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Spatial Distribution of Fluoride in Groundwater

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ABSTRACT:*Groundwater samples were collected from thirteen sampling stations in Kolar city, Karnataka, India in June 2015. Water quality variables such as pH, Total Dissolved Solids (TDS) and Electrical Conductivity (EC), Total hardness (TH), Bicarbonate, Calcium, Magnesium and Fluoride were estimated using the standard guidelines of APHA (1998). From the analysis it was found that 15.4% of the samples were out of the range prescribed by WHO (1993), 92.3% of the samples had the TDS values exceeding the permissible limit of WHO (1993), 70% and 54% of the groundwater samples had Total Hardness (TH) and Bicarbonate values exceeding the permissible limits of WHO (1993), 38.4%, 902.3% and 54% of the groundwater samples have shown the Calcium, Magnesium and Fluoride values to be above the permissible limits of WHO (1993). The correlation study has shown that the variables Fluoride and pH have shown insignificant correlation between themselves and with all the other water quality variables. All the results obtained are discussed in detail in the paper.*

KEYWORDS: Groundwater; APHA (1998); Kolar City; Fluoride; Correlation.

INTRODUCTION:

In today's scenario we are witnessing a two dimensional water crisis. On one hand the rate of Aquifer depletion has exceeded the rate of Aquifer recharge due to increase in fresh water demand, which is in turn a function of the elevated population. On the other hand the existing fresh water in the active sources are subjected to Geogenic and Anthropogenic pollution which is paving way for the further worsening of the situation. This paper analysis the groundwater pollution in Kolar city for its pollution with respect to Fluoride along with other water quality variables due to Geogenic causes.

The problems caused due to elevated concentration of fluoride in water is not new to India. The first problem related to Fluoride is India was reported as early as 1937 in Andrapradesh[1], later on 17 states were reported with endemic fluorosis in 1999[2]. Karnataka state also falls into this category where it has witnessed fluoride related problems mainly towards its eastern belt. A Physicochemical study of groundwater was carried out by [3] and [4] in Kolar and Chintamani taluks wherein higher concentration of fluoride were witnessed.

The most common minerals below through which fluoride enters into the groundwater are apatite, rock phosphate, topaz and fluorite [5]. Fluoride intake through water can be beneficial or detrimental to health depending on its concentration in water [6]. Consumption of water with Fluoride concentration about 1.5 ppm results in Dental and Skeletal fluorosis. Dental fluorosis includes discoloured, blackened, mottled or yellowish teeth, skeletal fluorosis includes stiffness of joints and calcifying of bones [7]. Both these types of 'Fluorosis' are irreversible and no effective treatment is known at the acute stages. A number of people suffering from dental fluorosis and bed-ridden through skeletal fluorosis was observed during the field work. Hence, it is high time that the concerned authorities in power should look into this situation with great concern and do the needful for the benefit of the people of Kolar city.

MATERIALS AND METHODS:

Groundwater samples from thirteen sampling stations were collected from Kolar city in pre-cleaned polythene containers of 2L capacity. Water quality variables namely pH, TDS and EC were

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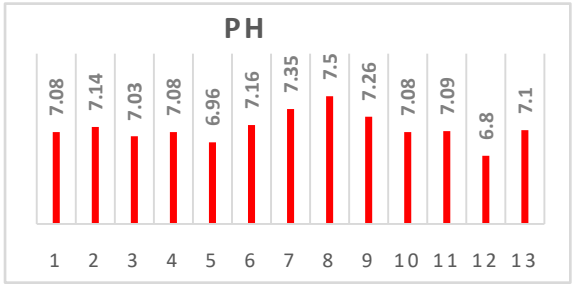
measured in situ, using the portable water analyser kit. In the laboratory of Atria Institute of Technology, Bengaluru, Total Hardness, Bicarbonate, Calcium and Magnesium were estimated using titremetry. Fluoride was estimated by SPADNS method using the Spectrophotometer Elico. Double distilled water and AR-grade chemicals were employed throughout the analysis.

TABLE 1: SHOWING THE VALUES OF ALL THE WATER QUALITY VARIABLES

Samples	pH	EC (µS/cm)	TDS (ppm)	TH (ppm)	HCO_3^- (ppm)	Ca^{++}(ppm)	Mg^{++} (ppm)	Fluoride (mg/L)
1	7.08	3600	1805	950	530	61.13	216.88	1.6
2	7.14	3400	1702	850	570	84.17	186.86	1.45
3	7.03	4100	2052	1000	580	108.21	217.6	1.57
4	7.08	2400	1204	620	460	61.14	136.37	1.32
5	6.96	2405	1202	680	540	84.17	145.38	1.78
6	7.16	2100	1054	520	560	60.12	112.21	2.06
7	7.35	1701	851	450	460	68.14	93.17	1.49
8	7.5	1900	954	340	410	72.14	65.36	1.36
9	7.26	1900	949	480	440	52.1	104.4	1.8
10	7.08	2700	1350	620	890	80.16	131.72	1.02
11	7.09	3600	1807	870	560	124.24	181.96	1.45
12	6.8	200	105	100	160	20.04	19.51	2.21
13	7.1	2700	1350	620	560	68.14	134.65	1.75
WHO Limits	7 - 8.5		500	500	500	75	50	1.5

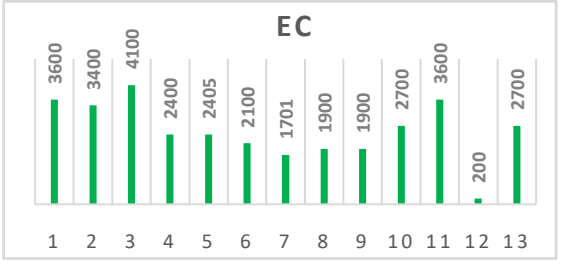
RESULTS AND DISCUSSION:

pH: pH is a Logarithmic scale which is used to indicate the acidity or alkalinity of an aqueous solution [8]. In the current study we have witnessed that except two samples (Sample Nos 5 & 12) all other samples have the pH values in the range prescribed by WHO (1993) as shown in table-1.



.Graph -1: Showing the pH values in groundwater of different study sites.

Electrical Conductivity: Electrical conductivity values give us a birds' eye view regarding the amount of ionisable substances present in the water[9]. In the current investigation the EC values ranged between 200 (µS/cm) to 4100 (µS/cm) with an average value of 2515.85 (µS/cm) as shown in table-1.



.Graph -2: Showing the EC values in groundwater of different study sites.

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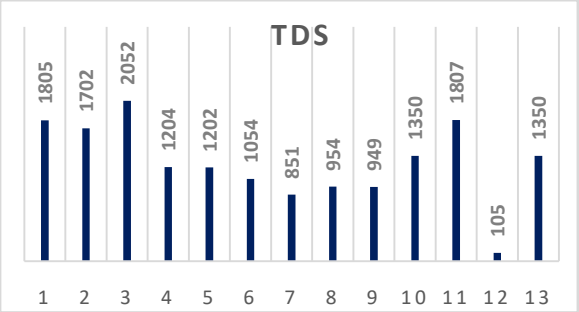
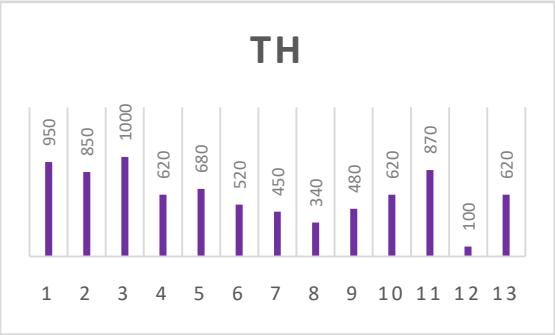
Total Dissolved Solids: According to [10] TDS of water with a value below or above 500 ppm is not suitable for consumption. In the current investigation we have witnessed an alarming situation of 92.3% of groundwater samples to have TDS values to be above the permissible limit of WHO (1993) i.e., 500 ppm as shown in table-1. The TDS values ranged between 105 ppm and 2052ppm with a mean value of 1167.92 ppm. Correspondingly the existence of high EC values of the groundwater samples reveal that there may exist a large number of ionisable substances in the groundwater samples.



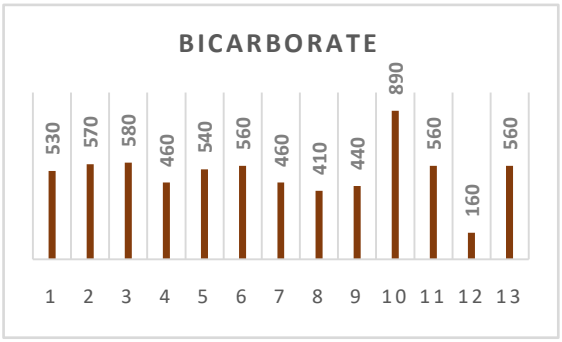
.Graph -3: Showing the TDS values in groundwater of different study sites.

Total Hardness: Hardness of water is caused due to the dissolved bicarbonates, chlorides and sulphates of Calcium and Magnesium in water[11]. Hardness of water is attributed to its soap consuming capacity wherein the lather formation is hindered due to the formation of insoluble precipitates by the reaction of $Ca^{++}$and Mg^{++} ions with soap. In the current study the TH values ranged from 100 ppm to 1000 ppm with a mean value of 623.08 ppm with is exceeding the WHO (1993) permissible limit i.e., 500 ppm as shown in table-1.



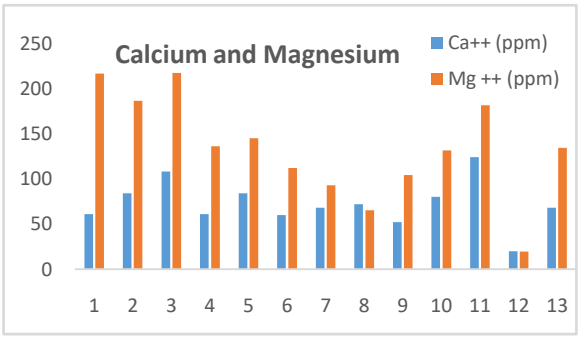
.Graph -4: Showing the TH values in groundwater of different study sites.

Bicarbonate: In natural waters the bicarbonates contribute to the total alkalinity of water. Total alkalinity is the measure of water's capacity to neutralize naturally encountered acids. It is caused due to the presence of carbonates, bicarbonates and hydroxides in water[4]. In the present investigation the Bicarbonate values ranged between 16 ppm and 570 ppm with a mean value of 505.85 ppm which is exceeding the WHO (1993) limit i.e., 500 ppm marginally as shown in table-1.



.Graph-5: Showing the bicarbonate values in groundwater of different study sites.

Calcium and Magnesium: The divalent cations i.e., Calcium and Magnesium and primarily responsible for the Hardness in water. Both these ions enter into groundwater due to its interaction with several minerals, mainly the igneous rocks [12]. In the current pursuit the Calcium values ranged between 20.04 ppm and 124.24 ppm with a mean value of 72.60 ppm, the Magnesium values ranged between 65.36 ppm and 217.6 ppm with an average value of 134.31 which is much above the permissible limit of WHO (1993) i.e., 50 ppm as shown in table-1.



.Graph -6: Showing the Calcium and Magnesium values in groundwater of different study sites.

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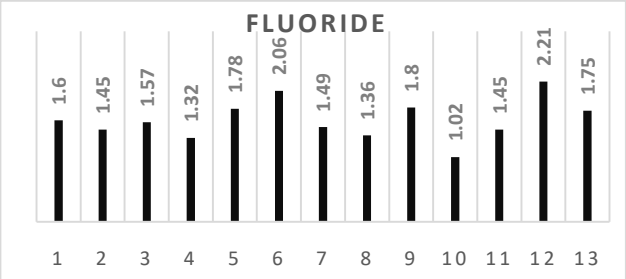
Fluoride: Elevated concentration of Fluoride is observed in the areas of bedrock possessing fluoride minerals [13] [14]. In the current study 54% of the groundwater samples are above the permissible limits of WHO (1993) i.e., 1.5 ppm as shown in table-1. A similar situation with respect to the fluoride concentration in groundwater is witnessed in the study carried out by [15]



.Graph -7: Showing the Fluoride values in groundwater of different study sites.

PEARSON'S CORRELATION:

Correlation matrix speaks about a mutual association among the water quality variables i.e., [16]. The values present in the table are called the correlation co-efficients (r). The correlation between two variables is significant when the (r) value is greater than 0.5[17]. Inspection of the correlation matrix shows that in the current study there exists an insignificant correlation between Fluoride and pH. All the other water quality variables have also shown insignificant correlation with them. The interesting insignificant correlation of Fluoride with all the other water quality variables paves way for the further Geochemical analysis of the study area.

TABLE 2: PEARSON'S CORRELATION MATRIX

	pH	*EC (µS/cm)*	*TDS (ppm)*	*TH (ppm)*	*HCO_3^- (ppm)*	*Ca^{++} (ppm)*	*Mg^{++} (ppm)*	*Fluoride (mg/L)*
pH	1							
EC (µS/cm)	0.012767	1						
TDS (ppm)	0.012065	0.999988	1					
TH (ppm)	-0.11846	0.976124	0.976069	1				
HCO3- (ppm)	0.084069	0.640262	0.638386	0.584585	1			
Ca++ (ppm)	0.123233	0.802849	0.802899	0.743499	0.583751	1		
Mg ++ (ppm)	-0.14109	0.965183	0.965119	0.997362	0.566856	0.692998	1	
Fluoride (mg/L)	-0.39197	-0.48484	-0.48421	-0.38951	-0.63983	-0.52815	-0.36261	1

CONCLUSION:

From the above study it is evident that the groundwater samples of Kolar city has got elevated concentrations of fluoride along with high values of TDS and Total Hardness. Water Softeners aresuggested to remove excessive hardness from the groundwater. Installation of Large scale 'Fluoride removal units' are strictly recommended in Kolar City to free the groundwater from excessive

concentration of fluoride. This greatly helps to control the passage of endemic fluorosis to the future generations. The authorities in power should address this burning issue immediately in depth by conducting a massive survey throughout the eastern belt of Karnataka and a large scale implementation of remedial measures and recommended.

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