INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

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PHYSICO-CHEMICAL ANALYSIS OF GROUNDWATER QUALITY IN ALIGARH CITY, UTTAR PRADESH

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ABSTRACT
The physicochemical properties of groundwater from various locations in Aligarh Local Government Area of Uttar Pradesh State were analyzed. The samples taken from sixteen different locations revealed that the study area has a mean of pH 7.8, Total acidity 46.5 mg/l, Phenolphthalein alkalinity 52.25 mg/l, Total alkalinity 528.8 mg/l, Total hardness 303 mg/l, Calcium 155 mg/l, Magnesium 148 mg/l, Dissolved oxygen 13.1 mg/l, Chemical oxygen demand 4.64 mg/l, Turbidity 0.5 NTU, Conductivity 1565.67 µS/cm, Total solid 1428.8 mg/l, Total dissolved solid 1175 mg/l and Chloride 168.073mg/l. The analysis revealed that drinking water quality in the study area is reasonably good and doesn't show any alarming level of pollutants. However it needs some degree of treatment before consumption as the concentration of the parameters such as Dissolved oxygen, Total alkalinity, Magnesium hardness, Calcium hardness, Total hardness, Total solid, Chemical oxygen demand and Total solid exceed the permissible limits for drinking water.

KEYWORDS: Water samples, Physico-chemical parameters, Water quality.

INTRODUCTION

The clean water is one of the essential compounds that profoundly influence life. The deficiency of the clean water increases day by day due to over pollution and pollution of water (rapid growth of industries) so the drinking water analysis for physical, chemical properties are very important essential for public health studies (Rafiullah *et al*., 2012, Bakraji *et al*., 1999, Kot *et al*., 2000). (Bheshdadia *et al.*, 2012) have analyzed the quality of underground drinking water in Morbi-Malia Territor. It is shown that essential elements in water like TDS, Salinity, Phosphate, Nitrate, pH, Total hardness, Chloride are higher than tolerance range. Therefore bore well water in this territory is not drinkable. Ground water is the major source of water for drinking, agricultural and industrial desires. The availability of water determines the location and activities of humans in an area, and our growing population is placing great demand upon natural fresh water resources (Oladipo *et al*., 2011). The physico-chemical contaminants that adversely affected the quality of ground water is likely to arise from a variety of sources, including land application of agricultural chemicals, infiltration of effluent from sewage treatment plants, municipal waste, ponds, etc. (Rajappa *et al*., 2011). (Manjare *et al*., 2010) have studied the physio-chemical parameters of Tanadalge water tank in Kolthapur district Maharastra, India, the result indicate that the tank is non-polluted and recommended for domestic, irrigation and pisciculture. Danuraj water from household shallow wells, deep wells and waste water from Palosi drain has been analyzed by Amir Ukyas abd Tahir Sarwar, 2003. It is concluded that the ground water in the study area is good quality and waste water in drain is apparently little of no effect of shallow wells. (FAO, 1997) defined water as one of the most valuable natural resources and is essential for the maintenance of all forms of life. Surface (rivers, lakes and dams), and ground *i.e.* (wells and boreholes) water are the principal sources of water. In recent years, because of rapid urbanization, industrialization and growing population, the rate of discharge of pollutants into the environment which ultimately finds their way into these water bodies is higher than the rate of purification (Rizwan Reza and Singh, 2009). It is believed that surface water are generally more polluted than ground water, hence the use of ground water such as borehole water as the major source of drinking water in many urban and rural areas is the only alternative (Chukwu, 2008) unfortunately, ground water can also be contaminated through various ways such as seepage from effluent waters, fertilizer from agricultural and mining activities, vehicle maintenance, sewage disposal and domestic waste (Adekunle, 2009). (Singh *et al*., 2003) reported that the groundwater is contaminated not only in developed countries but also in developing countries like India. The changes in quality of groundwater response to variation in physical, chemical and biological environments through which it passes. (Ademorati, 1996) reported that the importance of water in our daily lives is what makes it imperative for thorough analysis to be conducted. The analysis is the concern of the chemist to ensure that supply of water is maintained suitable for all purposes and to ensure that only water with good qualities is used for both domestic and industrial purposes. The objective of the present study is to analyze the physio-chemical parameters of drinking water samples collected from different sources in Aligarh district, India to assess the groundwater quality and it is fit or not for drinking purpose.

MATERIALS & METHODS

Study area

Aligarh is a city located in Uttar Pradesh state of Northern India. The city is about 90 miles east to New Delhi, situated on a plain between the Ganges and Yamuna. The city is the administrative district of Aligarh District.

Preparation of water samples

In the present investigation, sixteen groundwater samples were collected from sixteen different locations of Mangalayatan University to Sooth Mill, Aligarh district. The samples were collected in clean polythene bottles without any air bubbles. The bottles were rinsed before sampling and tightly sealed after collection and labelled in the field. The dissolved oxygen of the samples was measured in the field itself at the time of sample collection.

Aligarh is located at the co-ordinates 27.88°N 78.08°E. It has an elevation of approximately 178 metres (587 feet). The Mangalayatan University is strategically located on the Aligarh-Mathura Highway having close proximities to the Yamuna Expressway in Uttar Pradesh

METHODOLOGY

Analytical grade and chemicals were used to prepare reagents and calibration standards. The different parameters analysed (Table 1) are pH, Total acidity, Phenolphthalein alkalinity, Total alkalinity, Total hardness, Calcium, Magnesium, Dissolved oxygen, Chemical oxygen demand, Turbidity, Electrical conductivity, Total solid, Total dissolved solid, Total suspended solid and Chloride as per standard procedures recommended by APHA (1995) method. The water quality parameter values are in mg/l except pH and EC in µs/cm.

TABLE1: Methods used for estimation of physico-chemical parameters

S. No.	Parameter	Methods
1	pH	pH meter
2	Electrical Conductivity	Conductivity meter
3	Turbidity	Nephlometer
4	Alkalinity	Indicator method
5	TDS	Filtration method
6	TSS	Evaporation method
7	Dissolved Oxygen	Wrinkler's method
8	COD	Open reflux method
9	Chloride	Silver nitrate method

The data were subjected to analysis of average, sample variance and standard deviation using excel software.

RESULTS

TABLE 2: Reading physico-chemical parameters at different sites in Aligarh city

S.No	pH	TA	Phe.A	T.Alk	TH	Ca	Mg	DO	COD	Turbidi	EC	TS	TDS	TSS	Cl
1	7.8	48	100	744	232	140	92	12.2	0	1	1253.73	1660	840	820	169.947
2	7.6	24	72	580	296	112	184	14.3	0	0	1313.43	1060	880	180	153.952
3	8.5	16	92	488	252	108	144	13.7	3.2	1	835.82	680	560	120	75.9764
4	7.8	28	32	480	228	152	76	13.3	4.8	1	1074.62	840	720	120	149.954
5	7.9	32	72	476	136	80	56	14.3	16.6	0	1611.94	1280	1080	200	115.964
6	8.1	40	40	520	236	100	136	12.7	3.52	0	1522.38	1300	1020	280	99.969
7	7.7	40	20	524	280	152	128	14.7	4.8	0	1880.59	1420	1260	160	193.94
8	8.1	24	32	760	160	108	52	11.8	3.2	0	716.41	600	480	120	59.98
9	7.7	64	60	460	360	212	148	14.3	1.6	3	1552.23	1140	1040	100	199.938
10	7.7	64	40	500	220	140	80	11.6	10.6	0	1373.13	1080	920	160	209.935
11	7.6	36	84	420	340	176	164	12.7	6.72	0	1761.19	1260	1180	80	279.913
12	7.8	36	56	380	180	132	48	12	3.2	0	567.164	1060	380	680	69.9783
13	7.7	36	40	440	252	144	108	10.4	3.2	0	2000	1800	1340	460	69.9783
14	7.4	68	20	680	408	144	264	12.7	5.76	1	3343.28	2540	2240	300	279.913
15	7.6	72	64	500	580	252	328	15.7	3.2	1	334.283	2280	2240	40	299.907
16	7.3	116	12	508	688	328	360	12.7	3.84	0	3910.44	2860	2620	240	259.919
mean	7.8	46.5	52.25	528.8	303	155	148	13.1	4.64	0.5	1565.67	1428.8	1175	253.8	168.073
samp	0.1	631	722.1	12058	22126	3946	9009	1.88	16.6	0.667	879632	422505	427120	51912	6771
SD	0.3	25.1	26.87	109.8	148.7	62.8	94.92	1.37	4.08	0.816	937.887	650	653.54	227.8	82.2861
CV	3.6	54	51.43	20.77	49.09	40.5	64.13	10.5	87.9	163.3	59.9034	45.495	55.621	89.79	31.6583
max	8.5	116	100	760	688	328	360	15.7	16.6	3	3910.44	2860	2620	820	299.907
min	7.3	16	12	380	136	80	48	10.4	0	0	334.283	600	380	40	59.98

Where, TA-Total acidity, Phe.A-Phenolphthalein alkalinity, T.Alk-Total alkalinity, TH-Total hardness, *Ca*-Calcium hardness, *Mg*-Magnesium hardness, DO-Dissolved oxygen, COD-Chemical oxygen demand, EC-Electrical conductivity, TS-Total solids, TDS-Total dissolved solids , TSS- Total suspended Solid, *Cl*-Chloride, S.D-Standard deviation, C.V.-Co-efficient of variation in %, Min-Minimum, Max-Maximum. (Note: all parameters are in mg/l except pH, EC in µS/cm and Turbidity in NTU)

DISCUSSION

The pH value of the samples in the study area varied from 7.3-8.5 with a mean of 7.8 indicating slightly alkaline nature. High pH value induces the formation of trihalomethanes, which are toxic, while pH below 6.5 starts corrosion in pipe thereby releasing toxic metals such as zinc, lead, cadmium and copper (Shrivastava and Patil, 2002). It was noticed that the pH value of the water appears to be dependent upon the relative quantities of calcium, carbonates and bicarbonates. The water tends to be more alkaline when it possesses carbonates (Zafar, 1966; Suryanarayana, 1995). From the (Fig.1), it can be seen all the sampling sites had pH level falling with the recommended range of 6.5-8.5 (W.H.O, 1993).

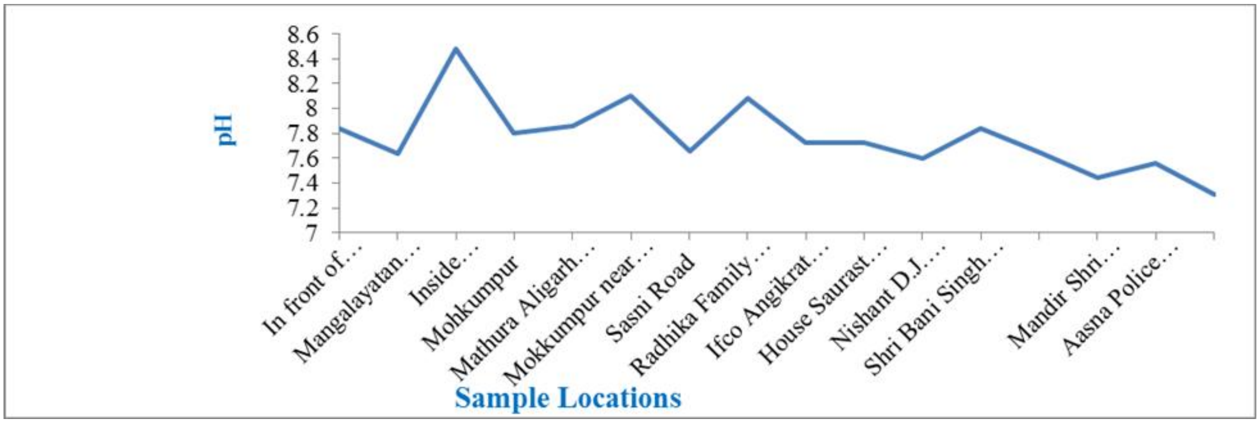

FIGURE 1: Sample Locations vs pH

Total acidity of the groundwater is due to the presence of carbonate as in the form of CO_2 in the environments. Acidity of the samples analyzed in the range of between 16-116 mg/l with a mean of 46.5. In the study area all the samples showed within the permissible limits. (Fig. 2)

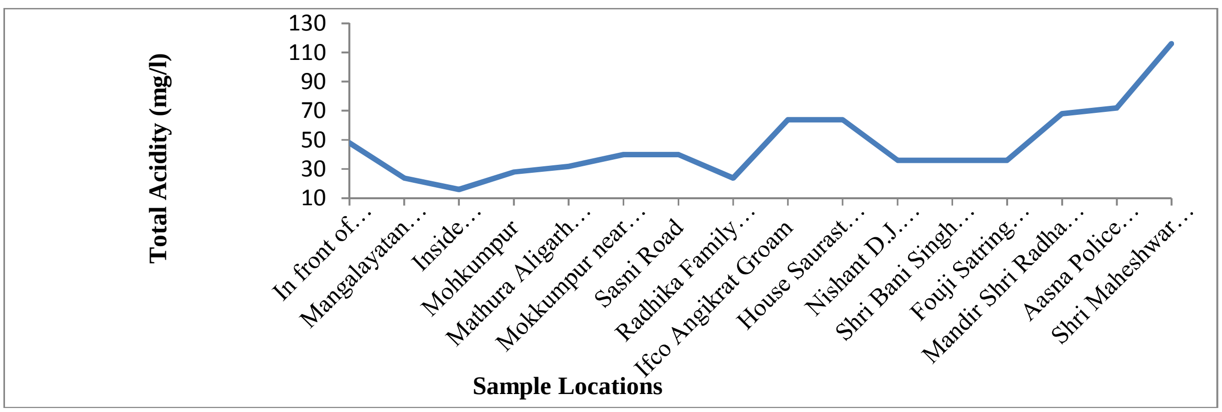

FIGURE 2: Sample Locations vs Total Acidity (mg/l)

Phenolphthalein alkalinity of the samples analyzed in the range of between 12-100 mg/l with a mean of 52.25. In the study area all the samples showed within the permissible limits. (Fig. 3)

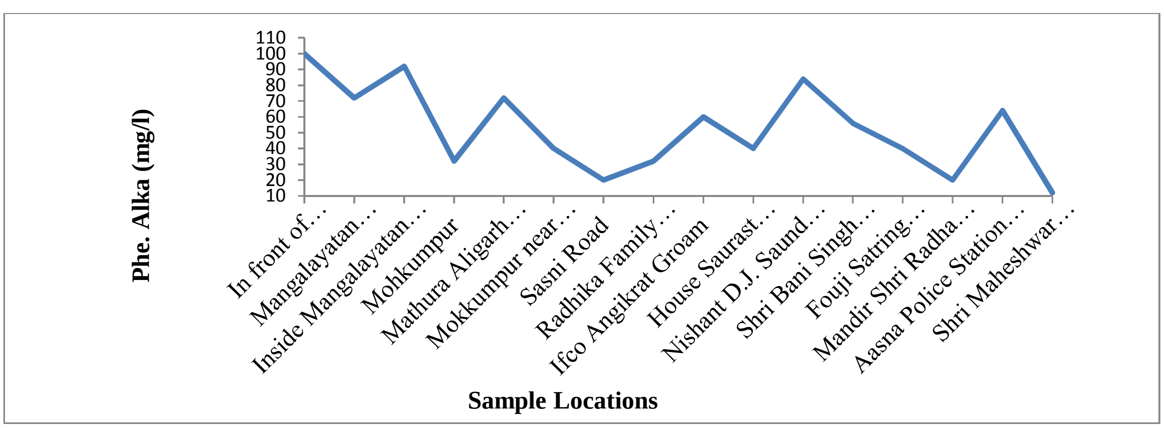

FIGURE 3: Sample Locations vs Phenolphthalein Alkalinity (mg/l)

The alkalinity ranged between 380-760 mg/l as $CaCO_3$ with a mean value of 528.8 mg/l as, $CaCO_3$ indicated high alkaline nature of water in the area and 18.75% of samples were found exceeding the acceptable limit of ICMR/BIS, (Fig. 4). The excess of alkalinity could be due to the minerals, which dissolved in water from mineral rich soil. The various ionic species that contribute mainly to alkalinity includes bicarbonates, carbonates, hydroxides, phosphates, borates, silicates and organic acids. In some cases, ammonia or hydroxides are also accountable to the alkalinity (Sawyer et. al., 2000).

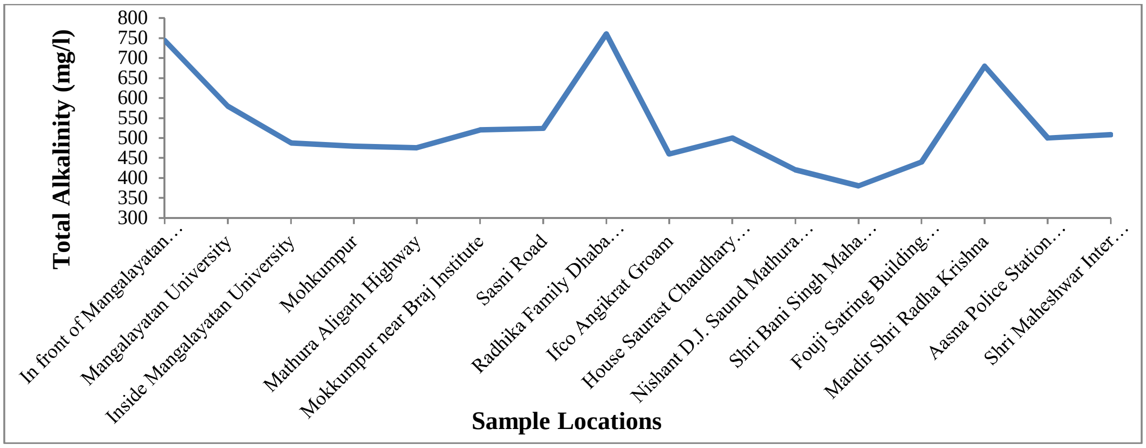

FIGURE 4: Sample Locations vs Total Alkalinity (mg/l)

The total hardness ranged between 136-688 mg/l as $CaCO_3$ with a mean value of 303 mg/l as $CaCO_3$ which indicated very hard water and 6.25% of samples were found exceeding the acceptable limits of ICMR/BIS, (Fig. 5). Hardness in water is caused by certain salts held in solution. The most common are the carbonates, fluorides and sulphates of calcium and magnesium. The principal hardness causing cations are calcium, magnesium, strontium, ferrous and manganese ions. The cations plus the most important anions that contributes are bicarbonates, sulphates, chlorides, nitrates and silicates. The hardness may be advantageous in certain conditions; it prevents the corrosion in the pipes by forming a thin layer of scale, and reduces the entry of heavy metals from the pipe to the water (Shrivastava et al., 2002). Water can be classified in terms of degree of hardness as follows:

Total hardness in mg/l	Degree of hardness
0 – 75	Soft
75 – 150	Moderately hard
150 – 300	Hard
> 300	Very hard

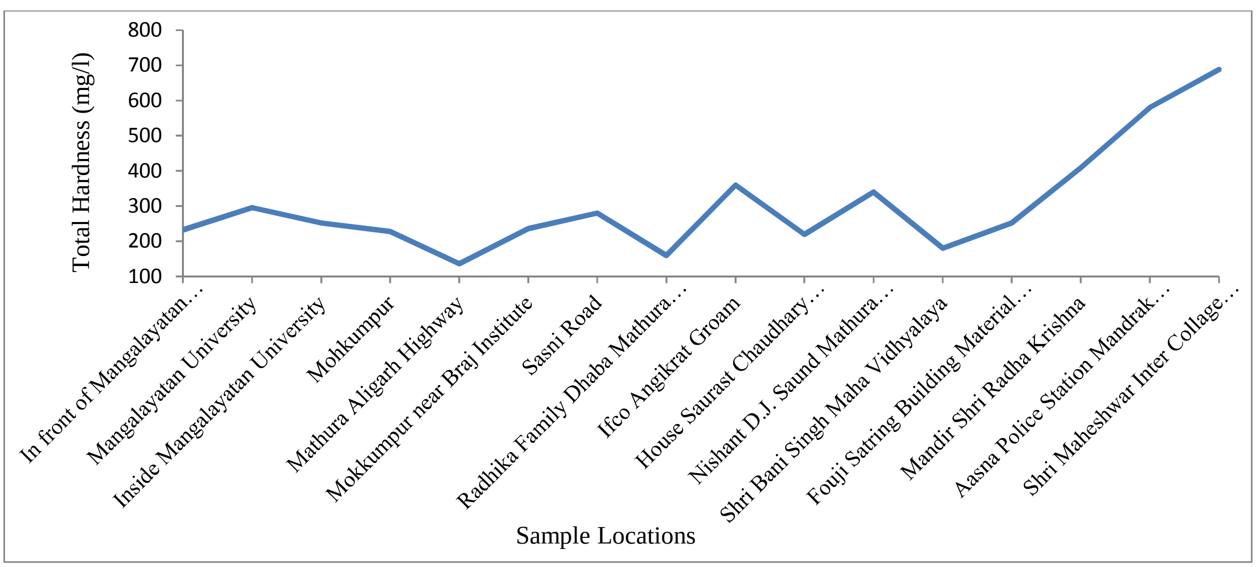

FIGURE 5: Sample Locations vs Total Hardness (mg/l)

Calcium hardness is one of the most abundant substances found in natural water in higher quantities in the rocks. Higher level of calcium is not desirable in washing, bathing and laundering while small concentration of calcium is beneficial in reducing the corrosion in pipes. Calcium in the study area varied widely from 80-328 mg/l as $CaCO_3$ with a mean value of 155 mg/l as $CaCO_3$ and 18.75% of samples were found exceeding the acceptable limits of ICMR/BIS, (Fig. 6). This might be due to the geology of the area. The area is basically of granitic terrain. Experts have opined that the difference in relative mobility of calcium, magnesium, sodium and potassium is more distinct in the groundwater from granitic terrain and the higher concentrations of calcium, magnesium, chlorides and bicarbonates in several cases are probably due to their low rate of removal by soil (Somashekar *et al.*, 2000).

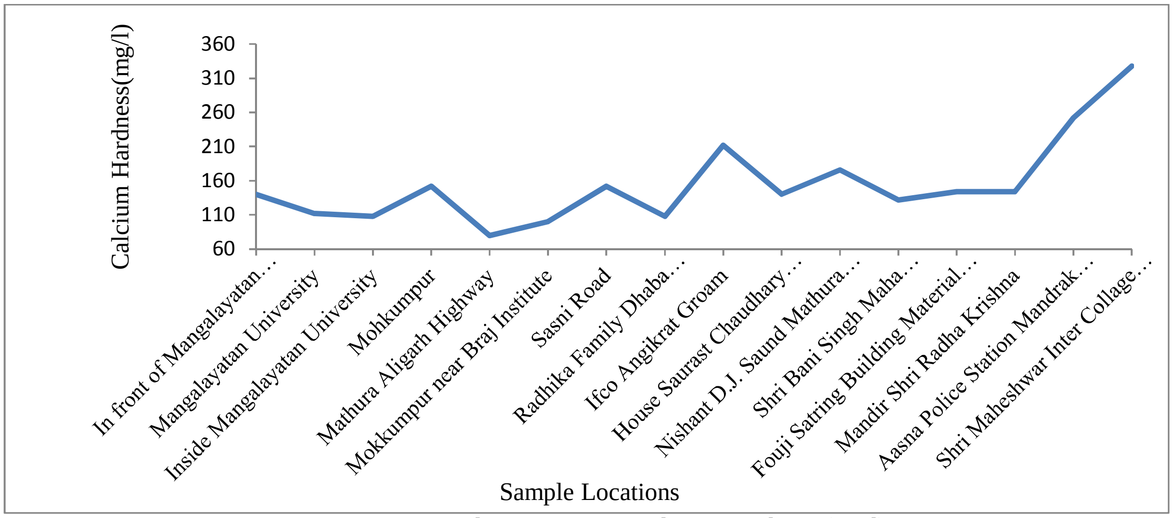

FIGURE 6: Sample Locations vs Calcium Hardness (mg/l)

Magnesium Hardness in the study area varied widely from 48-360 mg/l as $CaCO_3$ with a mean value of 148 mg/l as $CaCO_3$ and 31.25% of samples were found exceeding the acceptable limits of ICMR/BIS. (Fig. 7)

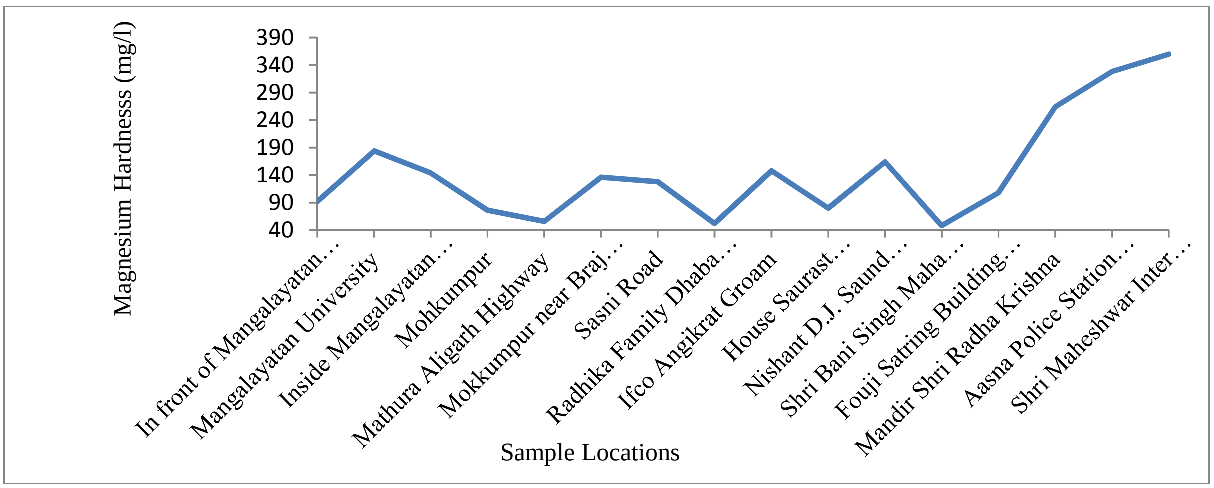

FIGURE 7: Sample Locations vs Magnesium Hardness

Dissolved oxygen is an important parameter in water quality assessment and biological processes prevailing in the water. The DO values indicate the degree of pollution in the water bodies. The presence of DO enhances the quality of water and also acceptability. An ideal DO value of 5.0 mg/l is the standard for drinking water (Bhanga *et al.*, 2000). DO of bore well water under the area determined in the present investigation ranged between from 10.4-15.7 mg/l with a mean value of 13.1 mg/l, which shows the high degree of pollution due to presence of bacteria and minerals in water. (Fig. 8)

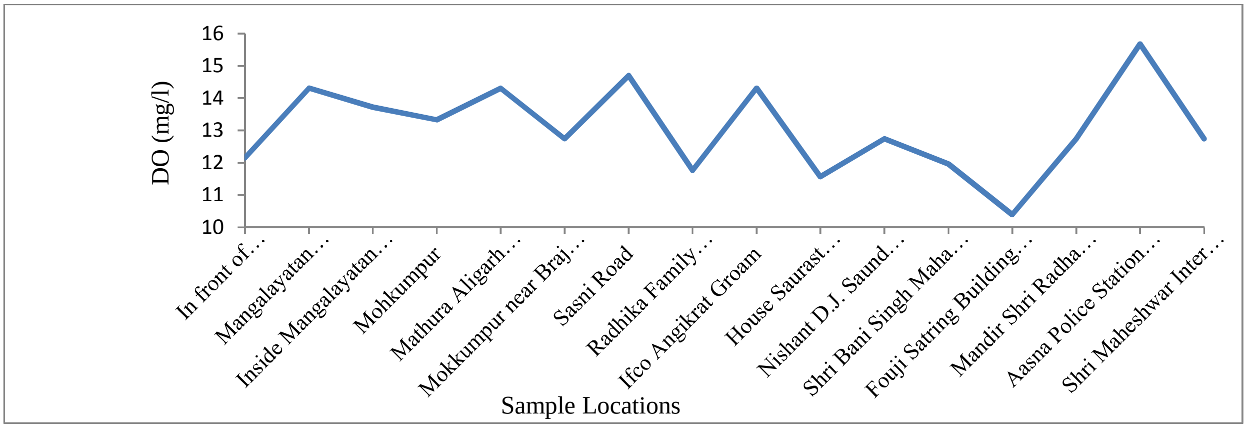

FIGURE 8: Sample Locations vs DO (mg/l)

Chemical Oxygen Demand is a measure of pollution in aquatic system. High COD may cause oxygen depletion on account of decomposition by microbes to a level detrimental to aquatic life (Shiva Kumar et al., 1989). In the present study COD values of various ground water samples were found from 0-16.6 mg/l with a mean of 4.64 mg/l and 12.5% of samples were found exceeding the acceptable limit of ICMR/ BIS. (Fig. 9)

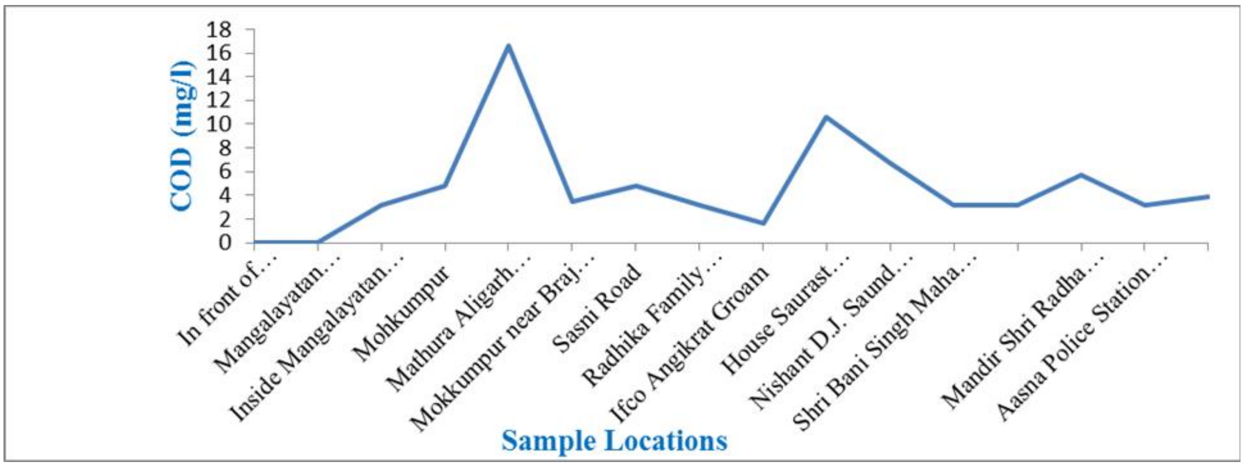

FIGURE 9: Sample Locations vs COD (mg/l)

Turbidity is an important parameter for characterizing the quality of water. Turbidity in water may be due to wide variety of suspended materials, which range in size from colloidal to coarse dispersions, depending upon the degree of turbulence. Turbidity in the study area range from 0 – 3 NTU with a mean of 0.5 NTU and the groundwater samples were found within the acceptable limits of ICMR/BIS. (Fig. 10).

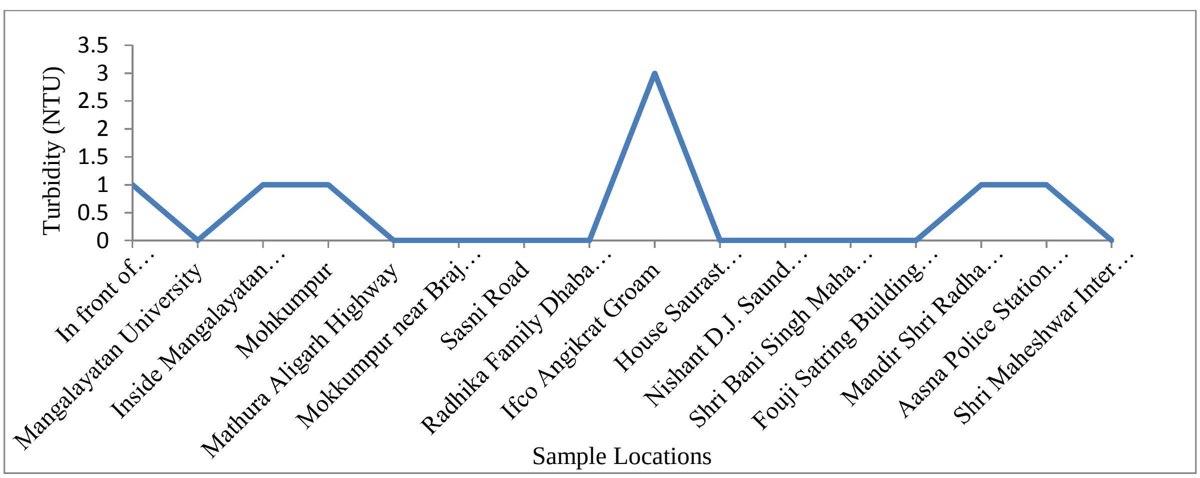

FIGURE 10: Sample Locations vs Turbidity (NTU)

Electrical conductivity value of the study area varied from 334.283-3910.44 µS/cm with a mean of 1565.67 µS/cm and 12.5% samples exceeded standards of ICMR/BIS prescribed for drinking, (Fig. 11). Electrical conductivity is a measure of water's capacity to conduct electric current. As most of the salts in the water are present in the ionic form, are responsible to conduct electric current. Generally, groundwater tends to have high electrical conductivity due to the presence of high amount of dissolved salts. Electrical conductivity is a decisive parameter in determining suitability of water for particular purpose and classified according to electrical conductivity as follows:

EC in µS/cm at 25°C	Classification
< 250	Excellent
250 – 750	Good
750 – 2000	Permissible
2000 – 3000	Doubtful
> 3000	Unsuitable

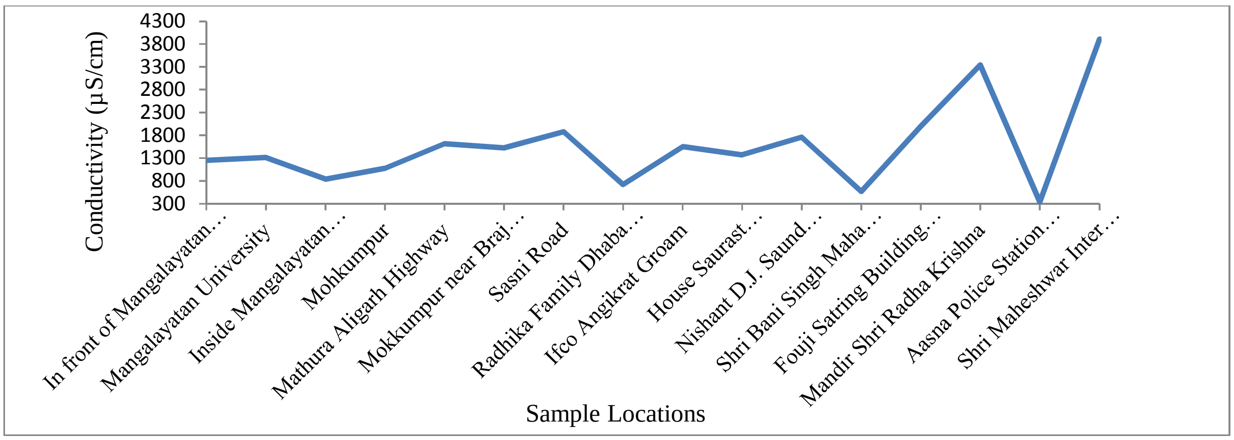

FIGURE 11: Sample Locations vs Conductivity (µS/cm)

Total solid value of the study area varied from 600-2860 mg/l with a mean of 1428.8 mg/l and 18.75% samples exceeded standards of ICMR/BIS prescribed for drinking. (Fig. 12)

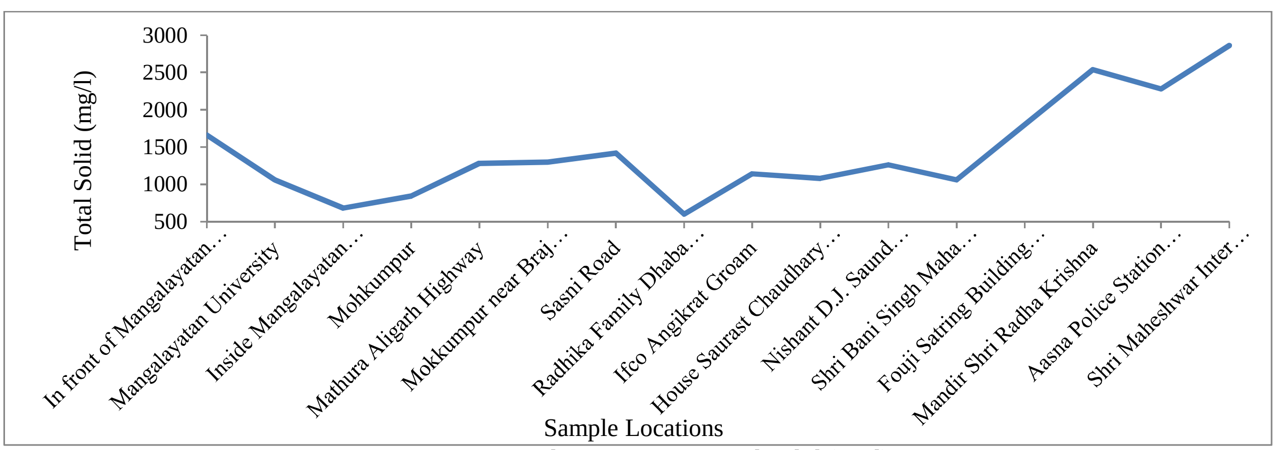

FIGURE 12: Sample Locations vs Total Solid (mg/l)

The total dissolved solids (TDS) in the study area varied from 380-2620 mg/l with a mean value of 1175 mg/l and all samples were found within the permissible limits of ICMR/BIS, (Fig. 13). In water samples, most of the matter is in dissolved form and consists mainly of inorganic salts, small amounts of organic matter and dissolved gases, which contribute to TDS. Based on TDS groundwater is classified as follows:

Classification	TDS in mg/l
Non-saline	< 1000
Slightly saline	1000 – 3000
Moderately saline	3000 – 10000
Very saline	> 10000

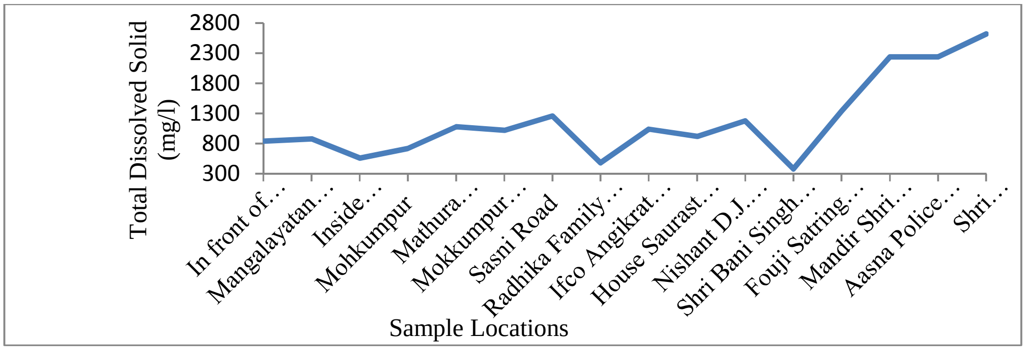

FIGURE 13: Sample Locations vs Total dissolved Solid (mg/l)

The total suspended solids (TSS) in the study area varied from 40-820 mg/l with a mean value of 253.8 mg/l and all samples were found within the permissible limits of ICMR/BIS. (Fig.14)

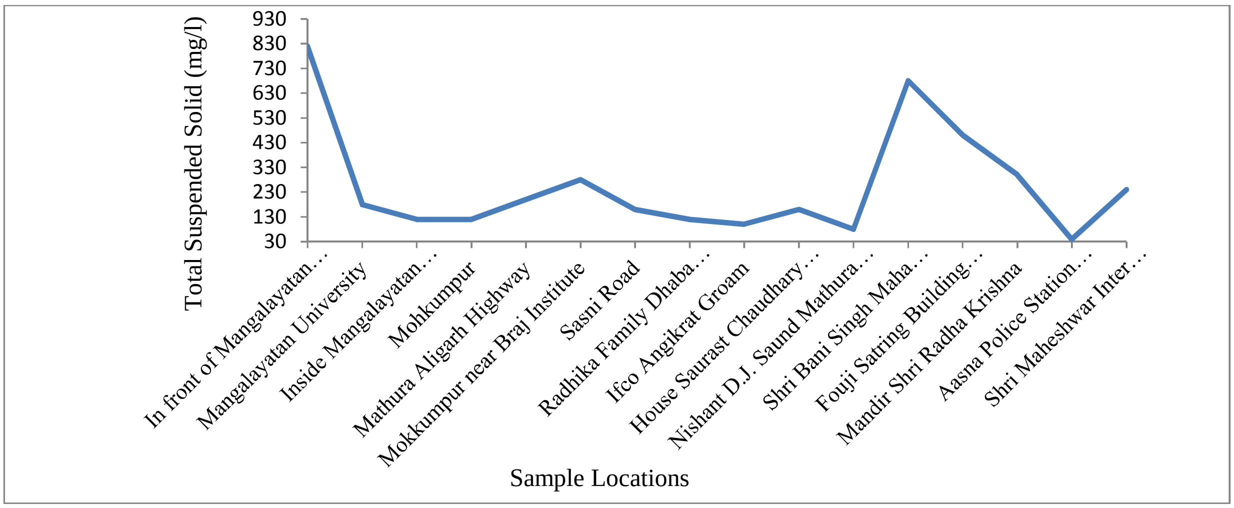

FIGURE 14: Sample Locations vs Total Suspended Solid (mg/l)

The chlorides varied widely from 59.98 – 299.907 mg/l with a mean value of 168.073 mg/l and all the samples were found within the permissible limits of ICMR/BIS. (Fig. 15). Naturally chloride occurs in all types of waters. The contribution of chloride in the groundwater is due to minerals like apatite, mica, and hornblende and also from the liquid inclusions of igneous rocks (Das and Malik, 1988).

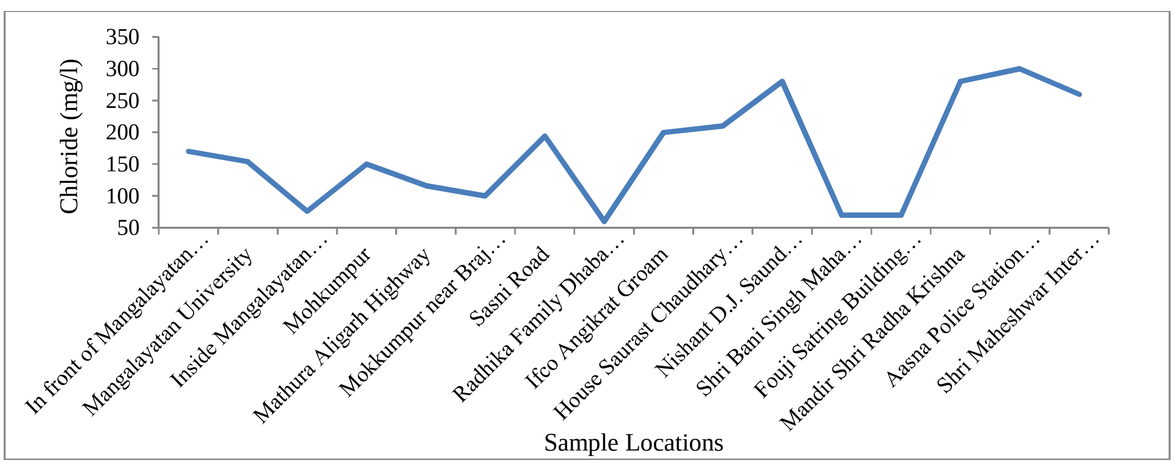

FIGURE 15: Sample Locations vs Chloride (mg/l)

CONCLUSION

The concentration of Total alkalinity, Total hardness, Calcium hardness, Magnesium hardness, Dissolved oxygen, Chemical oxygen demand, Conductivity and Total solid of a major percentage of the well water exceed the upper limit of drinking water standard of ISI (10500-1991). Overall it has been observed from the analysis that the drinking water quality in the study area is reasonably good and does not show any alarming levels of pollutants, however it need some degree of treatment before consumption as the concentration of the parameters such as Magnesium hardness, Calcium hardness and Total solid are higher so that the human beings can be protected from adverse health effect.

ACKNOWLEDGEMENT
The authors are thankful to the concerned authorities of A.M.U., Aligarh for providing facilities to carry out this work.

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