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ORIGINAL ARTICLE

Physicochemical Profile of Groundwater from Urban and Semi-Urban Regions of Agra

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ABSTRACT

The groundwater of most of urban and semi urban location in India is fast depleting, leaving a large population to suffer. The present paper presents the assessment of physicochemical parameters of groundwater of Agra region. Samples from 20 localities-urban and semi urban were collected during the two years period (2016-2018) which were divided into pre-monsoon, monsoon and post-monsoon seasons. Physicochemical analysis of water was done for the following parameters, viz., pH, TDS, Hardness, Alkalinity, Oxygen content, Fluoride content and Chloride content. Analysis of groundwater established that it was permanently hard and its use particularly for drinking purpose is not suitable. However, our survey revealed that a large population which is economically weaker is living in the outskirts of Agra relies entirely of groundwater drawn either through handpumps or submersible. In these remote regions, there is no water supply from Agra Jal Sansthan. People complained of gastric troubles in several forms which included acidity, loss of appetite, disturbed bowel movements, etc. Continuous consumption of this untreated groundwater over several years also results in formation of kidney stones. Some of the people that were surveyed switched over to bottled water (made locally in RO treatment plants) after experiencing severe problems. As rainfall in Agra was scanty, not much deviation in physicochemical parameters was noted and the results were consistent with the previous studies.

Key words: *Groundwater, Physicochemical Profile, Agra*

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INTRODUCTION

For almost any life form that exists on this planet water is one of the vital components, without which survival would become impossible and for human beings water is life. They require water for all their domestic, agricultural and industrial purposes and thus have utilized water from surface water bodies (rivers, lakes, ponds, etc.) as well as underground water resources.

Underground water has always been one of the major sources of drinking water. About 95% of the population residing in the rural areas depends on groundwater for domestic use (Moharir *et al*. 2002). There are several reasons for this dependence. It is generally assumed that the passage of water through the soil column purifies it and water becomes fir for domestic use, particularly for drinking purpose and chances of contamination of underground water are almost nil. These reasons have stimulated excessive consumption of groundwater in rural and semi-urban areas around the world (WHO 2011; Saha *et al*. 2008).

Taking these assumptions into consideration we have chosen Agra as our study site. The physicochemical and bacterial parameters need to be analyzed as a large number of

people rely either partially for entirely on groundwater resources for their domestic activities, particularly drinking.

Agra is situated at the banks of river Yamuna, which is also the only surface water source of the city. Agra is situated downstream to Delhi and Mathura and receives all its dirty water through Yamuna which becomes a filthy *nala* by the time it reaches Agra. The situation worsens during pre-monsoonal months when the flow if the river diminishes to a great extent.

The water supplied by AJS is 45% short of demand and is therefore unable to quench the thirst of a fast expanding city. The newly developed colonies of the semi-urban areas are entirely dependent on groundwater for all their household requirements. This has resulted in a large number of bore-wells as there is no governmental hold on withdrawal of underground water.

The dependence on groundwater has also risen considerably in urban city areas as the water supply of AJS is of poor quality and does not meet the set standards for drinking and domestic purposes. This rising dependence is stimulated by two major reasons. Firstly, people regard groundwater as pure and hygienic. Secondly, in absence of any government control they are free to bore even deep wells at their wish.

Earlier studies in areas adjoining Agra show that groundwater of this region is rich in fluoride content (Gupta *et al*. 1999), is highly saline and hard in nature and therefore unfit for drinking. Increased industrialization, urbanization, and agricultural activities during the last few decades have deteriorated the surface water and groundwater quality of Uttar Pradesh (CGWB 2005).

This scenario of the water problem has helped the water bottling plants to thrive in the city. There are numerous such plants which do not have a proper license, but still supply below standard drinking water to a large population which cannot afford to buy expensive water purification units. Agra being a city undergoing expansion faces the same problem. And still a lot many people rely directly on underground water which they use without any treatment. In any case the water drawn from groundwater aquifers might be contaminated.

In and around Agra, groundwater may be subjected to a variety of chemical and microbiological contaminants. There could be several reasons because of which contaminants find their way into groundwater. The domestic septic tanks are the most common reason, particularly, in the semi-urban region where many new ones are installed/build every year. Chemical and biological contaminants enter into the system by subsurface leaching from municipal water sites.

As with other developed cities of the country, Agra has different types of industries. The major ones include leather tanning, adhesive industry, metal plating industry and *petha* industry. The untreated water from these industries not only pollutes the surface water, it also seeps into the underground aquifers. Apart from these household industries also pollute water resources.

METHODOLOGY

PHYSICOCHEMICAL ANALYSIS:

Literature survey of the current state of knowledge on ground water quality of Agra. Purchase of chemicals and laboratory glassware and other minor equipment for research work: Sample bottles, filters, titration glassware, pH meters, etc. were purchased.

SAMPLE COLLECTION:

Extensive sample collection was carried out from various locations of Agra region. The main emphasis in sample collection was given to the proper representation of all the areas demarcated in the associated map (fig 1). The sampling strategy was focused to obtain maximum possible variations within the localities.

500 ml Sample were collected each time from each site. Total of 20 sites were exploited for sampling purpose. Ground water samples from the selected sites namely Sikandra (AS1), Khandari (AS2), Dayalbagh (AS3), Langre Ki Chaouki (AS4), Balkeshwar (AS5), Trans Yamuna (AS6), Rambagh (AS7), Balenganj (AS8), Agra City Station (AS9), Shahganj (AS10), Agra Cant A(S11), Balluganj (S12) and Tajganj (S13), Raja Ki Mandi (AS14), Loha Mandi (AS15), Agra Cantt (AS16), Idgah (AS17), Civil Lines (AS18), Bundu Katra (AS19), Near Airport (AS20). The samples were collected fresh and analyzed within 24 hour period. Once taken, the samples were placed under refrigeration till the analysis is done. Maximum precaution was taken to prevent contamination and cross contamination of samples.

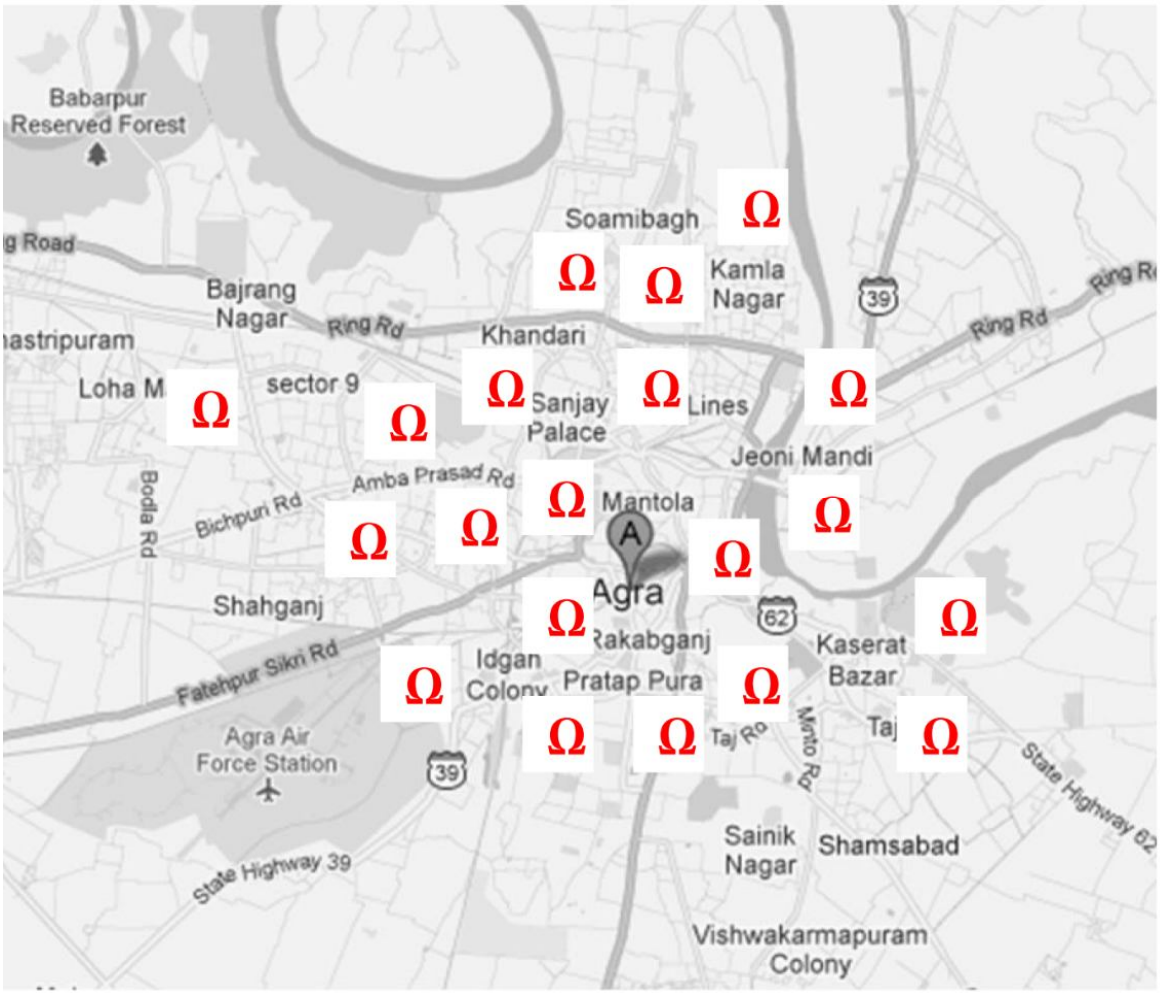

Fig. 1: Map showing various sites where ground water samples were collected.

The analysis of physicochemical parameters was conducted by standard methods as given in APHA (APHA *et al*., 1998) & IS:3025 (Standards, 2003).
The parameters were analyzed using the following methods-
pH: Using Standard single electrode pH meter.
TDS (Total dissolved Solids): Analyzed by using standard ISO certified TDS meter.
Alkalinity: Standard titration procedure: 20 ml of the sample in a 250 ml conical flask. Add about 2-3 drops of Phenolphthalein indicator, and the color changes to pink. This solution was titrated against standard N/50 HCl, till pink color disappears. To the same solution two drops of methyl orange was added, the color of the solution changes to

yellow. Continue the titration till orange color appears. Calculations of alkalinities was made based on consumed acid & calculated as calcium carbonate equivalents.

Level of Oxygen: Winkler's method: The samples were collected in BOD bottles, to which 2ml of manganous sulphate and 2ml of potassium iodide are added and sealed. This is mixed well, and the precipitate allowed settling down. At this stage 2ml of conc. sulphuric acid is added and mixed well until all the precipitate dissolves. 203ml of the sample is measured into the conical flask and titrated against 0.025N sodium thiosulphate using starch as an indicator. The end point is the change of colour from blue to colourless.

Calculation:

1ml of 0.025N Sodium thiosulphate = 0.2mg of Oxygen

$$\text{Dissolved oxygen (mg/L)} = \frac{(0.2)\ (1000 \text{ ml of Sodium thiosulphate})}{200}$$

Total Hardness: total hardness was determined by titrating the Ca^{2+} and Mg^{2+} present in sample with Na_2EDTA solution, using NH_4Cl-NH_4OH buffer solution of pH 10 and Eriochrome Black-T as the metal indicator.

Na_2H_2Y (Disodium EDTA solution) → $2Na^+ + H_2Y^-$

$Mg^{2+} + HD^{2-}$ (blue) → MgD (wine red) + H^+

The calculation was conducted using the following formula.

$$\text{Total Hardness as CaCO3(ppm)} = \frac{\text{Vol. of EDTA (mL)X 0.1 X molarity of EDTA X } 10^6}{\text{Vol. of Sample (mL)}}$$

Fluoride Content: Analysis was done by colorimetric method using zirconium SPADNS solution. A standard graph is prepared by using fluoride concentrations ranging from 0.005 mg/L to 0.150 mg/L at 570nm. A reference solution was prepared by adding 4ml of acid zirconyl-SPADNS reagent to 21ml of distilled water. A known volume of filtered sample (21ml) was taken in a test tube, 4ml of acid zirconyl-SPADNS reagent was added to the sample along with a reference solution. The mixture was left for about 30 min for complete color development and the optical density was read at 570nm.

$$F^- \text{ mg/L} = \frac{(\text{O.D sample}) \text{ X } (\text{Conc. of the Standard}) \text{ X } (1000)}{(\text{O.D Standard}) \text{ X } (\text{sample vol.})}$$

Chloride Content: Standard titration procedure (as per IS:3025) using AgNO3 & Potassium Chromate. 20 ml of sample was taken in a conical flask and titrated against N/50 **$AgNO_3$** solution & 1-2 drops of **K_2CrO_4** should be added as indicator to the solution. The burette readings are recorded. Calculation of Chloride content was performed based on the fact that 1ml of N/50 **$AgNO_3$** corresponds to 0.00071 gm of Cl^-

RESULTS AND DISCUSSION

Earlier, rivers, lakes and streams were particularly thought to be polluted but now-a-days scientific work has revealed that groundwater aquifers are also contaminated. In Agra, about 80% of the population is dependent on groundwater for drinking and other purposes and a large segment of this population uses underground water without any prior treatment like boiling or filtering, etc. The anthropogenic disturbances through industrial and agricultural pollution, increasing consumption and urbanization degrade the groundwater and impair their use for drinking, agricultural, industrial and domestic uses (Simeonov *et al.*, 2003; Sreedevi, 2004). Physicochemical analysis about groundwater of Agra consisting of various parameters was accomplished in this study. The results of the physicochemical analysis reveal that ground water of Agra is not suitable for drinking purpose without treatment. In every sample, one or the other

physicochemical parameter falls off-limit of safe drinking. The values of physicochemical parameters analyzed are shown in Table 1.

Table 1: Physicochemical parameters of Agra region in three seasons

Season	Physicochemical Parameters						
	pH	TDS (mg/l)	Hardness (mg/l)	Alkalinity (mg/l)	Oxygen content (mg/l)	Fluoride content (mg/l)	Chloride content (mg/l)
Pre-Monsoon	7.1-8.8	800-2500	210-1400	300-615	4.0-5.8	0.1-32	260-1200
Monsoon	7.1-8.8	800-2300	200-1400	280-615	4.0-5.9	0.1-32	260-1200
Post-Monsoon	7.1-8.8	800-2100	210-1200	300-615	4.2-6.9	0.1-28	270-1280

Table 1 clearly shows that the variation in the parameters between the two seasons have not been significant. This is probably due to lesser rainfall during the period of study. It can be envisaged that changes in these parameters are more prominent in surface water as compared to ground water which is less affected with scanty rainfall.

Location based variations of these parameters are being analyzed and depicted in the figure 2. It has been observed that groundwater samples taken from locations near Yamuna river showed less drastic variations among each parameter. Maximum variation observed was in the total dissolved solids and chloride content values.

Figure 2 also clearly indicates that pH showed least variation among all the samples tested. Maximum variation was observed in TDS and fluoride contents of groundwater.

It is known that the high amount of TDS in water is mainly due to the discharge of industrial and domestic waste into water Palanivel and Rajguru (1999). The water quality is also known to deteriorate mainly due to concentration of TDS (Agarwal and Kannan (1996)). pH levels of water might alter due to concentration of industrial effluents and sewage. Lorenzen and coworkers have recently studied the origin of salinity issues of groundwater in areas of Haryana adjoining Delhi (Lorenzen *et al*., 2012). It has been reported that high concentration of fluoride in drinking water might lead to fluorosis (Desai *et al*., 1988; Samal and Naik, 1988). Chemical contaminants in water cause several disorders and are responsible for relatively high incidence of human cancers at some places (Calderon, 2000; Landigran *et al*., 2002).

Most localities of Agra have permanently hard water which causes white scaling in utensils indicating its richness in calcium. The study reveals that groundwater of Agra has physicochemical parameters such as TDS, hardness, etc are beyond the permissible limits as per the international standards (Table 2).

Table 2: Comparison of standard and tested physicochemical parameters

	Physicochemical Parameters						
	pH	TDS (mg/l)	Hardness (mg/l)	Alkalinity (mg/l)	Oxygen content(mg/l)	Fluoride content(mg/l)	Chloride content(mg/l)
Tested Values	7.1-8.8	800-2500	210-1400	300-615	4.0-5.8	0.1-32	260-1200
As per WHO	*6.5-8.5*	*<1000*	*500*	*--*	*4-7*	*1.5*	*200*

It is therefore, concluded that groundwater of Agra region is not fit for human consumption (drinking and bathing) due to its physicochemical characteristics. Further, such water has a significant health impact since a large population is directly or indirectly dependent on it.

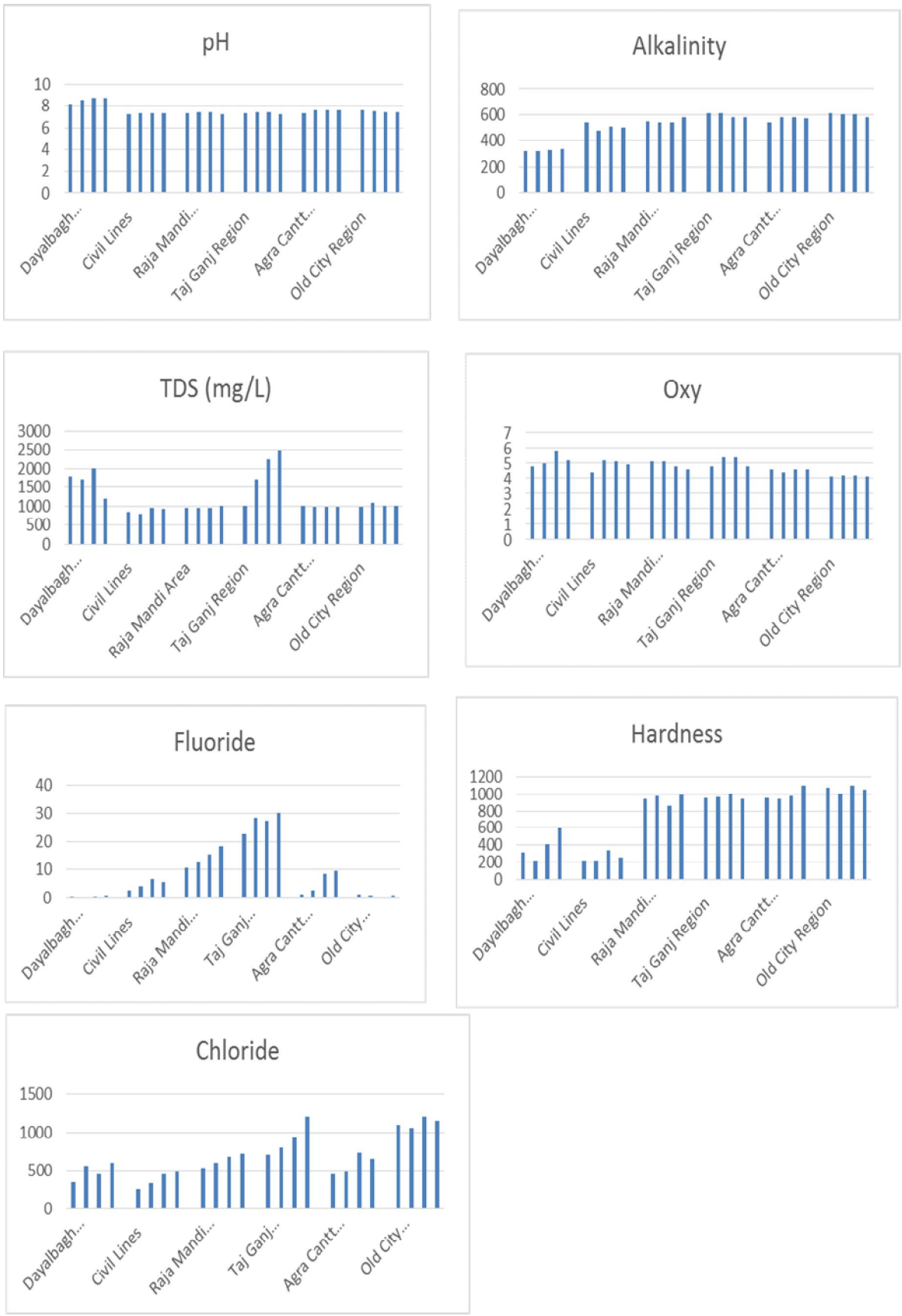

Fig. 2: Individual physicochemical characteristics of ground water from different regions in Agra. Values are in mg/l for all the parameters except pH.

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