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Statistical study on physico-chemical properties of groundwater in and around urban stretches of Delhi, India

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ABSTRACT

Groundwater samples collected at different locations in and around Delhi City were analysed for their physico-chemical characteristics. Sampling locations were selected covering all the zones and samples were collected. The present investigation is focused on the determination of physicochemical parameters such as pH, total dissolved solids, total hardness, calcium hardness, turbidity, chlorides, sulphate, nitrate and fluoride. To assess the quality of groundwater, each parameter was compared with the standard desirable limit of that parameter in drinking water as prescribed by different agencies. The parameters were determined according to procedures outlined in the Standard Methods for the Examination of Water APHA. A systematic calculation was made to determine the correlation coefficient 'r' amongst the parameters and the significant values of the observed correlation coefficient between the parameters was worked out. Suggestions were made to improve the quality of groundwater of Delhi area. The study of physico-chemical characteristics of these groundwater samples suggest that the evaluation of water quality parameters as well as water quality management practices should be carried out periodically to protect the water resources.

Key words: Groundwater, physico–chemical parameters, water quality, Delhi City

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INTRODUCTION

Water is the most important natural resource without which life would be nonexistent. Availability of safe and reliable source of water is an essential prerequisite for sustainable development. Groundwater is an increasingly important resource all over the world. The term groundwater is usually reserved for the subsurface water that occurs beneath the water table in soils and geologic formation that are fully saturated. Much of the present concern with regards to environmental quality is focused on water because of its significance in maintaining the human health and health of the ecosystem. Fresh water is limited resource, crucial for agriculture, industry and even human existence without fresh water of satisfactory capacity and quality, sustainable development will not be possible (Kumar 1997). Groundwater being a renewable natural resource is replenished by the precipitation. It is generally less prone to contamination and pollution when compared to surface water bodies (Zaman 2003). In addition, the natural impurities in rainwater, which replenishes groundwater systems, get removed while infiltrating through the soil strata (Veslind 1993). In India, where groundwater is used intensively for irrigation and industrial purposes, a variety of land and water based human activities are causing pollution of this precious resource (Trivedy 1990). Groundwater quality plays an important role in groundwater protection and quality conservation. Hence, it is very important to assess the groundwater quality not only for its present use but also from the viewpoint of a potential source of water for future consumption; as it supports drinking water supply, livestock needs, irrigation, industrial and many commercial activities (Veslind 1993).

Due to massive influx of people from other parts of country to Delhi city, the population of Delhi has increased from ten to fifteen million in recent times and there is an annual population increase of 3% (Kumar 1997). Therefore, there is an increase in the demand for portable water resulting in concomitant acute water shortage to meet the daily water consumption needs of the people. Most of the residents have resorted to the use of groundwater both for domestic and industrial usage. The rapid growth of urban areas has further affected groundwater quality due to overexploitation of resources and improper waste disposal practices. Hence there is always a concern for the protection

and management of groundwater quality. The aim of this research is to statistically compare the values obtained for the above stated physico- chemical parameters with World Health Organization (WHO) standard values in order to determine the water quality in Delhi city, India.

MATERIAL AND METHODS

Study area

Delhi, the capital city of India, is situated in North India (28°12'–28°63' N, 75°50'–77°23' E) at an altitude of 293m above sea level. Situated on the banks of River Yamuna; it is considered to be a part of the Aravalli Range. It supports a total area of 16.5 square miles (42.7 sq km). Delhi is divided into 9 zones, namely South, East, West, North, North West, North East, Central, New Delhi, and South West.

Sampling methodology

Ten sampling locations were selected covering all the zones and samples were collected (Fig. 1). The selected areas are extensively used for drinking, household purposes and industrial purposes. The methods employed for this study are sampling and laboratory analysis. A detailed field sampling exercise was carried out, while laboratory analyses of the water samples were carried out at the Delhi Pollution Control Committee, Department of Environment, Delhi Government, Water Laboratory. Water quality parameters analysed are physical properties such as: pH, colour, total dissolved solids (TDS), and hardness. Chemical parameters such as: chloride (Cl^-), fluoride (F), nitrate (NO_3^-), and sulphate (SO_4^{2-}) were also analysed from each sample. pH was analysed using a pH meter. Cations were analyse using an atomic absorption spectrophotometer (Perkin-Elemer AAS3110), while anions were analysed using the colorimetric method with UV, spectrophotometer (WPAS110). Total dissolved solids (TDS) were analysed using the gravimetric method (Ofoma et al. 2005). The parameters were determined according to procedures outlined in the Standard Methods for the Examination of Water (APHA 1998). The results were compared to World Health Organisation (WHO) and Bureau of Indian Standards (BIS). The simple linear correlation analysis has been carried

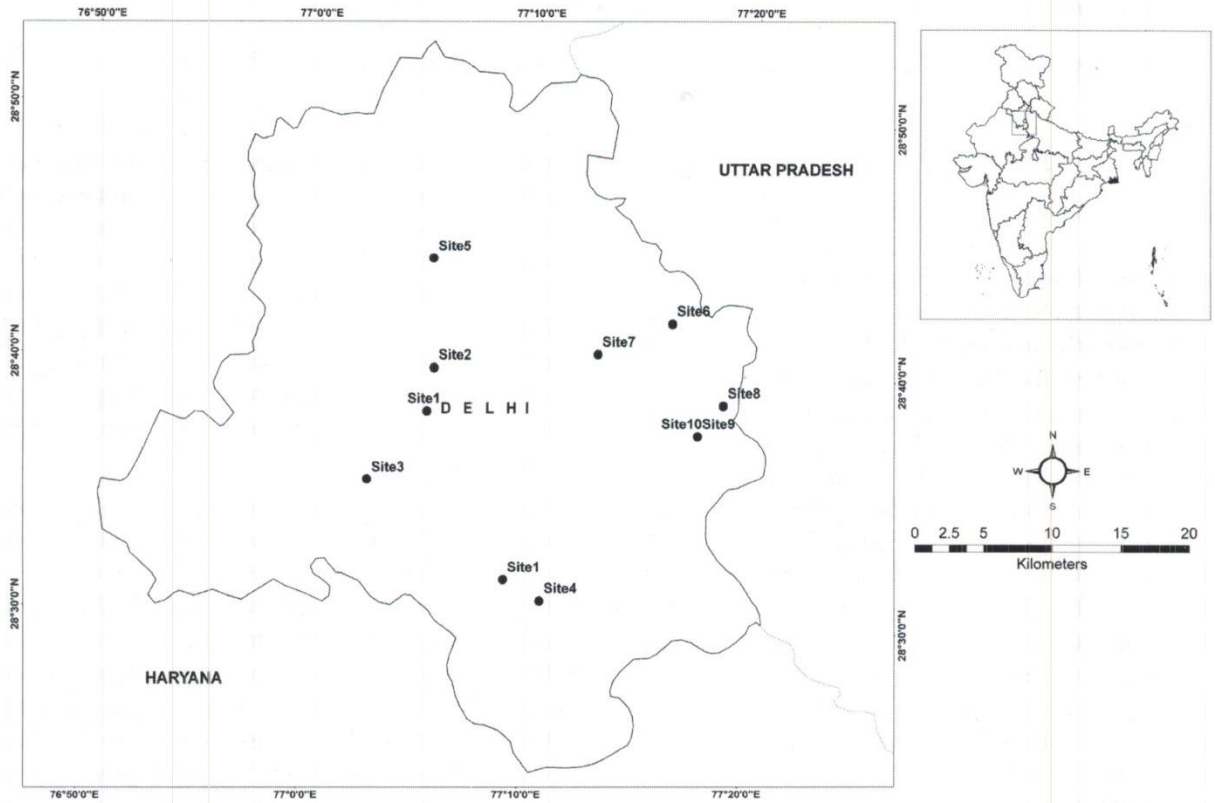

Fig. 1: Delhi City map showing the sampling locations.

out to find out correlation between two tested parameters.

RESULTS AND DISCUSSION

All the collected water samples were mainly from bore wells found in and around the city.The physical and chemical parameters are tabulated along with the standard values in Table 1.

All the water samples were colourless, clear and odourless indicating the absence of colloidal substances, suspended and decomposed vegetation. The collected water samples have pH within the permissible limits ranging from 7.77-8.17. According to BIS Standards, the acceptance limit for Total Dissolved Solids (TDS) in groundwater is 500 mg/L, which may go up to 1500 mg/L in case of any alternative source (Karunakaran et al. 2009). TDS also indicate the salinity behaviour of groundwater (Rao et al. 2000). As per classification of TDS groundwater of Delhi region come under moderately hard to hard especially the samples from sites S2, S3 and S9 which exceeded the BIS permissible limit. The chloride content of water samples collected lies in the range from 87.50 to 300.83 mg/L. Site 4 has high concentration of chloride content which exceeds the permissible limit proposed by both, BIS and WHO (250 mg/L) . High chloride content in water bodies harms metallic pipes and structure as well as agricultural crops (Suresh et al. 1992).

Total hardness of collected samples was found to be in the range from 521-2055 mg/L. Total hardness values for samples 2, 3 and 9 are high due to the high concentration of calcium and magnesium salts. Hardness leads to heart diseases and kidney stone formation (Lalitha et al. 2004). These samples were not suitable for drinking, washing, cleaning and laundering Calcium hardness ranged between 45.10 to 101.17 mg/L. Samples from Site3, S6, S7 and S9 are beyond the BIS prescribed limit, i.e., 75mg/L. Sulphate of water samples collected lies in the range from 15.09 to 37.88 mg/L. Concentrations of sulphate around 1000 mg/L has laxative effect and causes gastro intestinal irritation (Bhatia 2000). All ten samples have sulphate within the permissible limit proposed by BIS and WHO (200 mg/L). Nitrate of water samples collected lies in the range from 0.80 to 2.33 mg/L. Nitrate beyond 45 mg/L (According to BIS standard for ground water), in water bodies leads to organic pollution, causes blue baby syndrome and it can be removed by desalination (D Xanthoulis,and WW Wallender, 1991). Fluoride of water samples collected lies in the range from 0.05 to 3.23 mg/L. Sample 2, 4, 9 and 10 have slightly high values of fluoride and exceeds the permissible limit proposed by BIS (Table 2). High fluoride values may cause fluorosis, which is characterized by mottling of teeth-enamel, nervous and skeletal disorder (Siddiqui 2002).

It is shown in (Table 2) that all the parameters are within the permissible limit. The observed coefficient of variation (Cv) (Standard Deviation/Mean) for the parameters shows that the variations in the TDS (26.11%), turbidity (36.77%), and fluoride (34.18%) are of moderate range. From this, it is concluded that concentration of various parameter of the selected ten sites, are not highly varying in different locations. The correlation coefficient (r) has a value between +1 and -1. The correlation between the parameters is characterized as strong, when it is in the range of +0.8 to 1.0 and -0.8 to -1.0, moderate when it is having value in the range of +0.5

Table 1: Physical and chemical parameters, in mg/L.

	Paschim Vihar (S1)	Rohini (S2)	Tilak Nagar (S3)	Dwarka (S4)	Vasant Kunj (S5)	Mehrauli (S6)	Yamuna Vihar (S7)	Rajpura Road (S8)	Anand Vihar (S9)	Madawali (S10)
pH	7.82	7.77	7.98	8.17	7.95	7.93	7.87	7.87	8.03	7.98
Colour	cl	cl	cl	cl	cl	cl	cl	cl	cl	cl
Odour	ol	ol	ol	ol	ol	ol	ol	ol	ol	ol
TDS	635.00	2016.67	1798.33	1281.67	521.67	1086.67	730.00	841.67	2055.00	850.00
Cl	145.00	188.33	226.67	300.83	105.00	125.00	87.50	131.67	122.50	148.33
TH	388.33	576.67	648.33	291.67	331.67	541.67	651.67	401.67	568.33	478.33
CaH	47.85	71.27	101.17	52.23	45.10	91.47	92.23	61.07	83.40	69.83
Sulphate	37.88	25.80	22.03	30.92	33.08	27.22	15.09	35.39	22.74	15.34
Turbidity	1.00	2.33	2.00	1.00	0.00	1.00	0.67	0.67	2.00	1.00
Nitrate	1.62	1.61	1.49	2.33	1.75	2.15	1.67	0.80	1.58	1.66
Fluoride	0.12	3.23	1.04	1.55	0.76	0.64	0.72	0.05	1.81	1.21

cl - Colourless; ol - Odourless; TDS - Total Dissolved Solids; Cl-Chloride; TH-Total Hardness; CaH-Calcium Hardness

Table 2: Statistical estimation for different parameters in the groundwater samples from in and around Delhi City.

	Range	BIS	WHO	Mean	Standard Deviation	Standard Error	Coefficient of Variation%
pH	7.77-8.17	6.5-8.5	6.5-9.5	7.94	0.09	0.03	1.14
TDS (mg/L)	521-2055	500	500	118.67	308.55	97.57	26.11
Cl (mg/L)	87.50-300.83	250	250	158.08	26.95	8.52	17.04
TH (mg/L)	291.67-651.67	500	500	487.83	95.67	30.25	19.61
CaH (mg/L)	45.10-101.17	75		71.56	16.67	5.26	23.25
Sulphate (mg/L)	15.09-37.88	200	200	26.55	5.41	1.71	20.39
Turbidity (NTU)	0.67-2.33	5	5	1.17	0.43	0.14	36.77
Nitrate (mg/L)	0.80-2.33	45	45	1.67	0.21	0.07	12.64
Fluoride (mg/L)	0.05-3.23	1	1.0-1.5	1.11	0.38	0.12	34.18

Table 3: Correlation coefficient (r) for different parameters in the groundwater samples collected from in and around Delhi Citysamples from in and around Delhi City.

	PH	TDS	Cl	TH	CaH	Sulphate	Turbidity	Nitrate	Fluoride
pH	1.00	0.15	0.52	-0.31	-0.01	-0.13	-0.07	0.50	0.03
TDS	0.15	1.00	0.42	0.50	0.48	-0.27	0.93	0.03	0.76
Cl	0.52	0.42	1.00	0.42	-0.11	0.13	0.38	0.37	0.37
TH	-0.31	0.50	-0.25	1.00	0.92	-0.72	0.58	-0.16	0.28
CaH	-0.01	0.48	-0.11	0.92	1.00	-0.71	0.49	-0.02	0.14
Sulpahte	-0.13	-0.27	0.13	-0.72	-0.71	1.00	-0.29	-0.11	-0.33
Turbidity	-0.07	0.93	0.38	0.58	0.49	-0.29	1.00	-0.05	0.71
Nitrate	0.50	0.03	0.37	-0.16	-0.02	-0.11	-0.05	1.00	0.25
Fluoride	0.03	0.76	0.37	0.28	0.14	-0.33	0.71	0.25	1.00

to 0.8 and -0.5 to -0.8, weak when it is in the range of +0.0 to 0.5 and-0.0 to -0.5. The correlation coefficients (r) among various water quality parameters were calculated and the values of the correlation coefficients (r) are given in Table 3.

The strong positive correlation between total hardness and calcium hardness (0.919) and total dissolved solids and turbidity (0.933) were found. The correlation coefficients between pH and chloride (0.521), total hardness and turbidity (0.581), total hardness and sulphate (-0.718), total dissolved solids and fluoride (0.762) were found to have moderate correlation. Total hardness, turbidity and sulphate showed weak correlation with the other parameters.

CONCLUSION

Access to safe water is one of the key Millennium Development Goals of United Nation. It is an important foundation for sustainable poverty reduction (Pandey 2012). Groundwater is often defined as water occurring within the subsurface geological environment. The flow of groundwater and the pollutants that it may contain is very slow as compared with flow on land surface. It therefore, becomes imperative to device ways and means to protect it (Bhalerao and Tawde 2012). The groundwater samples of Delhi city area were collected and analysed for various physico-chemical parameters. The samples are taken from 10 locations across the city and were collected and analysed for pH, TDS, Cl, Total hardness, Calcium hardness, NO_3, SO_4, F and Turbidity. The values of all the groundwater samples were compared with the standard permissible value of WHO and BIS. TDS, Chloride, and Fluoride exceeded the permissible limit in most of the groundwater samples. In general this water may be boiled, cooled, filtered and used for drinking purposes. The statistical analysis of the water quality parameters on water samples yielded the range of the variation, mean, standard deviation and co-efficient of variation. Since the correlation coefficient gives the interrelationship between the parameters, correlation coefficients were also calculated. Results of correlation analysis showed that calcium hardness and total hardness; turbidity and total dissolved solids; fluoride and total

dissolved solids; have high correlation with most of the other parameters. From the obtained results, it is suggested to institute remedial measures on bore wells having poor quality characteristics and to monitor the groundwater quality and assess periodically in this study area to prevent further contamination.

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