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Hydro-quality Analysis of Ground Potable Water in Relation to Fluoride at Barkagaon, Hazaribag, Jharkhand, India

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ABSTRACT: *Quality assessment was carried out at 36 sites of Barkagaon Block of Hazaribag district. With reference to three different sources of potable water (i.e. 108 samples) different water parameters analysis was done in view of fluoridation. It reveals that out of 108 samples were fluoride observed in only 9 samples, in % contribution, the fluoride level zero (0) was observed in 91.67% while more than zero (0) was confirmed in 8.33% of water sample ranging in between 0.4-6.5 mg/ L. Lowest fluoride sites was Napokhurd and highest was Gali in the Barkgaon Block. Dental fluorosis cases were also observed at the study area, as per Dean's index. A correlative studies of different water parameters and fluoride indicated –ve relation with pH (r= -0.28), alkalinity (r=-0.21), total hardness (r= -0.02) and Calcium(r=-0.65), while +ve correlation was observed with temperature(r=+0.23) ,TDS (r=0.1) , chloride (r=0.25) and magnesium (r=0.62).*

KEYWORDS: Barkagaon , Fluoride , water parameters , correlation, Dean's index.

INTRODUCTION

Water is one of the important gift of nature which plays vital role in all living organism on the earth for their survival and growth (WHO, 2004). Clean and safe potable water is now recognized as a fundamental right of human beings. About 6-8 million people die each year due to lack of safe potable water (N. Rahmanian *et al.*, 2005). About 94% of total available water all over world is in the form of ground water (Kiran G. Chaudhari, 2014). Due to rapid growth of human population, industrization, use of fertilizes in the agriculture and manmade activities causes water pollution. Water is universal solvent and has the capacity to dissolve many substances including organic & inorganic compounds and ultimately change its nature i.e. the quality of water (Kumar and Sadhu, 2013). Therefore, it is very important that the quality of water should be monitored at regular time and interval for suitable growth of plants and animals (Patil P.N. Sawant et al. 2012). India is the largest user of ground water

and using over 25% of the total global use of ground water (Arbind Pd. Pandit, et al., 2014). The quality of ground water depends on the presence and concentration of various chemical constituents which are mostly derived from the geological formation of the particular region (N.C. Eboagu, 2019). Fluoride is 17th most abundant elements in the earth's crust (0.06-0.09%) and exists in combination with other elements as fluoride compound, which are constituents of minerals in rock and soil. It is one of the most essential nutrients for mineralization of bones and formation of dental enamel (Dhar and Bhatnagar,2005) but above the permissible limit i.e. 1.5mg/litre (BIS, 2003 and WHO, 2006), it causes severe health problems including dental fluorosis (Kumar and Sadhu 2013 & 2015). Geogenic contaminations including fluoride have affected ground water in more than 200 districts of 20 states of india (Gopal Pathak, 2014, Kumar & Sadhu, 2015). So, it is essential to assess the quality of ground water sources to ascertain their suitability for drinking and domestic purposes (N.C. Eboagu, 2019 and WHO,1993). In this regard present investigation is carried out to determine the extent of fluoride in potable ground water at Barkagaon block of Hazaribag district of Jharkhand State.

MATERIAL AND METHODS:

Study Area: The study area i.e. Barkagaon is 447.9km^2 which lies between 23º 52'5" North latitude and 85 º 14'15" East longitudes. The altitude is about 600 meters from mean sea level. It consists of 83 revenue villages of 23 panchayats having total population 1,10,958 as per census report 2011.

Collection Sites: For easy work, entire study area i.e. Barkagaon block has been divided in to four zones which consisting entire panchayat i.e. 23. The Zone-I are comprising of Mohugaikalan, Choundol, Harli, Badam and Godalpura panchayat, Zone-II are consisting of Chopdarbaliya, Ango, Tlashwar, Kandtari, Sirma and Sikri panchayats, Zone- III are comprising Garsulla, Urimari, Potnga and Napokhurd panchyats and Zone-IV are consisting of Barkagaon (East + West + Middle), Sindwari, Chepakalan, Nayatand,Sandh and Darikala panchayats. From each zone, three panchayats were selected randomly as collection sites i.e. total number of twelve panchayats which cover entire study area for analysis of potable water. Three places were selected from each panchayts as collection sites i.e. 36 sites in which three different sources of potable water were identified for collection of potable water i.e. well depth between 22 to 35 feet, hand pump below 150 feet and hand pump above 150feet during January 2019 to December 2019. Therefore total numbers of samples were 108 (=36*3) (fig-1). Before the collection of samples first, the water was left to run from the sampling source for 4-5 minutes to pump out the volume of water standing in the casing before taking the final samples and then water samples were collected in pre- cleaned sterilize polyethylene bottles of the one litter capacity.

Analysis Methods:

The ground water samples were analyzed to assess different Physico–chemical parameters such as pH, Temperature, TDS, alkalinity, Fluoride, Chloride, Total hardness, Calcium and Magnesium as par guideline of APHA-2005. The pH, TDS and temperature of the water samples were measured by using a potable pH meter (model- pH 009(I) pen type digital meter), TDS & Temperature by HM meter respectively. Measurement of Alkalinity was done by titrimetric method while Chloride test was done by Water testing kit (Nice Chemical pvt. Ltd.). The amount of Total hardness and calcium were measured by EDTA method (APHA-2005, 21th edition) while the amount of magnesium was measured by the calculation of difference between Total hardness and Calcium hardness. The fluoride concentration was measured by using the Hand Held colorimeter (fluoride HR code H1739 by HANNA Instruments Inc.).

RESULTS AND DISCUSSION

The result obtained after the analysis of various physico-chemical parameters in the different sources of potable water. This result showed in the table-1. The results show pH values vary from 6.7-8.8 (8.01±0.43) indicating alkaline nature of water while temperature values in between 25.3-27.9 (26.37±0.71) show very little change. The value of TDS of water samples from different sites varies between 67-793mg/L (338.6±161.15). It shows great variation but within the limit i.e. 600mg/L WHO, 2001. The alkalinity of the potable water varies from 20-310 mg/L (114.53±58.69) which were acceptable limit (300mg/L, WHO, 2001). The value of chloride ions varies from 50 to 420 mg/L which are higher than permissible limit i.e. 250mg/L, WHO, 2001 and BIS, 2009 but within the range (250-2000mg/). The total hardness of potable water from different sources ranges from 140-600mg/L (302.22±120.45 mg/L) which are higher than permissible limit (300mg/L, BIS, 2009) but within acceptance limit. The values of calcium and magnesium vary from 36 to 380mg/L (136.35±69.69) and 32 to 380mg/L (164.04±91.85) respectively. According to WHO, 2001 and BIS, 2009 permissible limit for Ca^{++} are 100mg/L and for 75mg/L and Mg^{++} are 30mg/L respectively. This result shows higher values than permissible limit (table-2). The concentration of fluoride in different sources of potable water from different sites varies from0 to6.5 mg/L. Out of 108 samples from different sites, only 9 samples are contaminated with fluoride (0 to 6.5mg/L), shown in table-1,2,3 and table-4 with highest fluoride level at Gali (6.5mg/L). The contaminated potable water is found in between ≥150 to ≤150 feet while no contamination of fluoride are found in well water. Only two samples show the level of fluoride within the range i.e. 1.5mg/L WHO, 2001 while 7 samples show above permissible limit. The higher concentration of fluoride is found in more than 150feet depth of ground water. The range fluoride concentrations are Gali-26>Cano-62>Chano-61>Lurunga-59>palandu-44>lurunga-58>Napokhurd-65>Gali-25> Napokhurd-65 i.e. 6.5mg/L >4.8mg/L> 4mg/L> 3.4mg/L> 2.9mg/L>

2.1mg/L> 1.5mg/L and >0.4mg/L respectively (Table-1). In terms of % contribution, the fluoride level 0 (zero) are observed in 91.67% but more than 0 (zero) observed in 8.33%. The distribution of fluoride level ≤1.5 mg/L are observed 1.85% at two sites i.e.Napokhurd-64 and Gali-25 between 1.5 to3mg/L, it was 1.85% at two locations (Lurunga-58 and Napokhurd-65), the fluoride level between 3 to 4.5mg/L, it is 2.79% at three sites (Palandu-44, Lurunga-59 and Chano-61) at the fluoride level between 4.5 to 6 ml/L, it was 0.92% at one collecting sample site (Chano-62) and at last range between 6 to7.5mg/L, it was 0.92% at one collecting sample sites (Gali-26). Further were studied at zone level (Table-2), out of four zone three were contaminated with fluoride while fourth control one. At panchayat level the result showed (Table-3) that out of 12 panchayat four were contaminated with fluoride and rest free from fluoride. Many cases of dental fluorosis were found in the fluoride prone areas. It was confirmed by Dean's index which are commonly used for identification of severity of dental fluorosis (Fig- 3). An attempt is made to correlate the fluoride with various parameters shown in table-3. The positive relationship exists between Temperature, TDS, magnesium and chloride while negative correlation with pH, alkalinity and total hardness (Table-4). After the use of ANNOVA it shows that value of F>F crit therefore result are significant and does not accept the null hypothesis follows alternate hypothesis (Table-5).

The major source of fluoride in ground water may be came from fragments of minerals such as apatite ($CaF_2.3Ca_3(PO_4)_2$), cryolite (Na_3AlF_6), fluorite or fluorspar (CaF_2), fluorapaptite ($Ca_{10}(PO_4)_6F_2$) or topaz (Al silicate containing F) (Pickering W.F.,1985) in the fluoride prone areas. The alkaline water can mobilize fluoride from fluorite with precipitation of calcium carbonate because the solubility of CaF_2 increase with an increase in $NaHCO_3$ rather than with other salts (Handa, 1975, Saxena and Ahmed, 2001, Salve P.R. et.al, 2008). In ground water the natural concentration of fluoride depends on the geological and chemical characteristics of the aquifer as well as the porosity and permeability of the soil and rocks present in the area, the temp., the action of other chemical elements and the depth of different sources of potable water. The aqueous ionic concentration of ground water may influence the fluoride solubility behaviour in the presence of excessive sodium bicarbonate and the dissociation activity of fluoride will be high(Tirumalesh et.al,2007, Salve P.R. et.al, 2008). The acidic from fluoride is absorbed in clay and in alkaline form, it is desorbed therefore alkaline, pH is more favourable for fluoride dissolution activity and can represented in table-3.

Table-1 Showing results (Zone I to IV) of potable water in the study area

Zone	pH	Temp.	TDS	Alkalinity	Fluoride	Chloride	T. hardness	Magnesium	Calcium
I	7.97 ±0.44	25.99 ±0.53	281.4 ±167.72	89.26 ±34.63	4 ±1.27	147.04 ±99.8	307.4 ±115.64	147.62 ±72.06	159.85 ±80.66
II	8.06 ±0.33	27.09 ±0.75	370.74 ±174.39	113.7 ±61.15	3.4 ±0.65	142.22 ±88.64	328.89 ±137.6	153.78 ±87.73	175.11 ±88.3
III	7.78 ±0.45	26.45 ±0.53	377.74 ±157.06	137.03 ±65.27	3.74 ±1.51	112.22 ±63.87	295.92 ±125.09	114.44 ±60.12	177.78 ±113.53
IV	8.23 ±0.45	25.94 ±0.53	324.52 ±157.06	118.15 ±65.27	0	108.52 ±63.87	275.55 ±125.09	129.55 ±60.12	143.41 ±113.53

Table-2 Comparison of Physico-Chemical parameters between Panchayat

PANCHAYAT	RESULT OF POTABLE WTER								
	pH	Temp.	TDS	Alkalinity	F	Cl	Total hardness	Mg	Ca
MAHUGAIKALAN	8.1 ±0.59	26.64 ±0.25	334.88 ±191.89	90 ±33.91	0	206.66 ±125.8	320 ±111.58	161.55 ±65.81	158.44 ±67.05
BADAM	7.7 ±0.23	25.56 ±0.31	239.55 ±155.02	80 ±25.98	0	103.33 ±54.77	290 ±112.23	122 ±69.87	168 ±90.4
GODALPURA	8.05 ±0.38	25.76 ±0.19	269.77 ±158.84	97.77 ±43.52	8 ±2.16	131.11 ±84.33	312.22 ±133.68	159.33 ±80.94	153.11 ±91.37
ANGO	8.19 ±0.29	26.97 ±1.06	354.33 ±137.76	112.22 ±82.43	0	135.55 ±72.3	305.55 ±119.7	140.67 ±96.25	164.89 ±61.97
TLASWAR	8.03 ±0.44	27.59 ±0.46	329 ±180.4	116.67 ±67.27	3.4 ±1.13	109.23 ±68.56	266.97 ±117.05	129.025 ±70.2	141.797 ±77.25
SIKARI	7.96 ±0.23	26.73 ±0.21	428.89 ±203.09	112.22 ±28.62	0	177.78 ±114.86	397.78 ±158.81	188 ±93.86	209.78 ±115.71
GARSULA	7.68 ±0.44	27.11 ±0.38	400.89 ±142.09	114.44 ±46.93	4.05 ±2.19	107.78 ±71.72	280 ±128.45	100.22 ±38.19	179.78 ±136.52
NAPOKHURD	8.08 ±0.51	26.08 ±0.16	396.44 ±144.55	180 ±62.25	1.25 ±0.7	104.44 ±35.74	302.22 ±130.84	98.89 ±32.96	203.33 ±130.57
POTANGA	7.6 ±0.25	26.17 ±0.13	335.89 ±190.06	116.67 ±68.19	0	124.44 ±81.1	305.56 ±129.62	144.22 ±87.78	150.22 ±67.86
SANDH	8.39 ±0.23	26.11 ±0.14	345.78 ±99.55	112.22 ±54.49	0	103.33 ±37.08	266.67 ±86.17	152.44 ±51.31	114.22 ±71.82
CHEPAKALAN	8 ±0.45	25.91 ±0.18	310.33 ±153.71	115.56 ±66.16	0	116.67 ±51.96	277.78 ±101.58	98.89 ±52.13	167.78 ±74.1
DADIKALAN	8.31 ±0.26	25.81 ±0.09	317.44 ±149.15	126.67 ±69.28	0	105.56 ±51.07	285.56 ±124.11	137.33 ±34.19	148.22 ±98.1

Table-3 Numbers of Fluoride contamination places and percentage

	ZONE	PANCHAYAT	SITE	SAMPLES
Total Number	4	12	36	108
No. of fluoride	3	4	6	9
% of fluoride	75%	25%	6%	8.33%

Table-4: Correlation between different parameters

Parameter	pH	Temp.	TDS	Alkalinity	Chloride	Total hardness	Mg^{++}	Ca^{++}	F
pH	0								
Temp	-0.9233	0							
TDS	-0.2448	0.111297	0						
Alkalinity	0.40647	-0.29382	0.312693	0					
Chloride	0.49891	-0.60741	0.516487	0.4012	0				
T. Hardness	0.49295	-0.76623	0.216497	0.1786	0.70633	0			
Mg++	0.42512	-0.49164	0.077444	0.1234	0.78567	0.505611	0		
Ca++	0.05239	-0.25437	0.13472	0.0503	-0.1054	0.471059	-0.52287	0	
Fluoride	-0.2817	0.22834	0.09193	-0.205	0.25403	-0.01937	0.62195	-0.65504	0

Fig.-1: Collection sites of the Study area

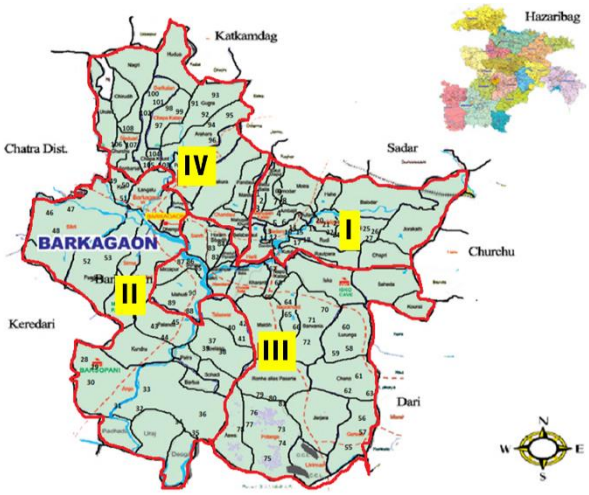


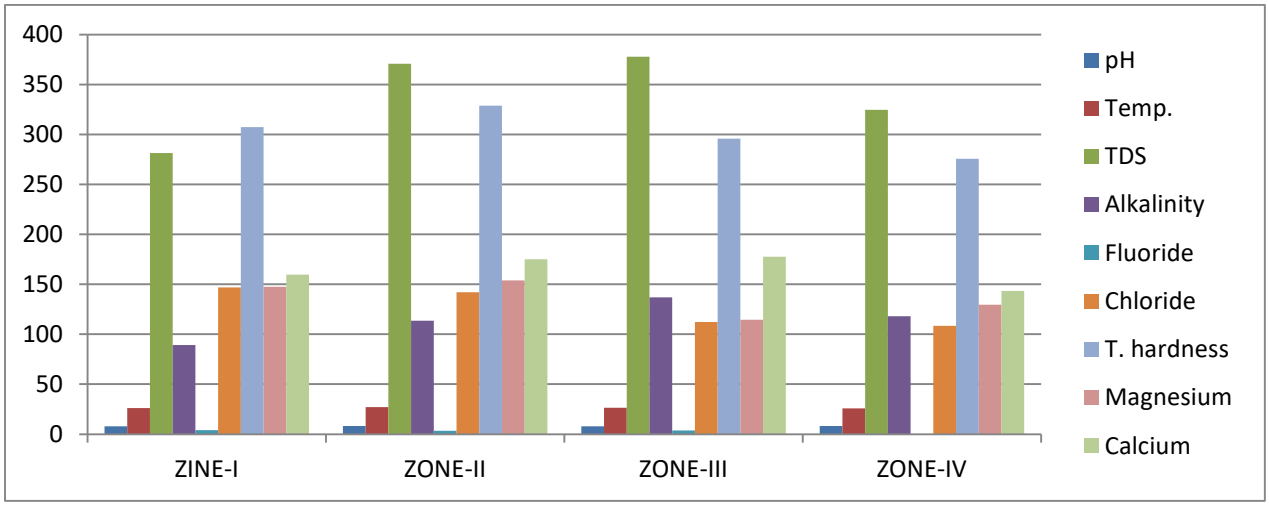
Fig. 2: Fluoride effected site of the study area

Table-5: ANOVAs: Single Factor

SUMMARY				
Groups	Average	Variance		
pH	7.8	0.44		
Temp.	26.85555556	0.727777778		
TDS	299.6666667	15862.75		
Alkalinity	124.4444444	4152.777778		
Chloride	85.55555556	602.7777778		
T hardness	227.7777778	2069.444444		
Mg	83.11111111	2216.111111		
Ca	144.6666667	2120		
Fluoride	3.344444444	3.457777778		
ANOVA				
Source of Variation	MS	F	P-value	F crit
Between Groups	91451.06244	30.4515592	3.37597E-20	2.069831642
Within Groups	3003.165185			
Total				

Fig. 3: Degree of dental fluorosis as par Dean's index

Chart-1: Showing comparison of different phyico-chemical parameters between different Zones


400
350
300
250
200
150
100
50
0
ZINE-I
ZONE-II
ZONE-III
ZONE-IV
pH
Temp.
TDS
Alkalinity
Fluoride
Chloride
T. hardness
Magnesium
Calcium

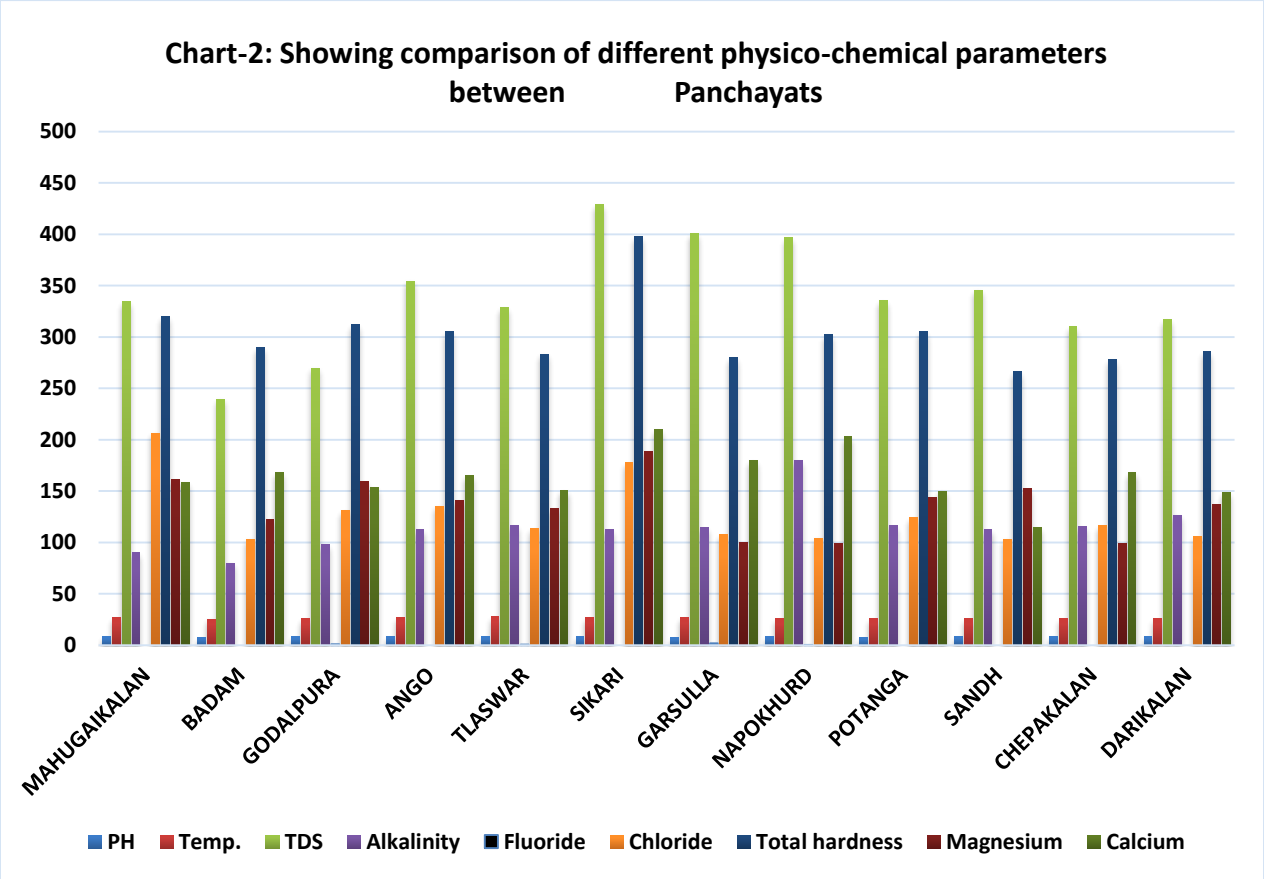


Chart-2: Showing comparison of different physico-chemical parameters between Panchayats
500
450
400
350
300
250
200
150
100
50
0
MAHUGAIKALAN
BADAM
GODALPURA
ANGO
TLASWAR
SIKARI
GARSULLA
NAPOKHURD
POTANGA
SANDH
CHEPAKALAN
DARIKALAN
PH
Temp.
TDS
Alkalinity
Fluoride
Chloride
Total hardness
Magnesium
Calcium

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