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Physicochemical analysis of water samples of Nujendla area in Guntur District, Andhra Pradesh, India

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Abstract: Ground water is the only source of potable water for majority of people in the study area. This ground water in almost all the villages consists of excess of fluoride. Hence the present study was undertaken to characterize the physicochemical nature (parameters) of Ground water in Nujendla area in Guntur District by taking water samples from thirteen different stations. Evaluation of physicochemical parameters was carried out. 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. 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. Suitable suggestions were made to improve the quality of groundwater of Nujendla areas.
Keywords: Water Pollution, Bore Well Water, Correlation Analysis, Nujendla.

INTRODUCION

Fresh water has become a scarce commodity due to over exploitation and pollution of water. Increasing population and its necessities have lead to the deterioration of surface and sub surface water. 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 1. It supports drinking water supply; livestock needs irrigation, industrial and many commercial activities 2. Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies 3. Also the natural impurities in rainwater, which replenishes groundwater systems, get removed while infiltrating through soil strata 2. But, 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[4]. Importantly, groundwater can also be contaminated by naturally occurring sources. Soil and geologic formation containing high levels of heavy metals can leach those metals into groundwater. This can be aggravated by over-pumping wells, particularly for agriculture 5. Pollution caused by fertilizers and pesticides used in Agriculture, often dispersed over large areas, is a great threat to fresh groundwater ecosystems.

Pollution of groundwater due to industrial effluents and municipal waste in water bodies is another major concern in many cities and industrial clusters in India. Groundwater is very difficult to remediate, except in small defined areas and therefore the emphasis has to be on prevention. Ground water is the only source of potable water for majority of people in the study area. However, the innavitants here are averse to drink bore well water or water from public water system. They say that water drawn from great depths is not tasty. Hence their preference is to open well water or hand pump water. So, the knowledge of extent of pollution and the status of water become essential in order to preserve the valuable sources of water for future generation. The main objective of this work has to analyze various physico-chemical parameters of the ground water of Nujendla area in Guntur District, Andhra Pradesh, India.

EXPERIMENTAL

STUDY AREA

The physico-chemical parameters of ground water of 13 stations in Nuzendla viz. V.Appapuram, Mupparajuvaripalem, Ravvaram, Mekapadu, Ramudupalem, Marellavaripalem, Kotha Reddypalem, Thimmapuram, J.C.Nagar, Lakshmipuram, Nuzendla, Gurappa Naidupalem, and Uppalapadu were studied.

PREPARATION OF WATER SAMPLES

For the present investigation, separate sets of samples are collected for chemical and biological analysis from the source. The bottles for sample collection have been thoroughly cleaned by rinsing with 8M HNO_3, followed by repeated washing with deionized distilled water. They are further rinsed with sample water before collection. For bacteriological examination, sterilized bottles are used.

ANALYSIS OF WATER SAMPLES

Analysis was carried out for various water quality parameters (Table 1) such as pH, Electrical conductivity (EC), Total dissolved solids (TDS), Total hardness (TH), Total alkalinity (ALK), Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Nitrate (NO_3), Nitrite (NO_2), Sulphate (SO_4), Phosphate (PO_4), Fluoride (F), Dissolved Oxygen (DO), Biological oxygen demand (BOD), chemical oxygen demand (COD) and Trace elements as per standard procedures.

STATISTICAL ANALYSIS

The simple linear correlation analysis has been carried out to find out correlation between any two tested parameters. The significance of correlation was also tested.

Table 1: Determination of Water quality Parameters

S.No	Water quality parameter	Method of determination
1	Hydrogen ion Concentration (pH)	pH metry
2	Electrical conductivity (EC)	Conductometry
3	Total dissolved Solids (TDS)	Evaporation method
4	Alkalinity (ALK) as CaCO3	Titrimetry
5	Total Hardness (TH)as CaCO3	EDTA –Titrimetry
6	Calcium(Ca)	EDTA –Titrimetry
7	Magnesium (Mg)	EDTA –Titrimetry
8	Sodium (Na)	Flamephotometry
9	Potassium (K)	Flamephotometry
10	Chloride (c l) (Argentometric method)	Titrimetry
11	Nitrate(NO3)	Spectrophotometry
12	Nitrite(NO2)	Spectrophotometry
13	Sulphate(SO4)	Spectrophotometry
14	Phosphate(PO4)	Spectrophotometry
15	Fluoride(F)	Spectrophotometer
16	Dissolved Oxygen (DO)	Titrimetry
17	Biological oxygen demand (BOD)	Incubation at 20^{o}C, Titrimetry
18	Chemical oxygen demand (COD)	Titrimetry
19	Trace elements	Aomic absorption spectrophotometry (AAS)

Table 2: Results of Physico-chemical analysis of water

Sample No.	Name of the village	pH	EC micro mhos	TDS	TH	Total Alkalinity
1	V.Appa puram	8.35	1483.00	718	388.00	221.62
2	Mupparajuvaripalem	8.35	1146.00	552	224.00	1032.72
3	Ravvaram	8.00	755.00	360	276.00	339.82
4	Ramudupalem	7.90	946.00	454	376.00	187.15
5	Marellavaripalem	8.16	892.00	426	280.00	462.95
6	Kotha Reddypalem	7.99	1002.00	477	300.00	300.42
7	Thimmapuram	7.93	1756.00	856	644.00	300.42
8	Mekapadu	7.79	1680.00	816	268.00	265.95
9	J.C.Nagar	7.18	1898.00	930	508.00	142.82
10	Lakshmipuram	8.04	1274.00	616	240.00	354.6
11	Nuzendla	7.93	1489.00	721	232.00	320.12
12	Gurappa Naidupalem	7.80	1551.00	753	268.00	389.07
13	Uppalapadu	8.14	975.00	468	232.00	241.32

RESULTS & DISCUSSIONS:

The results of physico-chemical analysis of the water from several villages of Nujendla mandal, Guntur district, AP are presented in Table 2.

pH

pH is considered as an important ecological factor and provides an important piece factor and piece of information in many types of geochemical equilibrium or solubility calculation. pH is an important parameter in water body since most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes. In the present investigation, the pH values vary from 7.18 to 8.35, (Table 2) in water from the study area respectively. The limit of pH value for drinking water is specified as 6.5 to 8.5 6. The results indicate that, the ground water source in the study area is alkaline in nature. Higher pH values are observed in samples 1, 2, 3,5,10 and 13. This may be due to the presence of higher amounts of carbonate and bicarbonate substances in the ground water. All the pH values of the samples are within the maximum permissible limit.

ELECTRICAL CONDUCTIVITY (EC):

EC measures the electric current, which is proportional to the mineral matter present in water. Conductivity is thus the measurement of total dissolved solids (TDS) in water. Conductivity is represented in μmhos/cm in water analysis. It is a very important parameter for determining the water quality for drinking and agricultural purposes. EC values in water samples ranged from 755 to 1898 μ mhos/cm (Table 2). The higher values may be due to the rock soils and the presence of high dissolved solids in the study area. The EC values are within the maximum permissible limit. For all domestic and agricultural urposes, the EC value is less than 2500 μ mhos/cm ideal. The results indicate that the distribution of EC in the water in the study area is not uniform. An observation of the results reveals that the variation of EC values in all samples is not uniform.

TOTAL DISSOLVED SOLIDS (TDS):

Dissolved solids, which are also referred to as total dissolved solids (TDS) are various kinds of mineral substances present in water. Some dissolved organic matter may also contribute to total dissolved solids. The concentration of dissolved solids in water gives an idea about suitability of this water for various uses including that of potable water. It also indicates the salinity of water. Dissolved solids tend to increase with increasing pollution of water. Water containing more than 500 mg/L of TDS is not considered desirable for drinking water supplies, though more highly mineralized water is also used where better water is not available. For this reason, 500 mg/L as the desirable limit and 15 mg/L as the maximum permissible limit have been suggested for drinking water 7. In the present investigation, the TDS values have varied from 360 to 930 mg/L in the study area.

TOTAL HARDNESS (TH):

Hardness is commonly understood as a property of water, which prevents the lather formation with soap. It is primarily caused by calcium and magnesium, but any

alkaline earth metal may contribute to hardness. Iron, strontium, manganese, carbonates, bicarbonates, sulphates, nitrates and silicates in water may contribute to hardness. Hardness is of two types. Temporary hardness, which is caused by carbonate and bicarbonate ions, may be removed by just boiling the water. However the permanent hardness, which is caused mainly by chlorides and sulphates of the metals, is difficult to be removed. Hardness is not deleterious to health although it has been suspected to be playing some role in heart disease. It is, however, a nuisance in industrial cooling where it forms scales reducing heat exchange. Most Industries employ ion exchange water softeners to reduce hardness (softening of water).

In this study area, the total hardness in water from all the groundwater resources ranges between 228 and 644 mg/L These values are well below the maximum permissible limits in water samples 7. The higher value of TH may be due to the presence of high amount of calcium and magnesium substances in the water. The higher amount of other substances such as sodium, chlorides, sulphates and nitrates may also contribute to the total hardness value. The TH values fluctuate in all the three types of samples.

TOTAL ALKALINITY (ALK):
Alkalinity of the water is its capacity to neutralize a strong acid and is characterized by the presence of all hydroxyl ions capable of combining with the hydrogen ion. Alkalinity in natural water is due to free hydroxyl ions and weak acids and strong bases form hydrolysis of salts.

$$A^- + HOH \longrightarrow HA + OH^-$$

where A^- is the salt of weak acid and strong base. The weak acid is unable to dissociate more, and when the titration is carried out with a strong acid, the equilibrium is shifted to the right and all the salt is hydrolyzed. The number of milli equivalents of acids used in the titration to combine all the hydroxyl ions is called total alkalinity. The total alkalinity values have varied from 103.72 to 462, 95 mg/L in water from bore wells in the study area. According to USEPA, the maximum permissible limit of total alkalinity is 120 mg/L. Here the observed values are above the maximum permissible limit 7. The results indicate that, the variation of alkalinity is not uniform in all the water samples in the study area. The pH and TH of the ground water also influences the change in alkalinity. Carbonate and bicarbonate substances are mainly responsible for alkalinity in the ground water.

MAJOR CHEMICAL CONSTITUENTS:
In natural water, calcium, magnesium, sodium and potassium are major cations and chloride, sulphate, fluoride, phosphate, nitrate and nitrite are major anions (Table 3).

CALCIUM (CA):
The concentration of calcium has varied from 59 to 490 mg/L. The results indicate that the distribution of calcium is not uniform in all the samples in the study area. The concentration of calcium is high in sample 1. Higher value of calcium may be due to the presence of rock soil in the study area. But the concentration of calcium fluctuates in all the three types of water samples in the study area. Seepage of surface run off may be the reason for the fluctuation.

MAGNESIUM (MG):
The concentration of magnesium varies from 13.0 to 132.0 mg/L in the study area. The concentration of magnesium in potable water ranges from 50 to 100 mg/L. The results in the tables indicate that the distribution of magnesium is uniform in all water samples. These are unlike those of calcium. The concentration of magnesium is higher in sample 1. This higher value of magnesium may be from leaching of rocks.

SODIUM (Na):
The concentration of sodium ranges from 40.0 to 380.0 mg/L in the study area. The maximum permissible limit of sodium in potable water is 200 mg/L. The higher concentration of sodium is toxic to human beings. The results of sodium indicate that water samples 1,9,10, 11 & 12 contain higher concentration of sodium.

POTASSIUM (K):
The concentration of potassium ranges from 2.0 0 to 23.0 mg/ L in the study area. The values are below the permissible limit. The results indicate that the distribution of potassium is uniform in all the samples.

CHLORIDE (Cl):
The concentration of chloride in all the samples in the study area ranges from 25.36 to 315.24 mg/L the higher concentration is usually indicative of polluted nature of water. The results indicate that the distribution of chloride in all the samples is not uniform.

Table 3: Results of Physico-chemical analysis of water samples

Sample No.	F ppm	Cl mg/L	NO_3 mg/L	NO_2 mg/L	SO_4 mg/L	PO_4 mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L
1	2.56	278.88	0.01	1.70	108.00	0.08	490.00	132.00	380.00	14.00
2	4.51	255.60	0.001	3.60	17.00	0.11	119.00	37.00	101.00	9.00
3	1.16	124.96	0.001	5.70	21.00	0.00	96.00	30.00	44.00	11.00
4	1.48	116.44	0.001	4.10	31.00	0.18	162.00	38.00	80.00	5.00
5	1.19	53.96	0.00	4.90	23.00	0.03	59.00	20.00	109.00	5.00
6	2.44	25.56	0.00	3.20	69.00	0.00	102.00	29.00	40.00	2.00
7	1.15	238.56	0.002	8.20	38.00	0.00	63.00	16.00	192.00	9.00
8	2.97	85.20	0.002	1.50	28.00	0.08	63.00	13.00	142.00	5.00
9	3.54	190.28	0.005	5.30	36.00	0.00	57.00	23.00	208.00	4.00
10	1.46	232.88	0.00	5.20	63.00	0.00	106.00	21.00	206.00	17.00
11	1.39	315.24	0.01	1.10	84.00	0.00	130.00	31.00	240.00	23.00
12	8.03	184.60	0.008	1.60	61.00	0.00	41.00	28.00	230.00	3.00
13	1.47	28.40	0.00	2.70	16.00	0.00	94.00	19.00	43.00	7.00

Table 4: Results of Physico-chemical analysis of water samples

Sample No.	Zn mg/L	Fe mg/L	Cu mg/L	Mn mg/L	Hg mg/L	Pb mg/L
1	3.48	0.38	0.19	0.00	0.00	0.00
2	0.65	0.21	0.08	0.00	0.00	0.00
3	2.42	0.49	0.05	0.00	0.00	0.00
4	2.52	0.34	0.00	0.00	0.00	0.002
5	3.56	0.49	0.06	0.00	0.00	0.00
6	2.38	0.51	0.09	0.00	0.00	0.00
7	1.71	0.14	0.11	0.00	0.00	0.00
8	0.66	0.23	0.00	0.00	0.00	0.00
9	1.36	0.51	0.10	0.00	0.00	0.003
10	1.02	0.23	0.00	0.00	0.00	0.00
11	0.67	0.48	0.17	0.00	0.00	0.00
12	0.64	0.23	0.10	0.00	0.00	0.00
13	1.08	0.63	0.00	0.00	0.00	0.00

SULPHATE (SO_4):

Sodium and magnesium sulphates exert a cathartic action in human beings. It is also associated with respiratory diseases 8. Therefore, the recommended content of sulphate in drinking water is limited from 200 to 400 mg/L 7. In the present study, the sulphate contents in all the water samples have varied from 16.00 to 108.00 mg/L. The results indicate that the distribution of sulphate is not uniform in water samples. The results also indicate that the value of sulphate in all the samples were within the permissible limit.

PHOSPHATE (PO_4):

The concentration of phosphate in all the water samples in the study area ranges from 0.00 to 0.11 mg/L. The values are relatively very low. The excess amount of phosphate may cause serious health hazard. The careful observation of the results reveals that the distribution of phosphate concentration is not uniform in the ground water in the study area.

NITRATE (NO_3) AND NITRITE (NO_2):

Nitrates are highly oxidized form of nitrogen. Natural waters are usually deficient in nitrates, thus restricting algal growth. Nitrates enter fresh waters through

discharge of sewage and industrial wastes and run off from agricultural fields. Some ground water naturally has high nitrate concentration. Concentration of nitrate above 4 mg/L can cause Methamaglobinemia (blue-baby disease) in children 9.

The concentration of nitrite content in all the samples is ranges from 1.10 to 5.70 mg/L. In some samples, nitrite content has not been traced. The results indicate that the nitrite concentration is low in all the regions of ground water sources. The values are well below the permissible limit. The results also indicate that the distribution of nitrite is not uniform in water samples.

FLUORIDE (F):

Fluorides have, of late, become a matter of great health concern due to 'Fluorosis' problem reported from various parts of the World 10. It is, however, ironical as fluorides have great therapeutic value in removing dental carries. If the concentration of fluoride in water is less than 0.5 mg/L, the incidence of dental carries is likely to be high. However, with higher concentration of fluoride, it causes a crippling disease called 'Fluorosis'.

The natural fluoride content in drinking water depends on the source, climatic and geological factors. The fluoride concentration of seawater is usually constant around 1-3 mg/L. The concentration is usually below 1 mg/L in unpolluted surface waters. Water bodies contaminated by industrial effluents may have higher fluoride content. The safe limit of fluoride for drinking water supply is 1.5 mg/L. The concentration of fluoride in all the samples in the study area has varied from 1.15 to 8.03 mg/L. A careful observation of the results reveals that, the distribution of fluoride level in ground water sources in all the regions in the study area is not uniform. The results also indicate that many water samples contain fluoride content above the maximum permissible limit.

TRACE ELEMENTS:

The objectives of the present investigation are to find out the status of the trace elements in ground water. For this purposes the following trace elements i.e. copper, iron, zinc, lead, manganese, arsenic and mercury are classified as highly toxic and moderately toxic or less toxic in nature 11. The results of the analysis of trace elements in the study area are given in Table 4.

COPPER (Cu):

Copper is an essential trace element in nutrition of plants and animals including man. It is required for the function of several enzymes and is necessary in the biosynthesis of chlorophyll 12. Higher level of copper is toxic to organisms but response varies greatly between different species. The World Health Organization has indicated that the highest desirable level of copper in drinking water is 0.05 mg/L and maximum permissible limit is 1.5 mg/L. Excess of copper in human body is toxic and causes hypertension sporadic fever, uremia, coma and even death.

In the present study, it has been observed that the concentration of copper has varied from 0.00 to 0.19 mg/L in the study area. The results indicate that the concentration of copper is below the maximum permissible limit in all the samples.

IRON (Fe):

Normally it causes slight toxicity, but excessive intake can cause siderosis and damage to organs through excessive iron storage. In the present study, it is observed that the concentration of iron has varied from 0.14 to 0.63 mg/ Lin the study area. These results are well below the maximum permissible limit.

ZINC (ZN):

Zinc is an abundant element in rocks and ores but it is present in natural water only as a minor constituent because of lack of solubility of the free metal and its oxides. Zinc is required and is a beneficial element in human metabolism. A deficiency of zinc in the diet of the children leads to growth retardation. It is necessary for functioning of various enzyme systems, including alkaline phosphatase; carbonic anhydrase and alcohol dehydrogenize 11. Zinc may be toxic to aquatic organisms but the degree of toxicity varies greatly depending on water quality characteristics as well as the species being considered. Symptoms of zinc toxicity in human beings include vomiting, dehydration, electrolyte imbalances, abdominal pains, etc.

In the present study, the concentration of zinc has been observed to varying from 0.64 to 3.48 mg/L in the study area. The results indicate that the concentration of zinc is below the maximum permissible limit in all the samples.

	pH	EC	TDS	TH	TA	F	Cl	NO_2	NO_3	SO_4	PO_4	Ca	Mg	Na	K
pH		0.3154	0.2827	0.3779	0.0401	0.1041	0.3324	0.2861	0.0895	0.4160	0.2257	0.4565	0.113	0.0256	0.1335
EC			0.66694	0.81526	0.383	0.45068	0.96681	0.52538	0.9641	0.72739	0.13126	0.79966	0.6769	0.80527	0.22567
TDS				0.41644	0.23845	0.37191	0.52902	0.56821	0.0080	0.89639	0.0087	0.46126	0.2550	0.69125	0.18136
TH					0.0604	0.45380	0.75069	0.48851	0.07212	0.53993	0.2803	0.97643	0.91501	0.34630	0.0982
TA						0.22063	0.15893	0.16013	0.21003	0.18940	0.37696	0.01223	0.0431	0.13301	0.0982
F							0.41091	0.04956	0.14199	0.42695	0.0930	0.44724	0.44919	0.30688	0.09471
Cl								0.45164	0.0542	0.60592	0.23827	0.72157	0.6210	0.78047	0.0803
NO_2									0.14326	0.60065	0.33055	0.47244	0.2982	0.41429	0.17682
NO_3										0.04146	0.01115	0.05148	0.01017	0.11689	0.01261
SO_4											0.0668	0.63102	0.3095	0.66912	0.09951
PO_4												0.32644	0.2392	0.42429	0.30581
Ca													0.8444	0.33917	0.2239
Mg														0.25031	0.2062
Na															0.24197
K															0.2554

Table 5: The Correlation coefficient (r) values among various water quality parameters of potable water

MERCURY (Hg):

Mercury (II) has a strong affinity for sulfhydryl groups in proteins, enzymes, hemoglobin and serum albumin. Because of the abundance of slufhydryl groups in active sits of many enzymes, it is difficult to establish exactly which enzymes are affected by mercury in biological systems.

The effect upon the central nervous system following inhalation of elemental mercury is largely psychopathological. Among the most prominent symptoms are tremor (particularly of the hands) and emotional instability characterized by shyness, insomnia, depression, and irritability. These symptoms are probably the result of damage to the blood-brain barrier. This barrier regulates the transfer of metabolic, such as amino acids to and from the brain. The effects of mercury probably disturb brain metabolic processes.

The kidney is the primary target organ of mercury (II). Chronic exposure to inorganic mercury (II) compounds causes proteinuria. In case of mercury poisoning of any type, the kidney is the organ with the highest bioaccumulation of mercury. Excretion of inorganic mercury occurs through the urine and faces. The results in table 4 indicate that all the samples do not contain mercury.

LEAD (PB):

Lead is a minor element in the earth's crust but is widely distributed in low concentration in uncontaminated sedimentary rocks and soil. The World Health Organization has established 0.1 mg/L as a tentative limit for lead in drinking water. However more significant contributions of lead come from atmosphere. Lead is toxic to aquatic organism but the degree of toxicity varies greatly, depending upon the characteristics of water as well as species being considered.

Lead in high doses has been recognized for centuries, as a cumulative general metabolic poison 12. Survey reveals that the inhabitants of the area are suffering from hardness, lassitude, slight abdominal discomforts, irritability and anemia, which are the symptoms of acute poisoning of the presence of high concentration of lead in drinking water.

The present study has revealed that the concentration of lead has varied from 0.00 to 0.003 mg/L in water samples. The observed values are very low when compared with the guideline values.

MANGANESE (MN):

Manganese occurs in ground water much less frequently and in smaller concentration (seldom more than 0.2ppm) than iron, which it resembles in behavior. It occurs as soluble manganese bicarbonate that s changed into insoluble sooty manganese hydroxide when it comes into contact with oxygen. The stains caused by manganese are harder than those of iron to remove. Slime forming bacteria, similar to iron bacterial may also oxidize the manganese salts into insoluble forms. The maximum permissible limit of the manganese in water is 0.5 mg/L. The results in table 4 indicate that all the samples in the study area do not contain manganese.

STATISTICAL ANALYSIS:

The correlation coefficient (r) coefficient of determination (r^2) and regression coefficients (A&B) are very important variable to evaluate the quality of water 13 -17. The correlation coefficient (r values) for various water quality parameters of bore wells water are presented in **Tables (5).**

CONCLUSIONS:

The pH values of water samples are greater than 7.0, indicating the alkaline nature of waters. However, all the pH values are within permissible limits. E.C. values are high in samples 1, 7, 8, 9 and 12. Such water is unfit for human consumption. The EC values of the remaining samples have not exceeded the desired limit. Higher TDS values, again in samples 1,7, 8 and 9 make these waters harmful for human consumption. TDS values in the rest of the samples are below the red mark. Hardness in the highest degree is found in samples 1, 4, 7 and 9. Such waters need to be softened to make them suitable for consumption by human beings. TH values in all other samples re below the danger-mark. All the samples have alkalinity in the highest degree, far above the desired limit.

Chloride concentration is high, once again the samples 1 and 11 stated earlier. However, this concentration in all other samples is not beyond the optimum limit. Calcium, potassium and magnesium values are within the permissible limit except in sample 2. Sodium concentration has exceeded the limit in all the samples. Manganese and mercury are not traced in any of the samples.

It is disheartening to note that fluoride content is found beyond the WHO limit in samples 1, 2, 6, 8, 9 and 12. Good correlations among various water quality parameters are observed in all samples. Defluoridation process is suggested to make study area water portable.

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