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Assessment of Ground Water Quality of Ellenabad Town & Its Near By Villages With Respect to Fluoride

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ABSTRACT: Groundwater is the major source of drinking water in both urban and rural India. Besides, it is an important source of water for the agricultural and the industrial sector. Being an important and integral part of the hydrological cycle, its availability depends on the rainfall and recharge conditions. Till recently, it was considered a dependable source of uncontaminated water. The quality of ground water is highly related to environmental and geological conditions. The quality of soil, rock and the water table determines the quality of ground water. The objective of the present study was to determine the fluoride and other water quality parameters in the ground water of Ellenabad town and its nearby villages of Sirsa district of Haryana, India. A total of twenty six groundwater samples were collected randomly collected at different depths from tube wells and hand pumps. The fluoride content in ground water is determined by SPADANS method. From the study it was observed that Ellenabad is highly fluoride endemic area. Fluoride is mainly of natural origin in ground water and fluoride gets deposited in the bone and teeth as calcium fluoraphatite crystals. Ingestion of fluoride in ground water may leads to mottling of teeth, skeletal fluorosis and dental caries. In Indian condition, water which is having fluoride content up to 1.5 ppm is acceptable. In present study fluoride content of the town varied from 0.45 to 7.20 67% samples are found within limits and 33% are out of limits of WHO. Therefore, the intake of fluoride concentration is very high as people use groundwater without any prior treatment. The results suggest that the groundwater should be used by the residents only after defluoridation.

Keywords: Fluoride, Ground Water Quality

I. INTRODUCTION

Earth has 330 million cubic of water with most occurring as non potable sea water, 0.06% of Earth's water is ground water. Ground water found in aquifers which have the capability of both storing and transmitting ground water. Groundwater is an integral part of the environment, and hence cannot be looked upon in isolation. There has been a lack of adequate attention to water conservation, efficiency in water use, water re-use, groundwater recharge, and ecosystem sustainability. An uncontrolled use of the bore well technology has led to the extraction of groundwater at such a high rate that often recharge is not sufficient. The causes of low water availability in many regions are also directly linked to the reducing forest cover and soil degradation. Presence of more than 200 chemical constitutes in the ground water has been documented including approximately 175 organic and more 50 inorganic and radio nucleotides. USEPA has detected volatile organic compounds (VOC) in 466 randomly selected public groundwater supply systems. Those occurring most often were tricolor ethylene and tetrachloride ethylene. In the developing countries like India the contamination of water supplies by organic compounds is of minor concern. At such places the major health problems are due to the presence of inorganic chemicals in groundwater. Therefore, it becomes necessary that water supply from municipality/private owned handpumps/tubewells should be monitored regularly to avoid associated health problem. Water resources are getting polluted day by day. The factors like over population, urbanization, industrialization etc. are contributing different percentage of pollutant to pollute the water bodies. The waste materials generated from these are always discharged into the lap of different water bodies. Thus the concentration of water pollutants goes on increasing day by day. Now, to protect various water bodies from different pollutants is a Global concern. Tireless efforts are going on by various governmental and non-governmental organizations to protect the water bodies like different lakes and various rivers throughout the globe. Fluoride is considered as a major pollutant of ground water on global scale. Nearly 25 countries in the world are suffering from excess of fluoride content in the groundwater and India is one of them. Periodic incidences of high fluoride content in ground water have been reported in various states of India. Approximately 20 states of India are facing the problem of excessive fluoride in the ground water and about 62 million people including 6 million children suffer from fluorosis because of consumption of water with high fluoride concentrations (UNICEF, 1999).

According to WHO (1997) the permissible limit for fluoride in drinking water is 1.5 mg/l, whereas, USPHS (1962) has set a range of allowable concentrations for fluoride in drinking water for a region depending on its climatic conditions because the amount of water consumed and consequently the amount of fluoride ingested being influenced primarily by the air temperature (Singh *et al*., 2007). The major sources of fluoride in groundwater are fluoride-bearing rocks such as fluorspar, cryolite, fluorapatite and hydroxylapatite (Agarwal *et al*., 1997). Fluoride ions from these minerals leach into the groundwater and contribute to high fluoride concentrations (Latha *et al*., 1999; Ramesam and Rajagopalan 1985).

II. MATERIALS AND METHODS

A. Study area

Ellenabad is a city, located in West Haryana on the border of Rajasthan and a municipal committee in Sirsa district in the state of Haryana, India. It is near about 300 kilometers from New Delhi and 42 kilometers from Sirsa and 57 kilometers from Hanumangarh (Rajasthan). Ellenabad is located at 29.45° N 74.65° E. It has an average elevation of 189 meters (620 feet).The area is characterized by extreme temperature in winter and summer and high wind velocity during summers. Geological formations are alluvial type. Soils are sandy loam and exhibit a wide variation in their composition. The subsoil water is stored in sand and gravel beds. The depth of water table is 7 to 30 meter. Hand pumps and electricity operated tube-wells are used to extract the ground water. The depth of tube wells varies from 50-110 meters in the study area. Main occupation of people is agriculture and landless people work as labourers in agriculture fields. The important crops grown in this area are wheat and rice.

B. Water sampling

Samples were collected in pre-cleaned, sterilized, polyethylene bottles of one liter capacity. It was ensured every time that bottle satisfies the following requirements:

(i) Free from contamination
(ii) Resistant to any internal pressure
(iii) Don't affect water characteristics.

A total of 26 samples were collected from Ellenabad town. The pH of the water samples was determined on the site. While sampling, all the precautions were taken as given by APHA (1989) manual of water analysis. The samples were kept in ice box and brought to lab within five hours of sampling and were refrigerated to avoid any change in the physico-chemical properties due to various contaminants. Sampling sites are given in Table 1.

Table 1: Sampling Sites.

Sr.No.	Sampling Location	Source
1	Bus Stop, Kashi ka bas	H.P.
2	Railway crossing, ward no. 16.	H.P.
3	Bahadur Saharan, Kashi ka bas	H.P.
4	Hazari Singh Kashi ka bas	T.W.
5	Sarvodaya School, Sirsa Road	H.P.
6	Yoga Ashram	H.P.
7	Tehsil	H.P.
8	Ambedkar Chowk Bypass	H.P.
9	Mameran Road	T.W.
10	Lakhji ki Dhani	H.P.
11	Sanskrit College, Sirsa Road1	H.P.
12	Gaur Brahmin Sabha, Nohar Road	H.P.
13	Kataria Sweets	T.W.
14	Baghichi Mandir, Nohar Road	H.P.
15	Kutia, ward no. 2	T.W.
16	Mandi Town office	T.W.
17	NAC-II, Mameran Road	T.W.
18	Devi Lal Chowk	H.P.
19	Ward no. 15	H.P.
20	Ward no. 1	H.P.
21	Govt. Girls School	T.W.
22	Ramdev Mandir	H.P.
23	Anaj Mandi	T.W.
24	Govind Ram, Kashi ka bas	T.W.
25	Brick Bhatta, Hanumangarh Road	H.P.
26	Shamshan Ghat, Hanumangarh Road	T.W.

III. RESULTS AND DISCUSSION

A. pH (hydrogen ion concentration)

The pH values of different analyzed samples are given table no. 5.2 WHO permissible limit for drinking water is 7 to 8.5. In the absence of any alternate source of water with pH 6.5 to 9.2 can be used. In the present studies the pH value of samples varies from 6.48 to 7.98. Highest pH was observed at location no. 11 as shown in Fig. 1.

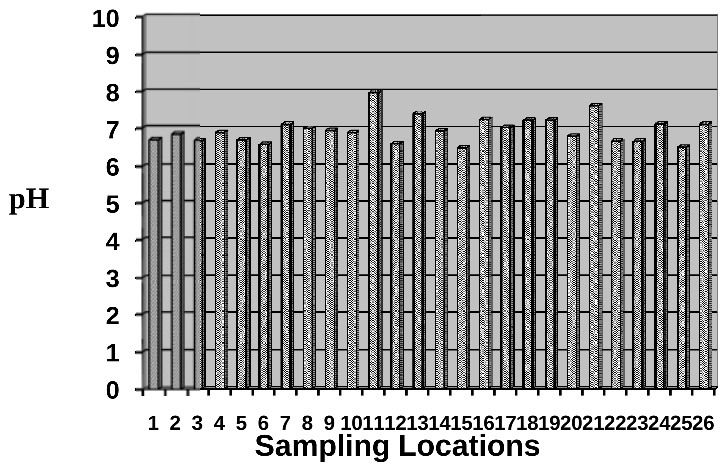

Fig. 1. pH of sampling locations.

B. Electrical conductivity and total dissolved salts

EC of a water sample signifies the amount of TDS or salinity of the sample which in turn indicate the inorganic pollution load in water sample. According to WHO the acceptable amount of TDS in ground water for drinking purpose is 500 ppm which can be extended up to 1500 ppm in case of non availability of any other alternate source. An attempt has been made to classify the samples of ground water from Ellenabad on the basis of classification of Rabinov *et al.* (1958) is given in Table 2.

Table 2: Classification of ground water samples on the basis of TDS values according to Rabinov *et al.* (1958).

SR. No.	Classification of ground water	TDS (ppm)	No. of Samples	% of samples
1	Non -saline	<1000	6	23.07
2	Slightly saline	1000-3000	17	65.38
3	Moderately Saline	3000-10000	3	11.53
4	Very- Saline	>10000	-	-

EC of collected water samples ranges from 1.1 to 7.1 mS as shown in Fig. 2.

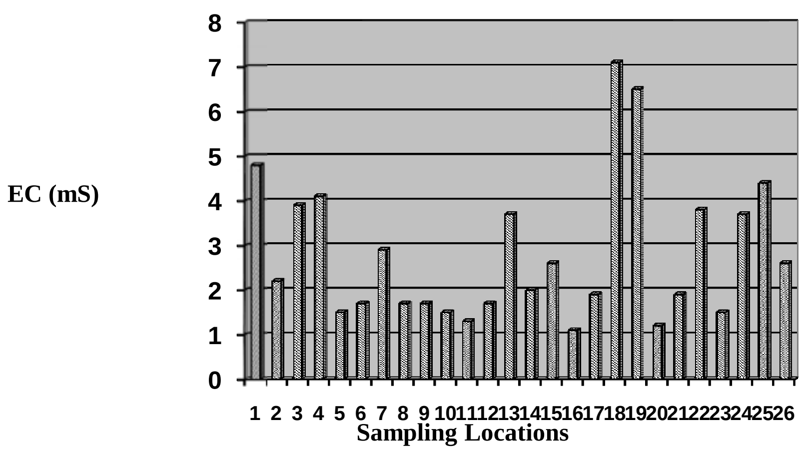

Fig. 2. EC (mS) of sampling locations.

TDS value ranged from 704 ppm to 4544 ppm as shown in Fig. 3.

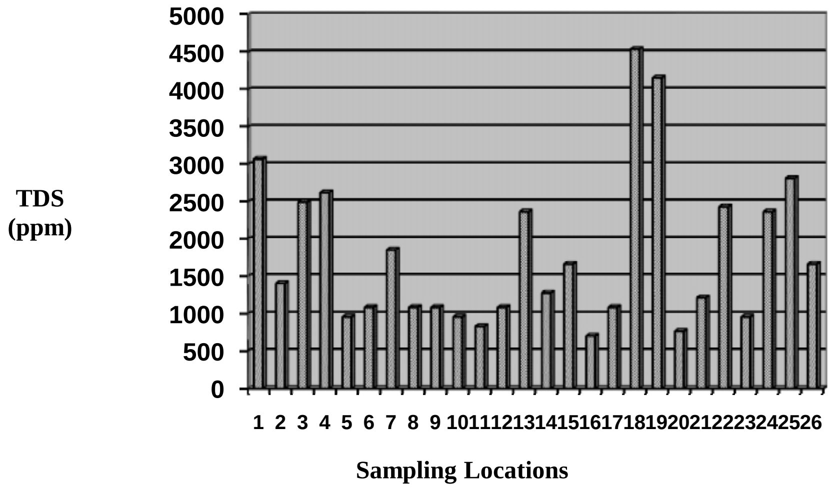

Fig. 3. TDS (ppm) of sampling locations.

C. Total hardness (TH), Calcium and Magnesium

Hardness is very important property of water from its domestic point of view. Hard water causes problems in boilers in industries. If hard water is used for long period, it may be one of the causes of stone formation in body. At domestic level if hard water is used for washing causes wastage of soap. In ground water hardness is mainly due to carbonate, bicarbonate, sulphates, chlorides and nitrates of calcium and magnesium. Hardness is one of the very important properties of ground water from utility point of view for different purposes. The value of TH ranged from 64 ppm to-1202 ppm as shown in Figure 4. The acceptable limit of total hardness (as $CaCO_3$) is 200 ppm, which can be extended up to 600 ppm in case of non availability of any alternate water source.

Ca^{2+} and Mg^{2+} are important parameter for total hardness. The acceptable limit for calcium and magnesium for domestic use are 75 and 30 ppm respectively. In ground water where as in case of non availability of water source calcium up to 200 ppm can be accepted (Ministry of rural development, India).

If these components are more than this leads to encrustation in water supply structure and adversely affect use of water. In Ellenabad ground water, Ca^{2+} range from 3.2 ppm to 204.8 ppm as shown in Figure 5. Magnesium ranged from 11.66 to 219.18 ppm. Only 8 locations have magnesium content less than 30 ppm where as another locations have Mg^{2+} content above permissible limits. An attempt had been made to classify the sample of ground water from Ellenabad town on the basis of classification of Durfor and Becker (1964) is given in Table 3.

It is reported in various studies that there is any inverse relationship between hardness of drinking water and cardiovascular disease (Smith et al., 1987; Ozik, 1989). The results of several studies suggested that a variety of other diseases are also inversely correlated with hardness of water including anencephaly (Bound *et al.,* 1981) and various types of cancer (Wigle *et al.,* 1986). Extremly hard water > 500 ppm may cuase kidney or gall blader stones (Garzon and Eisenberg, 1998), whereas, consumption of very soft water < 50 ppm lacking in essential minerals like calcium and minerals is also harmful for the body (Consumer Research, 1991).

Table 3: Classification of studied ground water samples on the basis of Total Hardness according to Durfor and Becker (1964).

S.No	Total hardness (ppm)	Description	No. of samples	% of samples
1.	0-60	Soft	-	0
2.	61-120	Moderately Hard	6	27.27
3.	121-180	Hard	3	13.63
4.	>180	Very hard	13	59.09

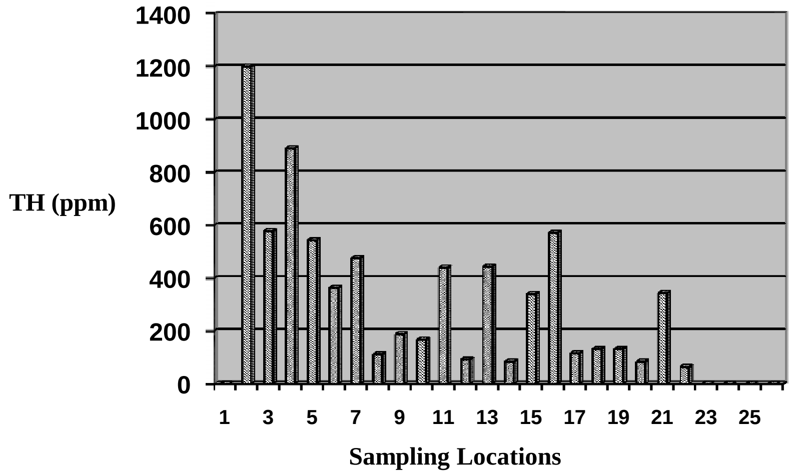

Fig. 4. TH of sampling locations.

D. Total alkalinity (T A), Carbonate and Bicarbonate
Alkalinity is measure of the ability of water to neutralize acids the constituents of alkalinity in natural system include mainly OH^-, CO_3^{2-} and HCO_3^- and other constituents which may contribute to alkalinity are $H_2SO_3^{2-}$, HPO_4^{2-}, HS^- and NH_3O. These compound results from dissolution of mineral in soil and atmosphere (Mittal and Verma, 1997) by far carbonate and bicarbonate may originate from microbial decomposition of organic matter also.

The WHO acceptable limit for alkalinity is 200 ppm in absence of alternate water source, alkalinity up to 600 ppm is acceptable for drinking purposes (Ministry of Rural Development, India). In the present study TA ranged from 56 (sample no. 9) to 1916 ppm (sample no 22) as shown in Fig. 5. Carbonate may cause heart problem if present in excess.

The carbonate content in ground water of Ellenabad found nil. The bicarbonate content varied from 68.32 ppm to 2337.52 ppm as shown in Fig. 6.

Chloride. Chloride occurs in all types of natural water. A high content of chloride gives salty taste to water. People who are not accustomed to high chloride in drinking water are subjected to laxative effects. Maximum permissible limit of chloride in potable water is 250 ppm which may be further relaxed up to 300 ppm in Indian condition. The chloride content in the ground quality of Ellenabad is ranging from 76.07 ppm to 990.9 ppm as shown in Fig. 7. **Fluoride.** The ground water usually contain higher amount of fluoride ion dissolved from geological conditions while the surface water usually contain lesser amount of fluoride. Ingestion of fluoride prior to the eruption of teeth has a cariostatic effect (chow, 1990).

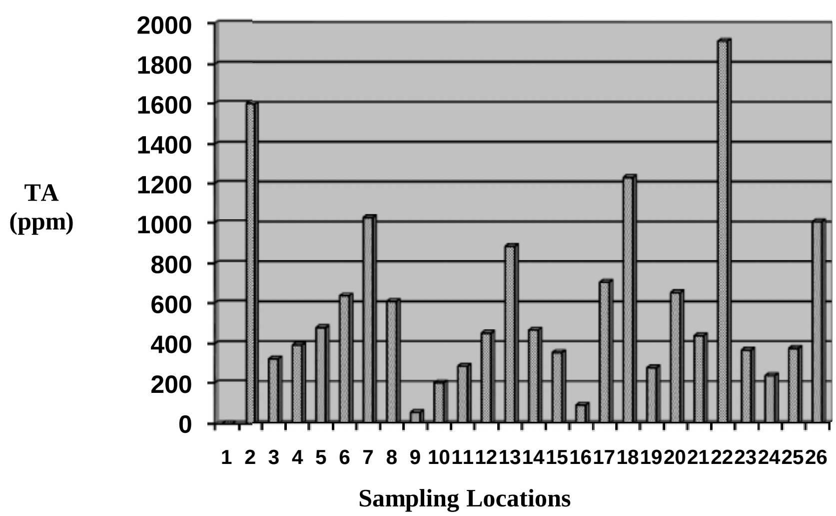

Fig. 5. TA (ppm) of sampling locations.

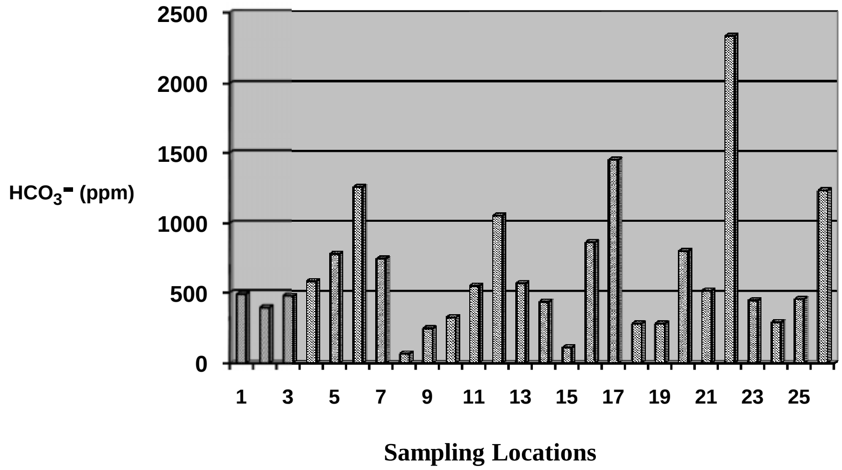

Fig. 6. Biocarbonate of sampling locations.

The risk of dental caries is reduced due to the uptake of fluoride by enamel crystallites and formation of fluorhydroxyapatite which resists acid solublization. The post-eruptive protective effect is attributed to the reduced acid production by plague bacteria and an increased rate of enamel remineralization (Marquis, 1995). Excessive fluoride intake can lead to fluorosis of both teeth and bones. Children between the ages of 2-3 year are at most risk of suffering from cosmetic fluorosis (Evans and Darvell, 1995).The fluoride acceptable in ground water in different areas varies according to source of water (surface or subterranean) geological formation of area, amount of rainfall and quantity of water lost by evaporation. The various factors that govern the release of fluoride ion in natural water by fluoride bearing minerals and rocks are basic chemical composition of water, presence and accessibility of fluoride ion and time of contact between source, minerals and water. The WHO permissible limit of fluoride in ground water is 1 ppm whereas in temperate region, this assessable limit is 1.5 ppm, where intake of water is low. In Indian conditions also, water which is having fluoride content up to 1.5 ppm is acceptable. In the present study the fluoride content in ground water varies from 0.45 to 7.20 ppm as shown in Figure 9. The fluoride content of 33% of studied sample is beyond the permissible limit that is 1.5 ppm. According to Lesen (1957) under tropical conditions fluoride concentration in drinking water should be below 1 ppm. If we divide the analyzed water samples in the safe (1 ppm) partially problematic (1-1.5 ppm), problematic (1.5 to 3 ppm) and highly problematic (> 3 ppm). The frequency distribution of fluoride in ground water sample from Ellenabad town is shown in Figure 8. (According to Lesen 1957).

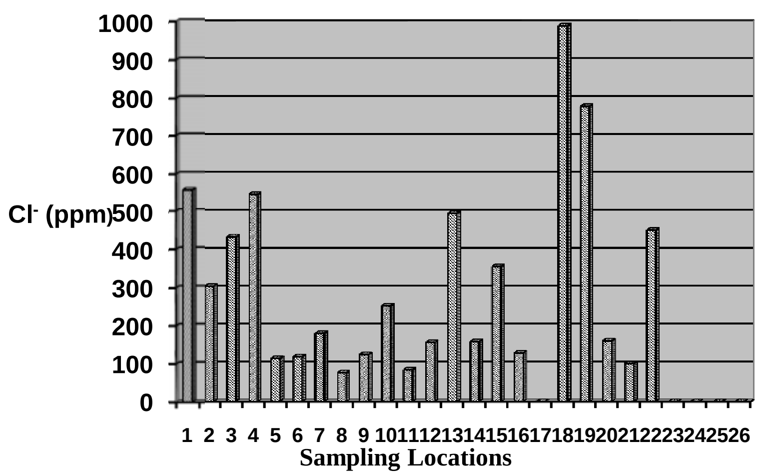

Fig. 7. Chloride of sampling locations.

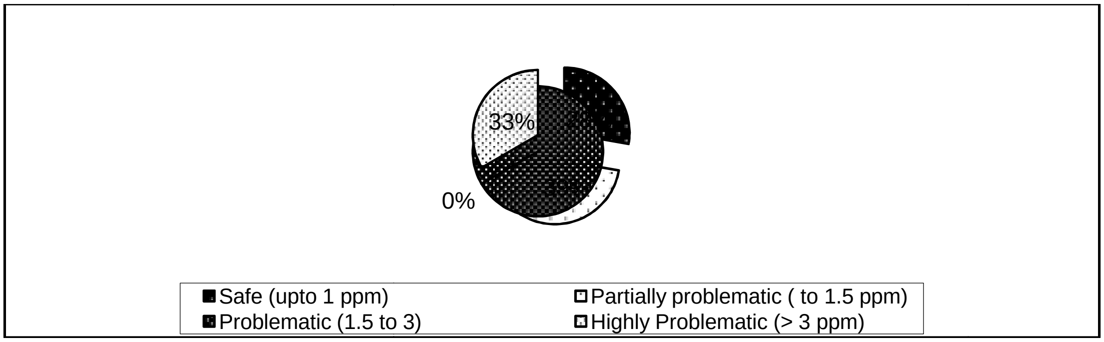

Fig. 8. Frequency distribution of fluoride in ground water sample from Ellenabad town.

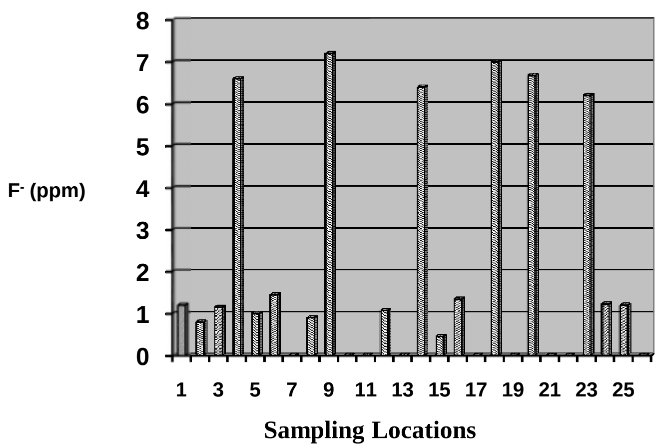

Fig. 9. Fluoride of sampling locations.

Nitrate-Nitrogen (NO_3^- -N). Nitrate is a poisonous component of ground water which is natural as well as of anthropogenic in origin, Nitrate in ground water may have originated from agricultural activities, industrial effluents, septic tank waste, animal waste etc. Nitrate is particularly dangerous to infants, below the age of 6 months. The excess amount of nitrate in water causes a disease in children, called blue baby syndrome (Methaemoglobinemia). The permissible limit of nitrate-nitrogen in ground water is 10 ppm. The nitrate content in present study ranges from 0.1 to 24.23 ppm as shown in Fig. 10.

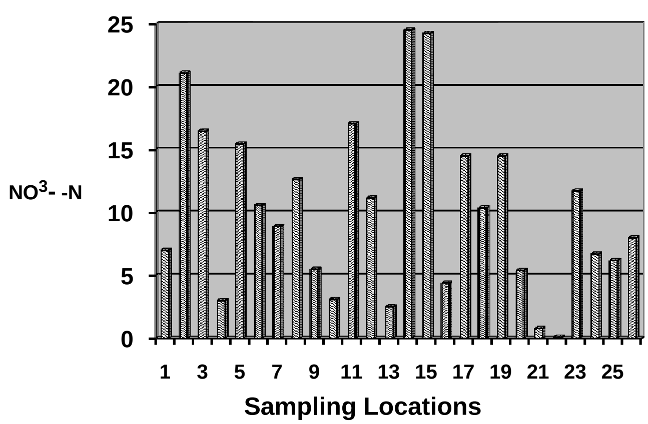

Fig. 10. Nitrate-Nitrogen of sampling locations.

Table 4: Physico-chemical characteristic of the analyzed ground water samples from Ellenabad Town.

Sample No.	pH	EC (mS)	TDS (ppm)	Total hardness as $CaCO_3$ (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	TA as $CaCO_3$ (ppm)	CO_3^{2-} (ppm)	HCO_3^- (ppm)	Cl^- (ppm)	F^- (ppm)	NO_3^- N (ppm)
1.	6.69	4.80	3072	1202	120	219.18	-	0	488.00	558.55	1.2	7
2.	6.84	2.20	1408	578	62.4	102.54	1600	0	395.28	304.33	0.8	21.08
3.	6.68	3.90	2496	892	204.8	92.34	324	0	478.24	434.43	1.15	16.45
4.	6.90	4.10	2624	544	44.8	104.97	392	0	585.60	546.54	6.60	3.0
5.	6.70	1.50	960	364	35.2	67.06	480	0	780.80	114.11	1.0	15.45
6.	6.58	1.70	1088	476	99.2	55.40	640	0	1259.04	118.11	1.45	10.57
7.	7.12	2.90	1856	112	17.6	16.52	1032	0	746.64	180.18	-	8.90
8.	7.01	1.70	1088	188	12.8	37.90	612	0	68.32	76.07	0.9	12.62
9.	6.95	1.70	1088	168	11.2	34.02	56	0	248.88	124.12	7.20	5.50
10.	6.90	1.50	960	440	51.2	75.81	204	0	326.96	252.25	-	3.10
11.	7.98	1.30	832	92	11.2	15.55	288	0	551.44	84.08	-	17.06
12.	6.60	1.70	1088	444	75.2	62.20	452	0	1054.08	156.15	1.07	11.15
13.	7.41	3.70	2368	84	3.2	18.46	888	0	570.96	496.49	-	2.5
14.	6.94	2.00	1280	340	36.8	60.26	468	0	439.20	158.15	6.40	24.5
15.	6.48	2.60	1664	572	118.4	67.06	356	0	112.24	356.35	0.45	24.23
16.	7.25	1.10	704	116	27.2	11.66	92	0	863.76	128.12	1.34	4.40
17.	7.04	1.90	1088	132	17.6	21.38	708	0	1454.24	-	7.00	14.48
18.	7.23	7.10	4544	132	4.8	29.16	1232	0	283.04	990.99	-	10.38
19.	7.23	6.50	4160	84	8.0	15.55	280	0	283.04	778.77	6.68	14.48
20.	6.80	1.20	768	344	46.4	55.40	656	0	800.32	160.16	-	5.40
21.	7.62	1.90	1216	64	4.8	12.63	440	0	517.28	100.10	-	0.8
22.	6.67	3.80	2432	244	20.8	46.65	1916	0	2337.52	452.45	-	0.1
23.	6.67	1.50	960	-	-	-	368	0	448.96	-	6.20	11.72
24.	7.13	3.70	2368	-	-	-	240	0	292.80	-	1.23	6.70
25.	6.50	4.40	2816	-	-	-	376	0	458.72	-	1.2	6.20
26.	7.12	2.60	1664	-	-	-	1012	0	1234.64	-	-	8

Table 5 : Comparison of Ground water quality parameters of Ellenabad Town with drinking water quality standard (Indian & WHO).

Parameters	Range of Samples		Mean	Std. Deviation	BIS Standards		WHO Limits
	Minimum	Maximum			Acceptable Limits	Maximum Limits	
pH	6.48	7.98	6.96	0.34	7.0-8.5	6.5-9.2	6.5-9.2
EC	1.4	7.1	2.8	1.58	-	-	-
TDS	704	4544	1792	1011.67	300	1500	500
TA	56	1916	604.48	446.70	200	600	-
TH	64	1202	346	264.44	300	600	300
Ca^{2+}	3.2	204.8	46.98	49.01	75	200	105
Mg^{2+}	11.66	219.18	54.82	45.80	30	100	50
CO_3^{2+}	0	57.60	35.52	14.74	75	200	75
HCO_3^-	68.32	2337.52	671.87	485.29	30	-	150
Cl^-	76.07	990.99	312.57	238.67	250	1000	250
NO_3^- - N	0.1	24.23	9.6	10.67	-	-	-
F^-	0.45	7.20	2.9	2.79	1.0	1.5	0.5

IV. CONCLUSION

1. pH measures hydrogen ion concentration and permissible limit of drinking water is 6.5-9.2. The pH of all water samples are found within the permissible limits WHO (6.5-9.2).
2. 65% ground water samples of Ellenabad town are slightly saline. 23% of samples are non-saline and rest 11% samples are moderately saline and out of permissible limit.
3. 59% samples of studied locations were found very hard which necessitate the softening of water prior to its use.
4. Ca^{2+} content was within the permissible limit in 86% samples and only one sample of Mg^{2+} was out of permissible limit.
5. Alkalinity of 92% of samples is beyond of permissible limits. CO_3^{2-} content was absent in all the samples.
6. HCO_3^- varies from 68.32 to 2337.52. Alkalinity is due to HCO_3^-.
7. Fluoride is mainly of natural origin in ground water fluoride gets deposited in the bone and teeth as calcium fluoraphatite crystals. Ingestion of fluoride in ground water may leads to mottling of teeth, skeletal fluorosis and dental caries. In Indian condition, water which is having fluoride content upto 1.5 ppm is acceptable. In present study fluoride content of the town varied from 0.45 to 7.20 67% samples are found within limits and 33% are out of limits of WHO.
8. About 50% of the samples showed NO_3^- - N content more than permissible limit. It is a cause of concern. Excessive NO_3^- - N content in drinking water gives rise to various health hazard.

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