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Study of physico: Chemical characteristics of ground water samples at Yamuna region, Allahabad, U.P

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Abstract
Water forms the most important component of existence. A dearth in its availability leads to a threat to life in totality. Human beings, animals, plants and all other forms of life require water for survival. Safe drinking water both in quality and quantity is the need of the hour. The presence of any foreign substance which has the potential to alter the physical, chemical or biological properties of water which can cause health hazards is considered as water pollution. Present research makes a sincere effort to analyze the physico-chemical characteristics of water samples from different sites of Allahabad in the Yamuna region where the dependency is mainly on groundwater. The water quality parameters like pH, TDS, EC, DO, BOD, Turbidity, Total hardness, Total alkalinity, and chloride were studied. From the study it was observed that most water samples were within the range of permissible limits as required by BIS specifications but some areas of Yamuna region water quality is deteriorated. The results showed that the physico chemical characteristics of water changed slightly during the summer months. The values of pH, TDS, EC during summer months of 2015 lie within the permissible limits. The values of total hardness indicate that there is a slightly higher degree of mineral content in Allahabad Yamuna region. The levels of total alkalinity in the region are higher than the desirable limits. The mean values range from 215.75 to 385 mg/l which is above the desirable limits but within the permissible limit of 600mg/l. The chloride content is found to range from 128.75 to 186 mg/l, which is within the prescribed limits of BIS in stations Y1, Y2 and Y5 but sampling sites Y3 and Y4 observed values in higher ranges which shows that there is seepage of sewage and untreated water into the lower layer of the soil. The present study conducted a parametric correlation on the observed data. Large data sets were used for the analysis. Statistical tools of SPSS version 17.0 was used for the analysis. A parametric correlation for summer season in the Yamuna region showed a strong positive correlation between EC and pH, EC and TDS, DO and pH.

Keywords: Physicochemical, groundwater, Yamuna region, water quality, Pearson correlation

Introduction
Water is essential for all forms of life. Water or Jal is one of the components prescribed by the Indian classical life theory which also include Air (vayu), Earth (prithvi), Fire (Agni), and Ether (akash). The theory of evolution says that life first began in water. It helps in the growth of the entire organism containing life on earth. Of all the matter present in the earth water is said to be above all because it gives life and without this we would not be able to survive even for a second. (Nighojkar *et al*. 2017) [1]. Human beings, animals, plants, and all other forms of life require water in more than one way and their survival depends on it. Earth is covered by 70% of water. Ground water plugs a vital role in human life. The consequences of urbanization and industrialization leads to spoil the water for agricultural purposes ground water is explored in rural especially in those areas where other sources of water like dam and river or a canal is not considerable. During last decade, this is observed that ground water get polluted drastically because of increased human activities (Dwivedi *et al*, 2014) [2]. Since water quality and human health are closely related, water analysis before usage is of prime importance. Certain physical, chemical and microbiological standards, which are designed to, ensure that the water is palatable and safe for drinking before it can be described as potable (Tebutt, 1983, APHA, 1998) [3-4] has been prescribed. Ground water quality has been determined in various parts of India by many researchers (Abbasi, Khan, Sentilvelan, & Shabudeen, 2002; Bishnoi & Arora, 2007; Gupta & Deshpande, 2004, Singh *et al*., 2015) [5, 6, 7, 8]. The ground water quality is normally characterized by physical characteristics, chemical composition, and biological parameters. These quality parameters reflect inputs from natural sources including the atmosphere, soil and water rock weathering, as well as anthropogenic influences of various activities such as mining, land clearance, agriculture, acid precipitation, and domestic and industrial wastes. (Behailu *et al*. 2017) [9].

Once the bottom (ground) water is contaminated, its quality cannot be renovated back easily, and to device ways to guard it, Water quality index is one among the foremost effective tools to speak data on the standard of water to the involved voters and policy manufacturers. It thus, becomes crucial parameter for the assessment and management of bore well water (Dwivedi *et al*, 2014) [2]. The data collected contains large information on the quality of water in and around those regions. The classification and interpretation of data are important aspects of quality assessment. The application of different statistical techniques also helps in finding out the different components which are responsible for bringing about the most variance in a data set. Environ-metric methods have been used for the assessment of surface water, groundwater and other environmental research by various workers. These methods extract the hidden information in the single sample and whole data and also the impacts of the environmental factors on the water quality and assist the environmental managers in terms of aiding the decision making process (Lopez *et al* 2004; Mohammed *et al*, 2016) [10, 11] Today the increased demand of water for different purposes such as drinking, industrial use, and agricultural sectors pressurized the extensive extraction of groundwater resources resulting in the lowering of the ground water level. These results in increased pollutants load of the sewage and solid waste which seepage into the groundwater and alter the water quality for drinking purposes (Raj *et al*, 2018) [12]. In this study an attempt has been made to understand the water quality of groundwater in the Yamuna belt of Allahabad city. The main purpose of this study is to evaluate some of the parameters and know about the distribution of solute in ground water and its suitability for drinking purposes. Even though ground water contains lesser quantity of bacteria or biological pathogens yet a study of dissolved oxygen and biological oxygen demand has also been considered as there are regions of sewage disposal and dumping grounds around the selected stations. The time period of the sampling and analysis is restricted to summer season in the year 2015.

Materials and Methods

The study area of Yamuna region is located at coordinates 25.2302°N and 82.0312° E. The area located at near the Yamuna belt region taken for study is namely Arail, Mahewa, Naini, and Chaka. The mix population resides near the selected region but Naini and Mahewa site is denser in population. A site map is given below indicating the area under study. The map has been taken from Google maps of Allahabad. Allahabad is one of the ancient and important town which is situated along the river Ganga and Yamuna. This great city is famous for the annual Magh Mela and for Maha Kumbh, the biggest Mela in the World. The main town is bounded by river Ganga on Northern and Eastern sides, the river Yamuna and Doab plain forms its Southern and Western boundaries respectively. The Kanpur- Varanasi Road, in most of its length runs on the ridge line dividing the town in two parts. The area on the north of this road slopes towards Ganga whereas the area on the south side slopes towards river Yamuna. (Ayush *et al*, 2014) [13].

Sampling Site and Frequency: Groundwater samples were collected from tube wells and hand pumps at selected sampling site situated in Yamuna region. Location of the sampling sites is shown in Figure 1 and Table 1. The water samples were collected from four different sites namely Arail (Y1), Mahewa (Y2), Naini (Y3), and Chaka (Y4). The sample was collected during the months of March, April, May, and June and collection frequency was monthly at selected sites.

Source: google maps

Fig 1: Sampling site and marked area of sampling location at Yamuna region, Allahabad.

Table 1: Sampling sites and source of water supply in Yamuna region.

Station Sites	Site Code	Source of water supply
Arail	Y1	Handpump
Mahewa	Y2	Tubewell
Naini	Y3	Handpump
Chaka	Y4	Handpump

2.2 Sampling methods and procedure: All samples were collected in plastic containers (PVC) previously washed with detergents and nitric acid and thereafter rinsed thoroughly with sampled water several times before collection. The containers were then filled with sample water and ample precaution was taken that no air bubbles were present in the jar which were then tightly sealed and labelled in the field. The collected samples directly transported to the laboratory of Department of Chemistry, SHUATS, Allahabad, for further analysis of collected water samples. The Dissolved oxygen was fixed at a sampling site. During sampling the hand pumps were continuously pumped so that the ground water to be sampled was a representative of groundwater and to avoid any contamination from the surface. The obtained data reported in Table 3 of water quality parameters are compared to appended Table 2 of water quality standards laid by Indian Standard specification (1S:10500:1991) [14] for drinking purpose. The water samples were analyzed for different physical, chemical parameters as per standard protocol of APHA/AWWA (1998) [4].

Table 2: Water quality standards with parameters

S. No	Parameters	Indian Standard (BIS) (IS-10500:1991)	
		Desirable Limit	Maximum Permissible Limit
1	pH	6.5	8.5
2	EC	-	-
3	TDS (mg/l)	500 mg/l	2000 mg/l
4	Turbidity (NTU)	5 NTU	10 NTU
5	Total Hardness (mg/l)	300 mg/l	600 mg/l
6	Alkalinity (mg/l)	200 mg/l	600 mg/l
7	Chloride (mg/l)	250 mg/l	1000 mg/l
8	Dissolved Oxygen	6 mg/l	-
9	Biochemical oxygen demand (mg/l)	2.0 mg/l	-

Results and discussion

pH indicates the acidic or basic level of water with respect to potential hydrogen. From the table 3 showed the variation of pH level in water samples. The ranges of pH varied from 7.0 to 8.28 in all the sampling station of Yamuna region and slightly increase in the pH values in stations Y2 to Y4. Since the human body maintains its levels naturally the pH of drinking water does not affect the body to a large extent, pH provides an important piece of information in many type of geochemical equilibrium or solubility calculation and is considered as an important ecological factor (Singh *et al*, 2014) [8]. Turbidity is an expression of light scattering and light absorbing property of water and is caused by the presence of suspended particles such as clay, silt and colloidal organic particles. Higher turbidity is known to affect the primary productivity by restricting the light penetration and photosynthesis (UNCSD,1997) [15]. Turbidity of the water samples range from value of 1.0 -2.25 NTU. The turbidity values indicate that the region has a higher turbidity level in comparison to the desirable limits but is well within the permissible limit of BIS standard for drinking purposes, the turbidity values at stations Y2 and Y4 is higher which may be due to the percolation of silt or sediment. Electrical conductivity is an algorithm to measure both salinity and TDS. It is used to understand the ions present in water which can conduct current. Higher value of EC indicates higher salinity and thus can decrease the presence of oxygen dissolved in water. The values of EC in the stations studied was ranging from 0.4 – 2.82 indicating that it is below the desirable limits and hence the water is safe for human consumption. Fig.1. indicates that level of Dissolved oxygen present in water samples. The dissolved oxygen varies between 1.38-3.05 mg/L, it reflects that water contained a good quantity of oxygen. Biological oxygen demand ranges from 0.33-1.78mg/L and are also within the prescribed range except for stations Y2 and Y3. The observed value of total dissolved solids (TDS) between 210.96-294.98 mg/l presented in fig 3, which is found to be within the BIS prescribed limit of 500 mg/l. Total dissolved solids is an indication of the dissolved matter such as small amounts of inorganic salts or even some organic matter. Total dissolved solids are a measure of total inorganic substances dissolved in water. TDS indicates the general nature of water quality or salinity. The TDS concentration above the permissible limit may be due to the leaching of various pollutants into the ground water which can decrease the potability and may cause gastrointestinal irritation in human and may also have laxative effect (UNWWD, 2003) [16]. The present study indicates that this region is safe in terms of TDS concentration. High TDS causes certain disorders in the kidneys disease. The values for total hardness range from 172-367.25 in the various sites. The water is above the desirable limit of 200mg/l as prescribed by BIS but within the permissible limit of 600 mg/l without alternate source.

Table 3: Physico-chemical parameters of groundwater of the Yamuna region at Allahabad

Date of sampling	Sampling Site	pH	Turbidity	TDS	EC	DO	BOD	Total Hardness	Total Alkalinity	Chloride
18/03/2015	Y1	7.55	1.25	239.75	2.67	2.80	0.59	253.50	224.25	129.25
18/03/2015	Y2	7.85	2.25	250.93	2.82	2.48	1.48	289.00	274.50	154.75
18/03/2015	Y3	8.28	1.50	294.98	2.54	3.05	1.78	335.50	330.75	186.00
18/03/2015	Y4	7.70	2.00	210.96	2.53	2.85	0.69	309.00	385.00	176.75
7/04/2015	Y1	7.28	1.25	237.25	2.49	2.70	0.55	268.25	238.25	152.50
7/04/2015	Y2	8.23	2.00	277.00	2.80	2.30	1.30	306.50	273.00	152.50

7/04/2015	Y3	7.68	1.50	277.37	1.60	2.80	1.70	344.00	324.25	149.10
7/04/2015	Y4	7.30	1.50	223.50	1.74	2.68	0.53	264.75	291.25	154.50
30/05/2015	Y1	7.38	1.25	218.30	0.74	1.47	0.49	275.00	231.00	147.50
13/05/2015	Y2	7.38	1.25	260.27	1.32	1.89	1.34	172.00	252.00	148.00
30/05/2015	Y3	7.35	1.75	280.58	1.06	2.32	1.69	367.25	282.25	168.50
30/05/2015	Y4	7.13	1.75	219.10	0.82	1.89	0.35	283.00	282.50	128.75
22/06/2015	Y1	7.00	1.00	224.26	0.40	1.43	0.55	302.25	215.75	144.75
22/06/2015	Y2	7.33	1.75	251.11	1.35	1.97	1.03	263.25	262.00	138.75
22/06/2015	Y3	7.15	1.25	249.35	0.98	2.33	1.63	306.75	281.00	167.50
22/06/2015	Y4	6.83	1.75	216.79	0.95	1.38	0.33	279.25	271.50	131.25

All values in reported in mg/l except pH, EC and turbidity

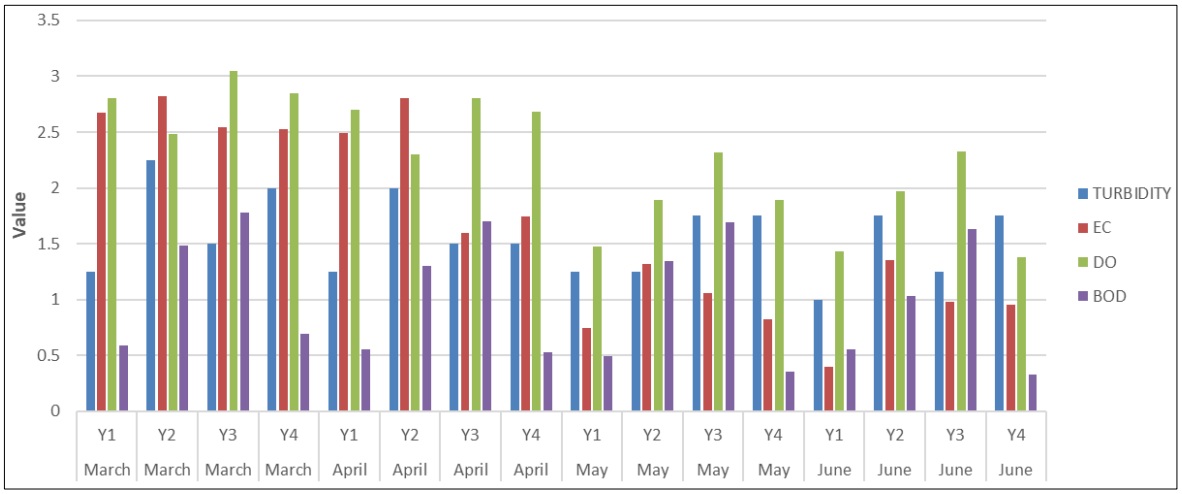

Fig 1: Variation of turbidity, electrical conductivity, dissolved oxygen and biochemical oxygen demand in different months.

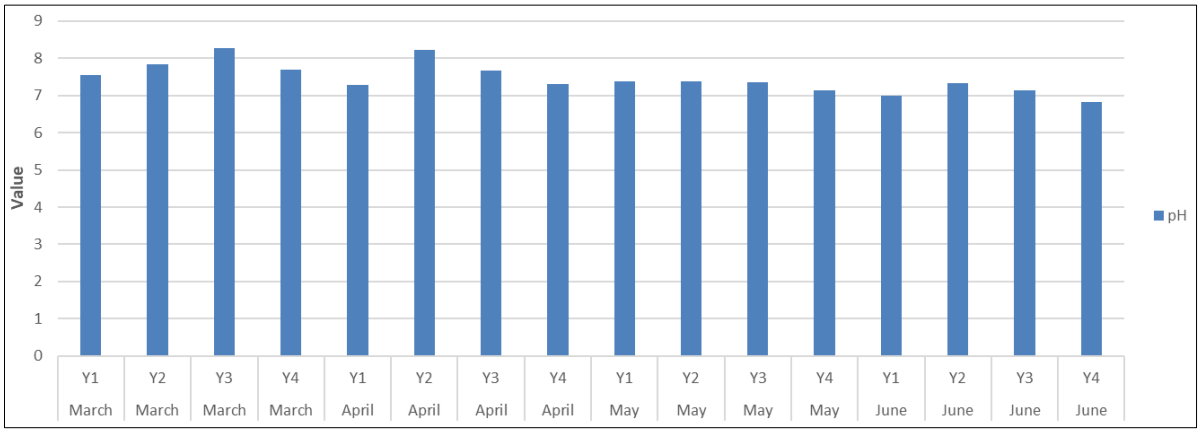

Fig 2: Variation of pH in different months at sampling sites

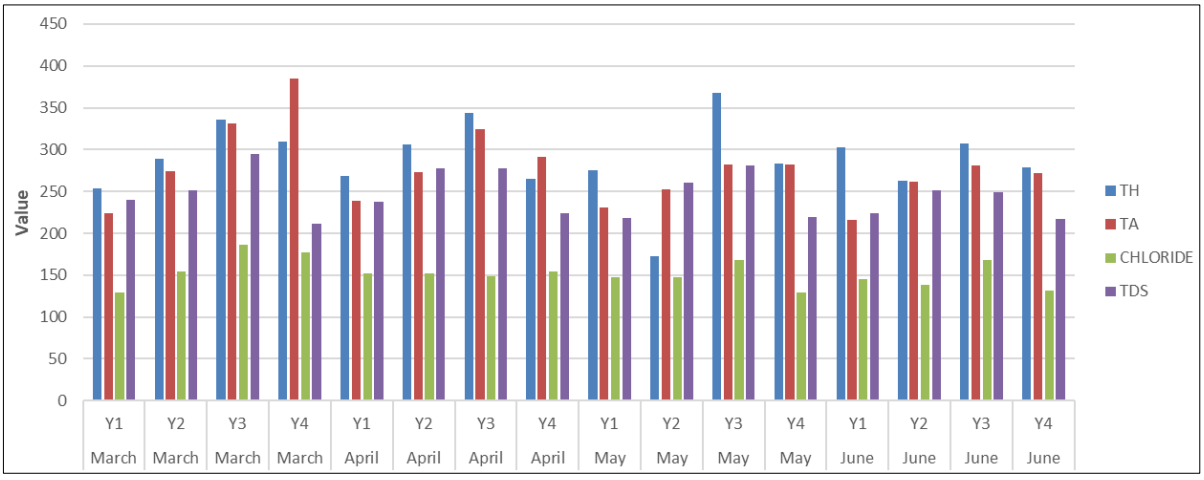

Fig 3: Variation of total hardness, total alkalinity, chloride and total dissolved solid in different months

Total hardness is an indication of the mineral content and is irreversible on boiling. The total hardness values indicate that there is an increased level of mineral content in Allahabad Yamuna region. The levels of total alkalinity in the region are higher than the desirable limits. The mean values range from 215.75 to 385 mg/l which is above the desirable limits but within the permissible limit of 600mg/l. The chloride content is found to range from 128.75 to 186 mg/l, which is within the prescribed limits of BIS in stations Y1, Y2 and Y5 but sampling sites Y3 and Y4 observed values in higher ranges which shows that there is seepage of sewage and untreated water into the lower layers of the soil.

Table 4: Correlation matrix of the nine variables for Yamuna region

		pH	Turb	TDS	EC	DO	BOD	TH	TA	CHL
pH	Pearson Correlation	1	0.410	.637**	.767**	.707**	-.322	.278	.427	.522*
	Sig. (2-tailed)		.114	.008	.001	.002	.224	.297	.099	.038
Turb	Pearson Correlation	.410	1	.109	.434	.330	.267	.277	.526*	.140
	Sig. (2-tailed)	.114		.688	.093	.212	.317	.299	.036	.604
TDS	Pearson Correlation	.637**	.109	1	.310	.301	.177	.359	.170	.434
	Sig. (2-tailed)	.008	.688		.242	.258	.511	.172	.529	.093
EC	Pearson Correlation	.767**	.434	.310	1	.900**	-.324	.030	.317	.317
	Sig. (2-tailed)	.001	.093	.242		.000	.221	.911	.231	.232
DO	Pearson Correlation	.707**	.330	.301	.900**	1	-.278	.218	.444	.400
	Sig. (2-tailed)	.002	.212	.258	.000		.297	.417	.085	.125
BOD	Pearson Correlation	-.322	.267	.177	-.324	-.278	1	.216	.122	.070
	Sig. (2-tailed)	.224	.317	.511	.221	.297		.422	.652	.797
TH	Pearson Correlation	.278	.277	.359	.030	.218	.216	1	.457	.489
	Sig. (2-tailed)	.297	.299	.172	.911	.417	.422		.075	.055
TA	Pearson Correlation	.427	.526*	.170	.317	.444	.122	.457	1	.623**
	Sig. (2-tailed)	.099	.036	.529	.231	.085	.652	.075		.010
CHL	Pearson Correlation	.522*	.140	.434	.317	.400	.070	.489	.623**	1
	Sig. (2-tailed)	.038	.604	.093	.232	.125	.797	.055	.010	

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Correlation matrix measures the closeness of the relationship between chosen independent and dependent variables. if the correlation coefficient is nearer to +1 or – 1, it shows the probability of linear relationship between the variables x and y. The correlation between the parameters is characterised 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 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. (Gummadi *et al*, 2014) [17]. In this study, the numerical values of correlation coefficient, R, for nine water quality parameters were tabulated in table 4. It showed a strong positive correlation between EC and pH, EC and TDS, DO and pH. A negative correlation existed between pH and BOD, EC and BOD, DO and BOD. However, the rest of the correlation matrix show in significant association with each others.

Conclusion

From the results of the study showed that pH levels of most sites are well within the permissible limits. Turbidity, Total Hardness are on a higher scale and so these factors are instrumental in decreasing the levels of portability of water in these regions. The results obtained show that the areas Naini and Chaka show that the groundwater quality is slightly above the standard limits as prescribed by BIS. During the months of March and April the values of DO and BOD were found to be higher. This may be due to the increase in temperature during the May month. The present study gives an insight into the groundwater quality of Allahabad and it can be inferred that the water quality is not above the maximum permissible limit prescribed by the Indian Standards and it is safe for human and animal consumption. From the study, it can be recommended that people should contribute to the access of safe drinking water and it is necessary for the public to understand about the quality of water they have access to. It is not only the responsibility of the authorities to keep the public informed about the quality of water they use but also to use different steps to see that the quality is maintained as per the standards is followed.

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