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Statistical Analysis of Ground Water Quality in Rural Areas of Uttar Pradesh City, India

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ABSTRACT
The importance of groundwater for the existence of human society cannot be exaggerated. Groundwater is the major source of water in both rural and urban India.Duringlast decade, it was observed that ground water get polluted drastically and hence, resulted into many water borne diseases which is a cause of many health hazards. In this paper an attempt has been made to test groundwater quality of different villages of Uttar Pradesh, India on the basis of thirteen parameters like pH, total dissolved solids, conductivity, total hardness, biological oxygen demand etc. The results obtained were compared with the BIS (IS 10500:1991) Permissible Standards for drinking water. Normal Distribution analysis was applied to describe various characteristics of the samples collected and Correlation Analysiswas done on the samples which measured the strength of association between twowaterparameters.On the basis of results obtained from analytical and statistical analysis, it was revealed that all the water sources chosen for study are not suitable for the utilization of water.

Article Impact Statement: Study of the present article has a significant impact as it draws attention towards the careless management of the ground water resources which is an important source for the basic necessity of rural people. The study validates the suitability of quality of ground water quality in the area of study. The study suggests systematic planning and implementation of appropriate technologies for the prevention of contamination of ground water. The study recommends that the Government should contribute in placing the resources at effective and most suitable sites for the implantation of various tube wells etc. so that maximum benefits can be obtained from these ground water resources.

Keywords:Water quality assessment, Bureau of Indian Standard, Normal Distribution Analysis, Karl Pearson coefficient.

I. INTRODUCTION

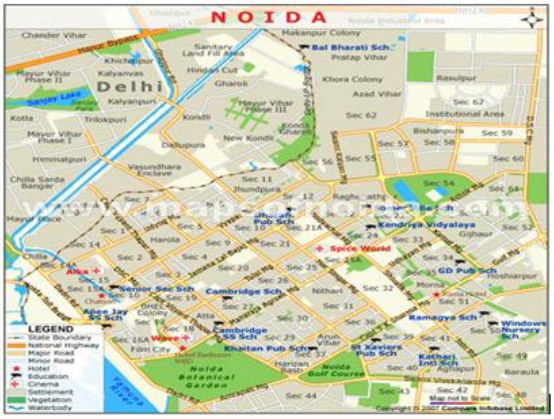
Water has a very significant role in anyliving beings life. According to reports 97% of earth's water supply is in the ocean, which is unfit for human consumption. 2% of water is locked in the polar ice-caps and only 1% is available as fresh water in river, lakes, streams, reservoir & ground water which is available for irrigation, industries, municipal &household purposes [1-4]. But because of urbanization, industrialization, modern agricultural practices and various other activities of human being interfere with the quality of fresh water which is major issue of concern. During last decade, it was observed that ground water get polluted drastically and hence, resulted into many water borne diseases which is a cause of many health hazards. Therefore, various methods are adopted to raise the quality of water and for monitoring the quality of water. Water should be free from various contaminations like heavy metals, fertilizers, pesticides, insecticides, organic & inorganic pollutants as well as other parameters like TDS, DO, chloride, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, hydroxides, nitrate, nitrite, iron, PH, conductivity, BOD & COD should be within permissible limit. Thus, it was, thought to assess ground water quality of various rural areas of Uttar Pradesh, India. Samples of ground water from fifteen marked rural areas of Noida city which is located in Uttar Pradesh were collected and analyzed for parameters, like hardness, TDS, pH, Conductance, fluoride, nitrate, sulphate, calcium, chloride etc. Statistical methods were also employed to establish the correlation between various physical & chemical parameters of ground water. In this study statistical techniques were used to analyze the water quality data collected from Noida villages (India) [5-7]. In the present study, normal distribution analysis was performed on various parameters of the water samples which were collected from Noida city of Uttar Pradesh. Also correlationanalysis was performed on the water parameters for all the sites is used to measure the strength of association between two continuous variables. This tells if the relation between the variables is positive ornegative that is one increase with the increase of the other. Thus, the correlation measures the observed co-variation. The most commonly used measure of correlation is Pearson's correlation ($\boldsymbol{\rho}$). It is also called the linear

correlation coefficient because r measures the linear association between two variables [8].

II. RESEARCH METHOD

Selection of Sites and Sampling Points

The water samples were collected from 15 sites of rural areas of Noida city of UttarPradesh.The study area as is being displayed in the map



Areas from where samples were collected

S. No.	Locations	Sample Codes
	Morna - Sector 35	G1
	Chaura - Sector 22	G2
	Sarfabad- Sector 73	G3
	Shahdra - Sector 141	G4
	Kakrala -Sector 80	G5
	Salarpur - Sector 81	G6
	Harola - Sector 2	G7
	Nithari - Sector 31	G8
	Salarpur - Sector 81	G9
	Raipur - Sector 126	G10
	Sultanpur- Sector 128	G11
	Gejha- Sector 93	G12
	Bhangel- Sector 102	G13
	Hazipur Sector 104	G14
	Barola -Sector 50, 78	G15

Collection of Samples

Grab Samples were collected as per APHA- Standard Methods for Examination of Water andSamples were collected 3 times, one each, in month of September, October and November during the duration of study.

Parameters Analysed

Physio-chemical parameters

The parameters analysed in this study were pH, TDS (Total Dissolved Solids), Chloride, Conductivity, Temporary Hardness, Permanent Hardness, Total Hardness, Fluorides, Nitrate, Sulphate, Calcium, Magnesium, and Alkalinity

Laboratory Used for analysis

Environmental Engineering and Chemistry Laboratory of G D Goenka University, Sohna Road, Gurgaon was used for conducting the experiments and analysing the Physico-chemical parameter.

Normal Distribution Analysis

Correlation Analysis

It is atechnique used for modeling and analyzing the variables present in a sample. A Correlation coefficient is a coefficient that illustrates relationships between two or more random variables or observed data values.The formula for ρ is:

$$\rho_{X,Y} = \frac{\operatorname{cov}(X,Y)}{\sigma_X \sigma_Y}$$

$$\rho_{X,Y} = \frac{\mathrm{E}[XY] - \mathrm{E}[X]\,\mathrm{E}[Y]}{\sqrt{\mathrm{E}[X^2] - \mathrm{E}[X]^2}\ \sqrt{\mathrm{E}[Y^2] - \mathrm{E}[Y]^2}}. \quad (1)$$

σ_Y, σ_X are standard deviation of variables Y and X, respectively, and E(X), E(Y), E(XY) are the expected value of variables X, Y and XY, respectively.

III. RESULTS AND DISCUSSION

Fifteen water samples collected from various villages of Noida city, Uttar Pradesh werefirstchemically analyzed for eleven physicochemical parameters like Hardness, TDS, pH, Conductivity, Fluoride, Nitrate, Sulphate, Calcium, Chloride, Alkalinity, Magnesium and then their comparison were carried out through statistical analysis. These results were compared with the standard limits set by Bureau of Indian Standards (BIS) [9].Using values of each water parameters, graphs are plotted as shown in figures 2-14.It was observed that the ground water was contaminated and was not fit for drinking use.

Table 2 shows mean, median, standard deviation, skewness and kurtosis of 13 water quality parameters in Uttar Pradesh. Using equation (1), correlation coefficient of all the water parameters in Uttar Pradesh were calculated and shown in Table 3. From the graphs and Table 2, the following results were observed. The Desirable & Permissible Standards as per BIS for Drinking water for various parameters are as follows:

Parameters	Desirable Limit	Permissible Limit
pH	6.5-8.5	No Relaxation
Total Dissolved Solids (TDS),mg/l	500	2000
Total Hardness on $CacO_3$ Scale, mg/l	300	600
Alkalinity, mg/l	200	600
Fluoride (F), mg/l	1.0	1.5
Nitrate (NO2), mg/l	45	100
Sulphate (SO4) mg/l	200	400
Calcium (Ca), mg/l	75	200
Chloride (CI), mg/l	250	1000
Magnesium (Mg), mg/l	30	100
Electrical Conductivity	1.5	3

The chemical analysis results of these parameters are as follows:

Hardness

Hardness of water is due to presence of sulphates, chlorides, carbonates and bicarbonates of calcium and magnesium which indicates not only pollution but quality of water. The Ground water samples were chemically treated and compared (Fig. 2).

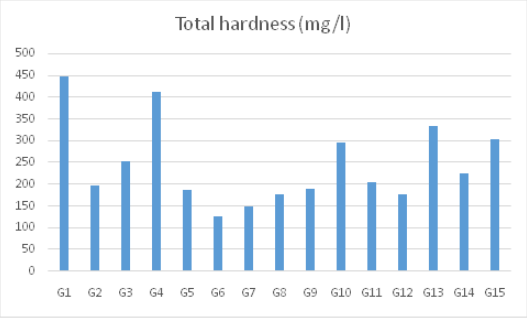


Fig. 2: Comparison of ground water samples for total hardness

As per Fig. 2, all the samples possess total hardness in the acceptable limit. Highest totalhardness was observed in G1 while sample G6 showed minimum total hardness.Also from Table 2 it is seen that mean, median values of total hardness are almost same, indicating that the data shows normal behavior. Standard deviation value (91.62) explains that the sample is spread out i.e. the values are not close to each other. The curve is platykurtic as the kurtosis value is less than 3.

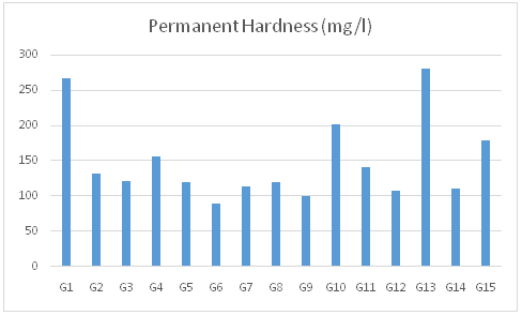


Fig. 3:Comparison of ground water samples for permanent hardness

All the samples were then studied for permanent & temporary hardness also. It was found that sample G13 possess highest permanent hardness while sample G6 possess minimum permanent hardness. Results of comparison of permanent hardness is shown in Fig.3.Also from Table 2, it is clear that the sample has a normal behaviour as mean and median values are almost same. Standard deviation value (58.67) is very
High so the data values are not close to each other. The curve is not symmetric as skewness is 1.41.The curve is platykurtic.From fig. 4 it can be concluded that maximum temporary hardness was observed in sample G4 while minimum was of G7. Table 2 shows that the data do not show normal behavior. Standard deviation value (59.17) suggests that the data are spread. The curve is not symmetric and is platykurtic.

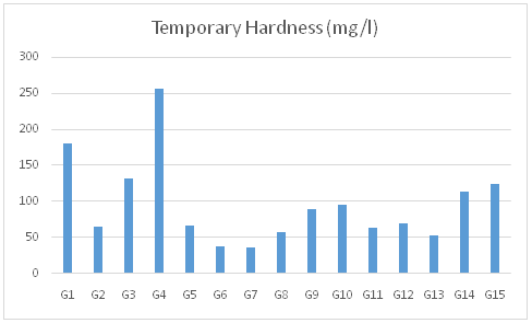


Fig. 4: Comparison of ground water samples for temporary hardness

Total dissolved solids

Total dissolved solidsarethe total organic and inorganic matter present in water. SampleG7 was found to possess 1200ppm TDS which is under the permissible limit.Sample G2 was found to show minimum TDS i.e. 227ppm. Rest of the samples were found to possess moderate TDS which may not resulted into any health problem.The values of TDS for Ground water samples have been shown in Fig. 5.

From Table 2 it is seen that mean, median values are different; thus the curve does not follow normal

behavior. Standard deviation value is high (287.29), thus the values of TDS are not close to each other. It is negatively skewed and the curve is platykurtic as the kurtosis value is less than 3.

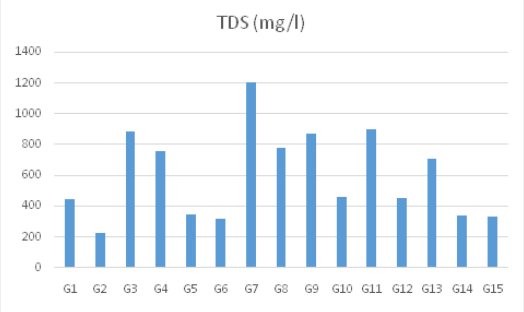


Fig. 5: Comparison of Ground water samples for TDS

pH

PH value is most important parameter which should be in range 6.5 to 8.5 for drinkable water. All the water samples have pH within the permissible limits except sample G1 & G11 which were found to possess pH 6 and 9.2 respectively which is not in acceptable limit. The comparison of groundwater samples was shown in Fig.6.Also from Table 2 it is seen that mean, median are 7.76 and 7.65 respectively; thus the data indicate normal behavior. Standard deviation (SD) is 0.87 and skewness is approximate to 0, thus pH is symmetrical and values are close to each other. The Curve is platykurtic.

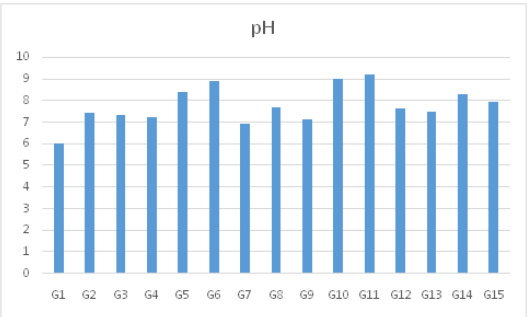


Fig. 6: Comparison of ground water samples for pH

Electrical conductivity

Conductivity is due to presence of ion in the water samples. Water samples G6, G2, G4, G10, G12, G13 & G15 showed high conductivity in the range 4-2.8 while sample G9 showed minimum conductivity. Fig. 7, shows comparative results of electrical conductivityof all water samples.Moreover from Table 2 it is clear that the data indicates normal distribution. Standard Deviation (0.82) suggests that the data are close to each other. The skewness value (0.00) shows that the curve is symmetrical and platykurtic as kurtosis value is less than 3.

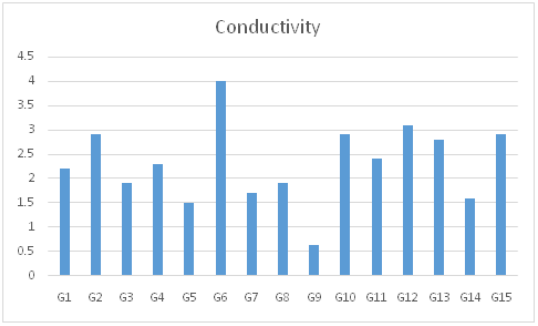


Fig. 7: Comparison of Ground water samples for conductivity

Fluoride

Fluoride content in water sample should be below 1.5 ppm, otherwise it may lead to health issues. Figure 8 illustrate that sample G2, G4, G11, G12 and G13 possess fluoride more than the permissible limit while other samples were found to have within the standard. Table 2 shows that the data does not have a normal behaviour. Standard deviation value (1.52) shows that the sample values are not close to each other. The curve is a platykurtic curve.

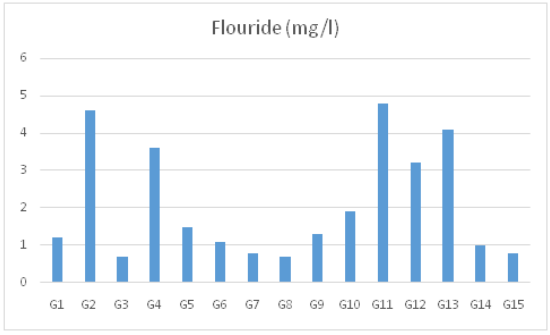


Fig. 8: Comparison of Ground water samples for Fluoride

Nitrate

Nitrates occur in high values in ground water. Maximum permissible concentration of nitrate should not exceed than 100 ppm in water sample otherwise it may lead to various health problems. Figure 9 shows that the water sample G4, G5, G14 &G15 were found to possess nitrate content more than the acceptable limits and rest of the samples were in permissible limit. Moreover Table 2 suggests that the data has a normal behavior as the mean and median values are same. Standard deviation (30.06) is very high so the data points are spread out. The curve is not symmetric and is platykurtic.

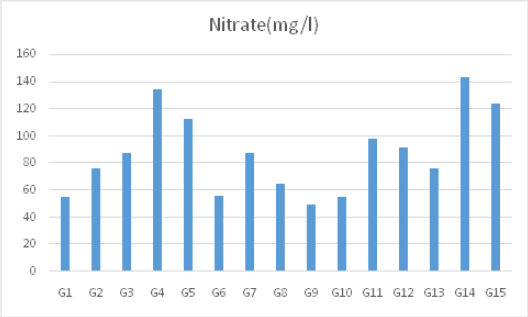


Fig. 9: Comparison of Ground water samples for nitrate

Sulphate

Sulphate present in natural water in concentrations ranging from a few to several thousand **ppm** but acceptable limit is upto 400ppm.

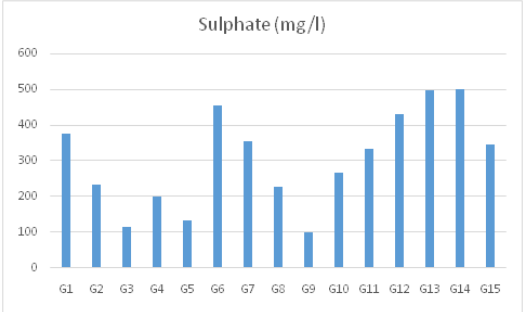


Fig. 10: Comparison of Ground water samples for sulphate

But as per Fig. 10, the sulphate in water samples G6, G12, G13 & G14 were found to possess sulphate above 400 ppm which is above the standard. Highest sulphate content was observed in sample G14. Whereas for rest of the samples it was found satisfactory. Table 2 shows that the data do not have a normal behaviour. Standard deviation is very high which suggests that the sample points are not close to each other. The kurtosis value is less than 3 therefore the curve is platykurtic.

Calcium

As per Figure 11, water samples G1, G2, G4, G5, G6 and G7 were found to possess calcium within the desirable limit while rest of the samples possess calcium more than the permissible limit i.e. 200ppm which is not desirable. Highest calcium content was observed in G10. Table 2 suggests that the data has a normal behavior as the values of mean and median are almost same. High value of SD (86.34) indicates a spread in the data. Skewness value is very small which shows that the curve is almost symmetric. The curve is platykurtic.

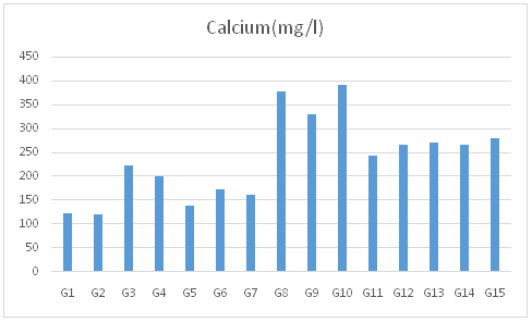


Fig. 11: Comparison of Ground water samples for calcium

Chloride

Chlorides are available in a human body and is relatively harmless. As per the chemical analysis done it was observed that all the water samples were within the acceptable limits.A comparison between the concentrations of chloride in Groundwater has been shown in Fig.12. Table 2 shows that the chloride sample is not normally distributed. Moreover high value of SD suggests that the data is spread out. The curve is platykurtic and not symmetric.

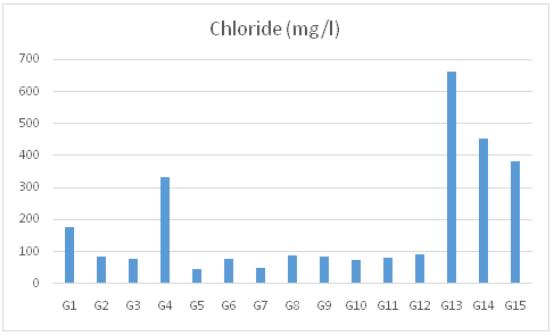


Fig. 12: Comparison of Ground water samples for chloride

Alkalinity

Alkalinity is due to presence of salts like magnesium bicarbonate, calcium carbonate etc. Water samples G8, G9, G11 and G15 on analysis were found possess more alkalinity than permissible limit but rest of the water samples were found within the desirable limit. Results of comparative study is given in figure.13.Table 2 suggests that the data of alkalinity is normally distributed as the values of mean and median are almost same. The curve is symmetric as skewness is approximately 0. The curve is platykurtic.

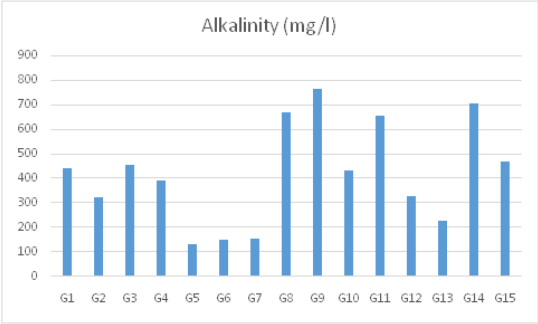


Fig. 13: Comparison of Ground water samples for alkalinity

Magnesium

According to the standard magnesium in the water should not exceed than 100ppm.

According to figure 14, water samples G1, G7, G8 & G11 were found to possess higher magnesium concentration than the acceptable limit. Rest of the water samples were found in permissible limit. Table 2 suggests that the curve is not normally distributed. Standard deviation is very high so the sample points are not close to each other. The curve is platykurtic.

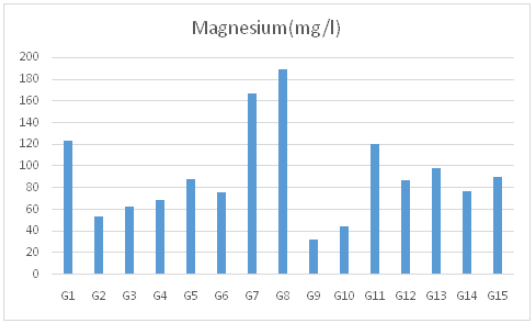


Fig. 14: Comparison of Ground water samples for magnesium

Normal distribution analysis of ground water samples

The data was subjected to the normal distribution analysis and Pearson correlation using Microsoft Excel 2010.Normal distribution analysis is an important statistical tool for identifying the distribution patterns of the different water quality parameters in water samples. Correlation coefficient of various parameters were calculated. Pearson's correlation coefficient is usually denoted by ρ and values vary from -1.0 to 1.0, where -1.0 is considered as a perfect negative correlation, 0.0 shows that there is no correlation and 1.0 shows that correlation is perfectlypositive while the variables with the values $0.5 < \rho < 0.5$ are supposed to be significant.The Table below indicates general characteristics about thedistribution of the data .It shows significant variations between mean and median

For parameters, Total hardness, Temporary Hardness, TDS, Chloride, and Permanent Hardness were observed, which indicated that these parameters were not found to be completely distributed in a normal way in the sample. However, small difference of mean and median for parameters pH, conductivity Fluoride, Nitrate, Sulphate, Calcium, Alkalinity&Magnesium indicated that these parameters were seemed to be distributed normally in Ground water samples. Parameters like TDS, pH, fluoride, nitrate, sulphate, calcium & alkalinity have negative values of Kurtosis indicating that the distribution of these parameters have flat peak compared to normal distribution pattern. The negative value of Skewness for pH & sulphate indicated that the data were distributed towards the lower values or have a negative tail in the negative direction. Positive Skewness values indicates that the distribution is towards the higher values and the data were distributed in the right direction of the tail.

Table-2: Normal distribution analysis pattern of different water quality parameters of rural areas of Noida ground water

	Total Hardness	Temporary Hardness	TDS	pH	Conductivity	Fluoride	Nitrate	Sulphate	Calcium	Chloride	Permanent Hardness	Alkalinity (mg/l)	Magnesium(mg/l)
Mean	244.93	149.0	601.6	7.76	2.32	2.09	87.20	304.80	237.47	184.40	149.00	419.33	91.80
Variance	8994.07	3500.78	82536.54	0.76	0.67	2.31	903.89	18157.17	7454.27	34305.40	3442.71	43216.67	1861.31
SD	91.62	59.17	287.29	0.87	0.82	1.52	30.06	134.75	86.34	185.22	58.67	207.89	43.14
Skewness	0.99	1.64	0.54	-0.01	0.00	0.84	0.53	-0.05	0.31	1.62	1.41	0.20	1.00
Kurtosis	0.14	2.88	-0.69	-0.14	0.49	-1.02	-0.78	-1.20	-0.76	1.87	1.09	-1.03	0.80
Median	204.00	70.00	457.0	7.65	2.30	1.40	87.00	333.00	243.00	86.00	121.00	432.00	87.00

Correlation among water quality parameters greatly enables the task of rapid monitoring of water quality parameters. Table below presents the Pearson correlation coefficient matrix between major physiochemical parameters of groundwater of the study area. The variables having coefficient with $\rho > 0.5$ are considered significant.The analytical data showed close significant positive association of TDS with Calcium, Alkalinity & Magnesium. It indicates that TDS increases with

increase in these parameters in Ground water samples. Also pH has positive correlation with Conductivity, Fluoride. Nitrate, Sulphate, Calcium & Alkalinity and with rest all other parameters it shows negative correlation. Conductivity shows positive correlation with Total hardness, pH, fluoride, sulphate, chloride. Alkalinity shows positive correlation with TDS, pH,
Nitrate, Calcium & Chloride. Moreover calcium shows negative correlation withalmost all parameters except TDS, pH, chloride, permanent hardness & alkalinity.
Total hardness shows negative correlation with TDS, pH, calcium & magnesium.
It reflects a decreasing trend of total hardness with increase in TDS, pH, calcium &
Magnesium.

Table-3:Correlation matrix between major physico-chemical parameters of Noida ground water

	Total Hardness	**Temporary Hardness**	**TDS**	**pH**	**Conductivity**	**Fluoride**	**Nitrate**	**Sulphate**	**Calcium**	**Chloride**	**Permanent Hardness**	**Alkalinity**	**Magnesium (mg/l)**
Total Hardness	1	0.81	-0.09	-0.43	0.03	0.14	0.14	0.04	-0.07	0.51	0.80	0.07	-0.12
Temporary Hardness	0.81	1	-0.04	-0.40	-0.14	-0.01	0.38	-0.23	-0.12	0.26	0.30	0.22	-0.25
TDS	-0.09	-0.04	1	-0.27	-0.48	-0.04	-0.11	-0.26	0.17	-0.14	-0.10	0.17	0.40
pH	-0.43	-0.40	-0.27	1	0.36	0.16	0.15	0.15	0.32	-0.10	-0.29	0.02	-0.18
Conductivity	0.03	-0.14	-0.48	0.36	1	0.32	-0.12	0.53	-0.11	0.10	0.20	-0.47	-0.08
Flouride	0.14	-0.01	-0.04	0.16	0.32	1	0.24	0.13	-0.15	0.19	0.24	-0.10	-0.19
Nitrate	0.14	0.38	-0.11	0.15	-0.12	0.24	1	0.11	-0.16	0.42	-0.16	0.03	-0.01
Sulphate	0.04	-0.23	-0.26	0.15	0.53	0.13	0.11	1	-0.05	0.52	0.29	-0.19	0.24
Calcium	-0.07	-0.12	0.17	0.32	-0.11	-0.15	-0.16	-0.05	1	0.13	0.01	0.58	-0.03
Chloride	0.51	0.26	-0.14	-0.10	0.10	0.19	0.42	0.52	0.13	1	0.55	0.04	-0.06
Permanent Hardness	0.80	0.30	-0.10	-0.29	0.20	0.24	-0.16	0.29	0.01	0.55	1	-0.11	0.06
Alkalinity	0.07	0.22	0.17	0.02	-0.47	-0.10	0.03	-0.19	0.58	0.04	-0.11	1	-0.05
Magnesium(mg/l)	-0.12	-0.25	0.40	-0.18	-0.08	-0.19	-0.01	0.24	-0.03	-0.06	0.06	-0.05	1

IV. CONCLUSION

Statistical analysis shows that pH shows positive correlation with Conductivity,

Fluoride, Nitrate, Sulphate & Alkalinity while Conductivity, Fluoride, Chloride wasrelated with the change of some specific parameters out of total parameters chosen for the study. It was observed through the analysis that in the villages' ground water was not up to mark.The present study clearly reveals that all the water sources chosen for study are not managed suitably for the utilization of water. There is an immediate and urgent need for the implementation of a better water quality management policy incorporating the following recommendations. Tube wells and other drinking water sources should be installed in a safety place. A proper planning and management is required to mitigate the problem of drinking water contamination.

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