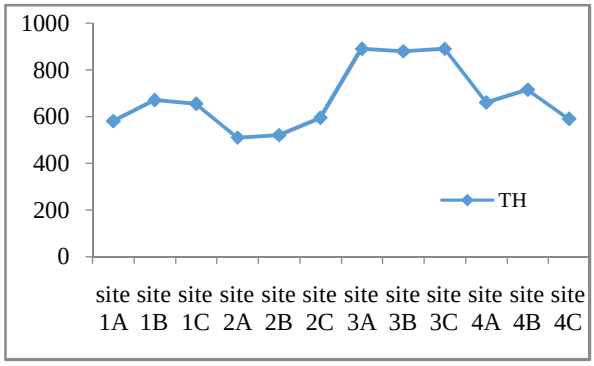


Figure 7. Total Hardness in drinking water of selected Industrial areas of Agra City.

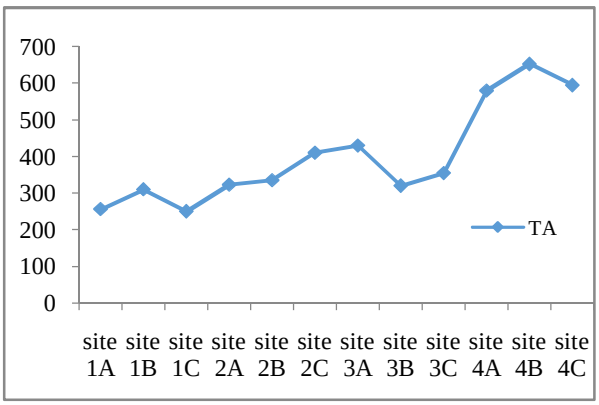


Figure 8. Total Alkalinity in drinking water of selected industrial areas of Agra City.

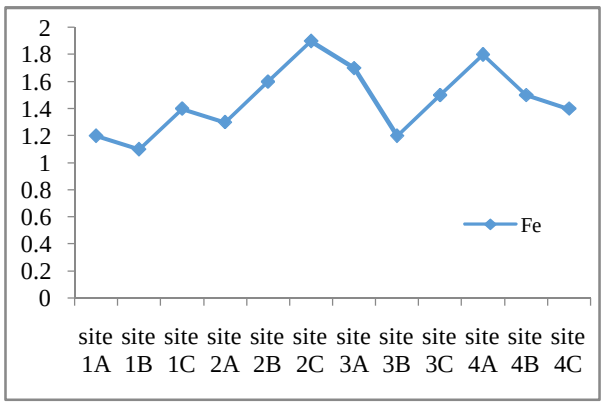


Figure 9. Iron in drinking water of selected industrial areas of Agra City.

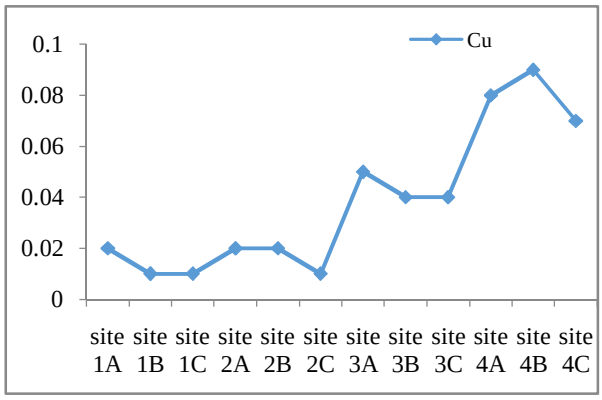


Figure 10. Copper in drinking water of selected industrial areas of Agra City.

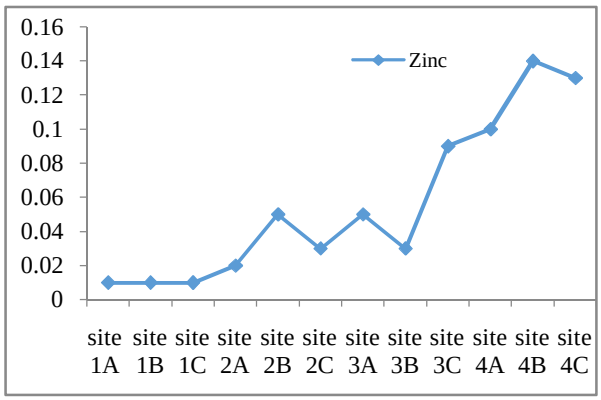


Figure 11. Zinc in drinking water of selected industrial areas of Agra City

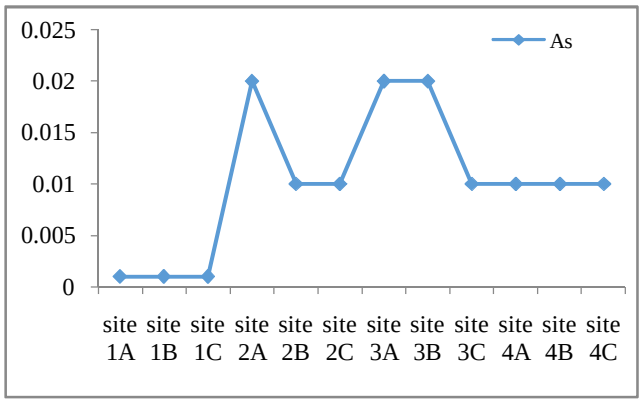


Figure 12. Arsenic in drinking water of selected industrial areas of Agra City

APPLICATION

These 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 most 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 2.Also the values of EC are high. Higher values of EC indicate higher TDS.

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