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Water quality assessment and physicochemical parameters of groundwater in District Hapur, Uttar Pradesh, India

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Abstract

The present study investigation of the ground water contamination of Hapur district (U.P.), India has been carried out. The ground water samples were collected from different locations from hand pumps mark II in Hapur district.Water Quality Index (WQI) of drinking water has been assessed by using various physicochemical & biological parameters for the ground wateranalysis. Water samples were analysed using various physicochemical and biological parameters such as pH, Electrical Conductivity, Total Dissolved Solid, Total Hardness, Chloride, Fluoride, Nitrate, Sulphate, Total Acidity, Total Alkalinity, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and Dissolved Oxygen (DO)etc. and the results compared with the standards given by WHO, ICMR and BISThe correlation between different parameters was also assessed. The average values of physicochemical and biological parameters were observed as pH 7.86, Electrical conductivity 1206.67mmhos/cm, TH 734.17 mg/l, acidity 352.08 mg/l, total alkalinity 464.17 mg/l, TDS 645.17 mg/l, chloride 85.50mg/l, fluoride 0.77 mg/l, nitrate 45.99 mg/l, sulphate 160.39 mg/l, COD 12.79 mg/l, DO 4.08 mg/l and BOD 1.99 mg/l respectively. The WQI of different blocks of district Hapur reveals that the water quality is poor for drinking and other activities.

Keyword*: Physicochemical parameter, WQI, correlation coefficient, ground water quality*

Introduction

The indiscriminate use of chemical, fertilizers, pesticides and industrial effluents thronging in the ground water and mixing in the water level has become a serious environmental and public health problem everywhere in India and as a whole in the world. The urbanization and rapid population growth has also produced a vast amount of health hazards (Degremont, G.1991). The waste is often piled as high as the industrial unit allows. Most commonly reported danger to human health from the landfill is from the use of groundwater that has been contaminated by leachate. Water quality performs important role for all living beings. Ground water quality has become an essential water resources issue due to rapid increase of population, rapid industrialization, unplanned urbanization, flow of pollution from upland to lowland, and too much use of fertilizers, pesticides in agriculture (Jameel, A. 1998). Ground water is one of the earth's widely distributed, renewable and most important resources. It is generally considered least polluted compared to other inland water resources, but studies indicate that ground water is not absolutely free from pollution though it is likely to be free from suspended solids (Mishra et al. 2003).Several million of theworld's population is suffering from water-bornediseases due to consumption of contaminatedwater with >250 million such new cases each year (Barabas 1986). The major problem with the ground water is that once contaminated, it is difficult to restore its quality (Goel, 2000). Hence there is a great need for the protection and management of ground water quality. It is well known that no straight forward reasons can be advanced for the deterioration of water quality as it is dependent on several water quality parameters. Some of these parameters constitutea risk to human health, others affect the aesthetic quality of the water supplied, and others

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relate totreatment issues (Ratnayaka *et al.* 2009).The strong correlations amongst different parameters and combined effect of their inter-relatedness indicates the groundwater quality. The quality in the Industrial areas is determined by measuring the concentration of some physico-chemical parameters and comparing those with drinking water standards. As it is well known that the use of water is being carried out for consumption for various activities. (Khanna *et al.* 2005 and Miller, 1985). Many studies on groundwater quality with respectto drinking and irrigation purposes have been carriedout in the different parts of India (Sunitha *et al.* 2005; Subba Rao 2006; Giridharan*et al.* 2008; Das *et al.*2010; Krishna Kumar *et al.* 2011; SarathPrasanth*etal.* 2012).The developed regression equations for the parameters having significant correlation coefficients can be successfully used to estimate the concentration of other constituents. A systematic study of correlation and regression coefficients of the water quality parameters not only helps to assess the overall water quality but also to quantify relative concentration of various pollutants in water and provide necessary clues for implementation of rapid water quality management programmes. In the present study, an attempt has been made to evaluate the quality of ground water in the area for correlation and regression studies of various physico-chemical parameters.

Material and methods

Study area: Hapur district is located at 28.72°N 77.78°E covering an area of 660 sq. miles. It has an average elevation of 213 meters (699 feet). Hapur district comprises four blocks Hapur, Garhmukteshwar, Dhaulanaand Simbhawali (Table 1). Many small growing Industries are established in different blocks of district like sugar mills, bottling plant, crashers, Paper and pulp factories etc. The treated and untreated contaminated effluent from these Industries is being discharged into the ground which is absorbed by the soil and thus reaches the ground water table and contaminate it. Once it is contaminated, it is difficult to restore the original quality of water so it is our duty to assess the quality of groundwater for consuming in various activities for mankind.

Collection of samples: In the present study 28 water samples were collected from different blocks, Hand pumps (Mark II) of Hapur district (Figure 1). The samples were collected in pre-cleaned and well-dried sterilized screw-capped polyethylene bottles (2.5 L) with necessary precautions of standard method according to APHA and WHO. The sample bottles were labelled with collection details to minimise any errors. The collected samples were stored in an icebox and brought to laboratory for determining both physical chemical and biological parameters.

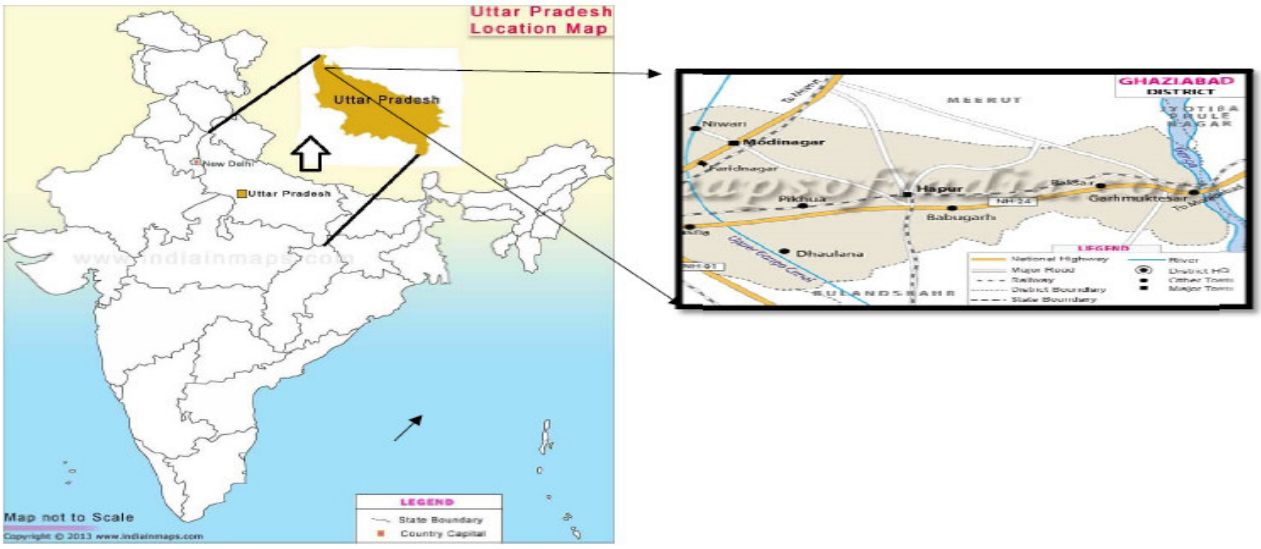

Fig. 1: Map showing different sampling sites

Table1: GIS points of water collection

Block	Location (n)	Latitude	Longitude	Height
Hapur	Ahmad Nagar(3)	28^0 38' 25 N	$77^0$51'06E	213
	Babugarh(2)	28^0 43' 19 N	$77^0$50'50 E	217
	Hapur railway station (1)	28^0 44' 22 N	$77^0$46'51 E	219
Dhaulana	Dhaulana (3)	28^0 45' 38 N	$77^0$48'21 E	221
	Shyamnagar(2)	28^0 45' 35 N	$77^0$49'34 E	218
	Khera(3)	28^0 46' 16 N	$77^0$46'25 E	217
Garh	GarhRailway station (2)	28^0 46' 55 N	$77^0$04'06E	218
	Salarpur(2)	28^0 43' 43 N	$77^0$05'06E	217
	Dehra Rampur (2)	$28^0$43' 13 N	$77^0$04'06E	214
Simbhawali	SimbhawaliRailway station (3)	$28^0$46' 05 N	$77^0$59'06E	220
	Baksar(3)	$28^0$45' 43 N	$78^0$01'06E	219
	Athseni(2)	$28^0$46' 53 N	$78^0$02'06E	217

n = no of samples collected

Methods: AR grade chemicals were used for this studies. Double distilled water was used for the preparation of all the reagents and solutions. Glasswares were cleaned with Thomas Baker Thromaklin liquid soap followed by distilled water and dries in the oven before the analysis. (APHA, 2005; BIS 1998).The pH and Electrical Conductivity were measured by using Systronics digital pH meter (model 335) and Systronics digital conductivity meter (model 304). TDS was determined by using Century TDS meter. Total Hardnesswas measured by EDTA titration method. The total alkalinity ofwater is determined by titration with a strong acid to methyl orange. Chloride was measured volumetrically by silver nitrate titrimetric method using potassium chromate as indicator and was calculated in terms of mg/L. Sulphate was measured by Gravimetric method using Barium chloride as precipitating agent. Nitrate was measured by the spectrophotometric method. DO was measured by Winkler's titration method. COD was measured by closed reflux method and BOD was measured by the 5 days incubation method. The physicochemical analysis was carried out according to standard methods.

Water Quality Index (WQI): WQI was estimated according to the formula (Mahuya *et al*., 2003) as given below.

$$WQI = Antilog (\sum Wn \log Qn)$$

Where, Wn = weightage of the parameter in the sample = K / Sn

K= constant = 1/ (1/S1+1/S2+1/S3……..+1/Sn)

Sn= standard values for different water quality parameter.

Qn= water quality rating = 100(Vn- Vi)/(Sn-Vi)

Vn= observed value, Vi= ideal value= 7.0 for pH, 14.6For DO, 0 for other parameters.

The water quality of different sites and has been rated according to the WQI (table 2).

Table 2: The water quality of different sites has been rated According to the WQI as given below

WQI	Water quality rating
0 – 44	Poor
45-64	Marginal
65 - 79	Fair
80 - 88	Good
89 -94	Very good
95 -100	Excellent

Results and discussion

The results of various physico-chemical parameters like pH, electrical conductivity, total dissolved solids, total hardness, acidity, total Alkalinity, chlorides, fluorides, sulphates, nitrates, chemical oxygen demand, dissolved oxygen and biochemical oxygen demand are shown in Table 4 while correlation and coefficient are given in table 5. The appearance of all the tested samples of ground water have no odour and taste. The pH studies showed that the pH of the water samples was range from7.62 – 8.00 (mean 7.86) which is within the permissible limits (BIS 1998 and WHO 1997). Chaurasia and Pandey (2007) have also reportedslightly basic pH of water in Faizabad region.The electrical conductivity of water samples ranged from 530 – 2080mmho/cm. However the prescribed limit is 1000 mmho/cm according to WHO for drinking water and the mean 1206 mmho/cm which is higher than the BIS and WHO (1997). Few water samples possess higher values than the permissible limits may be due to presence of dissolved inorganic substances. The TDS in water comprises of inorganic salts and small amounts of organic matter which varies from 380-1221mg/l. Water with higher solid content indicated that the groundwater is of poor potability and may induce an unfavourable physiological reaction(Shankar et al. 2008).The desirable limit of TDS for drinking water is 500 mg/l. The total hardness ranged between 307- 786.6 mg/l. and was higher than the prescribed standard value (500 mg/ l). Increase in value pertains to the excess presence of the salts of Ca and Mg. Chlorides, which have been associated with pollution as an index were found in the range of 14.2- 227.2 mg/l. The concentration of chlorideion in the present observations was within the higher range of desirable limit of WHO (250 mg/l).The chloride limits have been laid down primarily from taste view point.However, no adverse health effects on human being have been reported by the use of water havinghigh chloride concentrations (Jain *et al.* 2010). The phenolphthalein alkalinity was found to be absent in all the samples analysed and the methyl orange alkalinity varied from 315- 615 mg/l. This indicates the absence of hydroxyl alkalinity and the presence of carbonate and bicarbonates. However, the values of all the sampling sites were quite higher than the desirable limits (120 mg/l). According to Sharma and Rao (1997) the value of hardness and fluoride is higher than the permissible limits. The fluoride content of all the sampling sites ranged between 0.46-0.97mg/l, which were below the recommended limits (Sharma & Rao1997). Sulphate content ranged from 71.98 – 372.47 mg/l, whereas the permissible limit for sulphates is 200 mg/l. The level of nitrates in the ground water ranged between 16.10 – 74.89 mg/l. Nitrate concentration more than the recommended value (45 mg/l) was observed on five sampling sites. The amount of DO ranged between 2.67 – 5.87 mg/l in water of all nine sampling stations and was less in comparison to minimum DO recommended by WHO (Table 3).

Table-3: Comparison of ground water quality with drinking water standards

Parameter	WHO	BIS	ICMR	Present study report
PH	6.5-9.2	6.5 - 8.5	6.5-8.5	7.62-8.00
EC, mmho/cm	300	-	-	530 - 2080
TDS	500	500	500-1500	380- 1221
Total Hardness	-	200	300	590 - 900
Chloride	200	250	250	14.20 – 227.20
Fluoride	1.5	1		0.46 – 0.97
Total Acidity	-	-	-	185 - 565
Total Alkalinity	-	200	-	315 – 615
Nitrate	45	45		16.10 – 74.89
Sulphate	200	200	200	71.98 – 372.47
COD	10	-	-	7.92 – 25.74
DO	>5	-	-	2.67 – 5.87
BOD	<5	-	-	1.06 - 2.90

Table 4: Comparison of various physico-chemical parameters of different blocks

Parameters	Hapur	Dhaulana	Simbhawali	Garh	Mean	Median	Std error	95 % conf	99% conf
pH	7.62 - 7.85	7.87 – 8.00	7.70 – 7.93	7.85 – 7.96	7.86 ± 0.11	7.88	0.03	0.07	0.10
EC (µmhos/cm)	1060 - 1490	720 – 1270	1150 – 1790	530 – 2080	1206.67 ± 440.63	1175.00	127.2	279.97	395.09
TH (mg/l)	750 – 830	620 – 710	630 – 750	590 – 880	734.17 ± 99.59	730.00	28.75	63.28	89.29
Acidity (mg/l)	385 – 540	270- 390	280- 565	280- 543	352.08 ± 116.57	327.50	33.65	74.07	104.52
TA (mg/l)	375- 475	315- 485	340 – 600	395 - 615	464.17 ± 96.81	465.00	27.95	61.51	86.80
TDS (mg/l)	86.80 – 263.18	121.91- 162.49	133.11 – 156.53	71.98 – 160.49	645.17 ± 263.08	601.00	75.94	167.16	235.89
Cl (mg/l)	65.39 – 74.89	19.06- 25.46	43.63 – 72.43	16.10 – 38.35	85.50 ± 65.83	74.55	19.00	41.83	59.03
F (mg/l)	102.95 – 227.20	28.4- 99.4	14.2 – 92.3	31.5 – 134.9	0.77 ± 0.15	0.82	0.04	0.10	0.14
NO_2 (mg/l)	0.83 – 0.88	0.46- 0.52	0.76 – 0.84	0.64 – 0.97	45.99 ± 22.97	40.99	6.63	14.60	20.60
SO_4 (mg/l)	9.90 – 16.83	7.92- 11.88	9.90 – 14.85	11.88 – 25.74	160.39 ± 82.53	144.82	23.82	52.44	74.00
COD (mg/l)	3.47 – 4.27	3.63-3.73	2.67 – 5.33	4.27 – 4.80	12.79 ± 4.73	11.39	1.36	3.00	4.24
DO (mg/l)	1.73 – 2.69	1.06 – 1.31	1.55 – 2.90	1.31 – 269	4.08 ± 0.89	3.73	0.26	0.56	0.80
BOD (mg/l)	655- 829	396- 622	380 – 946	482 - 1221	1.99 ± 0.65	1.90	0.19	0.41	0.59
WQI	28.25 – 28.72 **(Poor Quality)**	27.50 – 28.63 **(Poor Quality)**	28.86 – 29.33 **(Poor Quality)**	28.41 – 28.78 **(Poor Quality)**	28.42 ± 0.52	28.48	0.15	0.33	0.46

Table 5: Correlation coefficient of various physico-chemical parameters

	pH	EC	TH	Acidity	TA	TDS	Cl	F	NO2	SO4	COD	DO	BOD
pH	1												
EC	-0.31	1											
TH	-0.35	0.006	1										
Acidity	-0.65	0.596	0.260	1									
TA	-0.27	0.698	0.240	0.187	1								
TDS	-0.47	0.781	0.145	0.473	0.468	1							
Cl	-0.30	0.726	0.209	0.431	0.445	0.730	1						
F	-0.56	0.167	0.309	0.182	0.329	0.199	0.248	1					
NO2	-0.63	0.631	0.082	0.639	0.234	0.691	0.634	0.513	1				
SO4	-0.19	0.615	-0.212	-0.041	0.554	0.672	0.600	0.088	0.405	1			
COD	-0.009	0.651	0.119	0.097	0.433	0.797	0.655	0.160	0.542	0.617	1		
DO	0.21	-0.152	-0.520	-0.537	-0.017	-0.054	-0.175	0.378	-0.015	0.143	0.102	1	
BOD	-0.14	0.010	0.243	-0.219	0.238	0.209	0.112	0.792	0.249	0.038	0.369	0.668	1

The lower amount of DO in ground water may be due to the fact that an iron pipe is being used for fitting the hand pumps to supply ground water and both mechanical and chemical processes involved

may lead to maximum utilization of O_2 and iron leading to formation of iron oxide. The low dissolved oxygen in surface water may be attributed to elevated microbial load and their metabolic activities (Meck 1996).The BOD ranged between 1.2-3.5 mg/l and was observed to be within the permissible limit prescribed by WHO.

WQI: A WQI may be defined as a rating reflecting the composite influence of the overall quality of a number of quality characteristics or water quality parameters (Yazdandoost and Katdare, 2000). The WQI of the nine sampling sites ranged between 17.98 – 26.12 (Table 1 and 3) indicating that the ground water of the Hapur district is poor quality for drinking. Without taking proper precautions this water is not suitable for drinking and other domestic activities. The WQI of different blocks of district Hapur is approximately same but the water quality of block Dhaulana is good comparatively than others blocks and the Simbhawali block is in very bad condition.

Conclusion

Analysis of ground water samples collected from different locations of Hapur district revealed that, the drinking water quality is very poor for drinking purpose. According to the analysis in some samples the water quality parameters (EC, total acidity, Total alkalinity, total hardness, TDS, sulphate, chloride, nitrate) were beyond the permissible limit as per WHO standard. This is a great need of the suitable environment management plan which may be adopted to control drinking water pollution. The ground water of this area needs some degree of treatment beforedrinking and it needs to be protected from contamination so as to prevent adverse healtheffects on human beings.

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