Fluoride Concentration and Correlation Coefficients between Physico-Chemical Parameters of Ground Water in Berhampur Ganjam, Odisha, India

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Abstract

The fluoride content of the ground water in and around Berhampur, the Silk city of Odisha (India) located in eastern coastal line of Ganjam district was determined during Jan-2009 -Dec-2012 to find the suitability for drinking purpose. Samples were collected from 25 locations of Berhampur city from various ground water sources in rainy, winter and summer seasons. In this study fluoride content present in the ground water having different location with the correlation coefficient between the various physic-chemical parameters were determined. Fluoride has a good positive correlation with total dissolved solid (TDS) in 2009-10, a positive correlation with nitrate, TDS & slightly positive correlation with alkalinity in 2010-11 and has a positive correlation with nitrate and slightly correlation with Alkalinity during 2011-12. It is observed that the fluoride content of ground water in the selected reason is varies from 0.09 to 1.7 mg/l during the research period.

Key words: *Ground water, Physico-Chemical Characteristics, Fluoride, Nitrate, Correlation coefficient.*

I. INTRODUCTION

Ground water is used for domestic, Industrial and irrigation all over the world. The importance of ground water for the existence of human society is very essential. Fluoride is one of the minor constituent in ground water [1]. The quality of water is a vital factor for mankind as it is directly related with human health [2]. Though the purity of water decreases by human activity, the increasing industrialization, urbanization and growth of mechanization are also the main factors for water crises [3]. Again due to rise in soil pollution by dumping of municipal wastes & by heavy use of chemical fertilizers in agriculture land, the properties of underground water has been change time to time [4]. Berhampur, one of the largest city of Odisha nick name silk city is located in eastern coast line of Ganjam district, Odisha, India. It is situated in between latitude 19°58'E and longitude 84°51'N. The city is grown into Municipal corporation which consists of 40 wards and population of about four lacks & the city is situated about 10 km away from Bay of Bengal which makes the city condition extremely humid. The maximum temperature during summer season 33°C, whereas minimum temperature reaches to 16°C during winter season. The city experiences average annual rain fall of 102 mm with the set of south west monsoon. The soil in the study area in characterized by sandy solid with high percentage of sand (85%) and low clay content of clay (7-12%). For this reason the soil is non-saline in nature with pH 7 to 7.6. The Male, Female Population of Berhampur is given bellow in fig.-1.

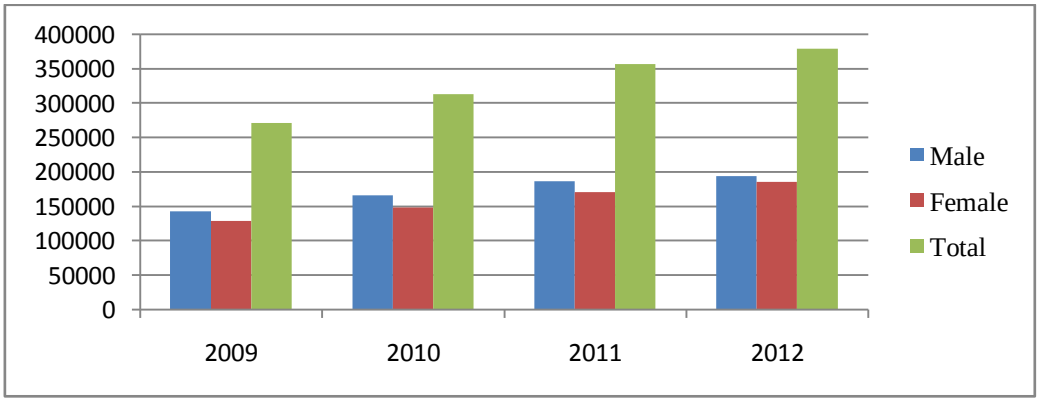

Fig 1: Male, Female Population of Berhampur

Fuoride bearing water is usually high alkalinity and low in hardness, chloride and sulphate [5]. Fluoride generally exists in the form of different mineral complexes including calcium fluoride [CaF_2], sellaite [MgF_2], fluorapatite [$Ca_5(PO_4)_3F$], cryolite [Na_3AlF_6], villiaumite [NaF], topaz[$Al_2(SiO_4)F_2$], tourmaline, muscovite & biotite [6]. Due to strong electronegativity, fluoride is attracted to positive charged calcium in teeth and bones [7]. Major health problem caused by fluoride are dental fluorosis, teeth mottling, skeletal fluorosis and deformation of bones in children as well as adult [8]. These are dangerous because there is no effective cure of these diseases [9]. Therefore it is advisable to drink water having a fluoride concentration less then certain value [10]. Hence drinking water with more than 1.5mg/l of fluoride concentration is necessary for treatment before drink [11]. The details effect of fluoride with different concentration to human health is given below in table-1.

TABLE 1: Concentration of Fluoride in drinking water and its effect on human health

Sl. No.	Fluoride(mg/l)	Effect on human health
1	Nil	Limited growth and fertility
2	Below 0.5	Dental caries
3	0.5-1.5	Promotes dental health, Prevents tooth decay
4	1.5-4.0	Dental fluorosis (Mottling and pitting of teeth)
5	4.0-10	Dental and skeletal fluorosis
6	Above 10	Crippling fluorosis

II. MATERIALS & METHODS

The water samples are collected from hand pumps or bore wells at different 25 sampling stations around the city, shown in figure-2 & given in table-2. The samples were collected in 5 litre plastic containers, which were thoroughly washed with the water to be analysed. The fluoride concentration and other parameters of these samples is measured by the procedure given by APHA [12]. The investigation period is divided into three season's i.e. Pre-monsoon, Monsoon and Post monsoon.

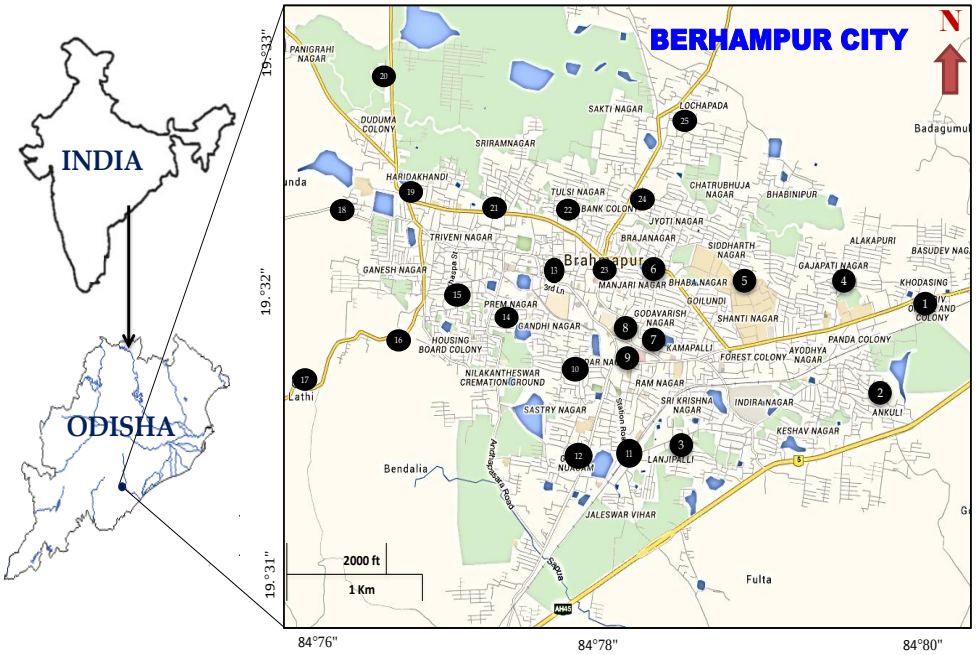

Fig 2: Location of sampling point along Berhampur city

TABLE 2: Location of sampling station at Berhampur Town

Serial number	Sample station	Location Coad	Latitude	Longitude
1	Khodasingi	S_1	$19^0.320'$	$84^0.562'$
2	Industrial estate	S_2	$19^0.381'$	$84^0.821'$
3	Lanjipali	S_3	$19^0.326'$	$84^0.786'$

4	Gajapatinagar	S_4	$19^0.311'$	$84^0.878'$
5	MKCG medical	S_5	$19^0.307'$	$84^0.811'$
6	New Bus stand	S_6	$19^0.382'$	$84^0.829'$
7	Kamapalli	S_7	$19^0.301'$	$84^0.810'$
8	Tata Benz square	S_8	$19^0.304'$	$84^0.811'$
9	MAV school	S_9	$19^0.302'$	$84^0.808'$
10	Bijipur	S_{10}	$19^0.306'$	$84^0.793'$
11	Railway station	S_{11}	$19^0.296'$	$84^0.796'$
12	SBIGosaninuagan	S_{12}	$19^0.296'$	$84^0.792'$
13	Old Bus stand	S_{13}	$19^0.311'$	$84^{0+}.790'$
14	PremNagar	S_{14}	$19^0.326'$	$84^0.786'$
15	Thakurani temple	S_{15}	$19^0.319'$	$84^0.775'$
16	Old Berhampur	S_{16}	$19^0.324'$	$84^0.784'$
17	Lathi	S_{17}	$19^0.325'$	$84^0.842'$
18	Mahurikalua	S_{18}	$19^0.321'$	$84^0.771'$
19	Haradakhandi	S_{19}	$19^0.320'$	$84^0.722'$
20	Auto Nagar	S_{20}	$19^0.323'$	$84^0.729'$
21	Taluka	S_{21}	$19^0.395'$	$84^0.693'$
22	Tulasi Nagar	S_{22}	$19^0.219'$	$84^0.720'$
23	Gate Bazaar	S_{23}	$19^0.321'$	$84^0.821'$
24	Radio station	S_{24}	$19^0.314'$	$84^0.794'$
25	Luchapada	S_{25}	$19^0.325'$	$84^0.802'$

II. RESULTS AND DISCUSSION

The range of fluoride concentration in water sample in the study area varied from minimum 0.09 mg/l in the sample station S-6 in the month of November, 2009 in post monsoon season to maximum 1.70 mg/lt monsoon April, 2010 at sample station S-24. The sample station S-1 in post monsoon is minimum located at Khodasingi. The maximum concentration of fluoride is within the range of WHO standard. This proves that there is no evidence of any addition of fluoride in to ground water neither by artificial means nor by the presence of mineral in the soil such as fluorite and Fluor apatite. So there is no evidence of fluorosis disease, tooth decay or abnormal bone development among the people living in the study area. The average fluoride content during 2009-10 is shown in figure-3.

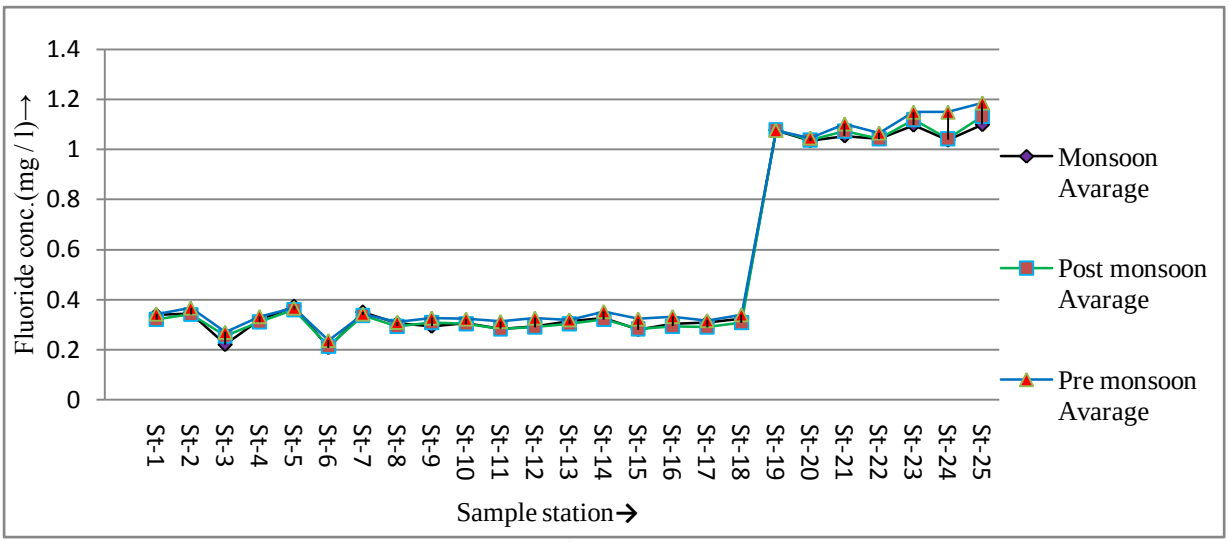

Fig 3: Fluoride concentration of ground water sample during-2009-10

Total hardness(TH) has a good +ve Correlation with Calcium (r=0.742), Magnesium (r = 0.649) and Chloride (r = 0.647).`Calcium has a good +ve Correlation with Cl^- (r = 0.626), Alkalinity (r = 0.294).Magnesium has +ve Correlation with Chloride (r = 0.255)Chloride has +ve Correlation with EC (r = 0.179)Fluoride has a good +ve Correlation with TDS (r = 0.571), Alkalinity(r = 0.252).TDS has good +ve Correlation with alkalinity (r = 0.449).EC has +ve Correlation with Alkalinity (r = 0.392).Maximum +ve correlation observed between the TH with Calcium. The maximum +ve correlation

value (r = 0.742) is observed. The minimum +ve correlation is observed between TDS and TH with the minimum correlation value (r = 0.006) is observed which is identified from table-3

TABLE 3: Correlation coefficient of ground water quality parameters in Berhampur town during 2009-10

	pH	Turb	TH	Ca	Mg	Cl	F	NO_3	TDS	EC	ALK
pH	1										
Turb	0.276	1									
TH	-0.121	0.179	1								
Ca	-0.003	0.268	.742**	1							
Mg	-0.174	-0.034	.649**	-0.028	1						
Cl	0.254	0.198	.647**	.626**	0.255	1					
F	-.584**	-0.227	-0.224	-0.083	-0.239	-0.261	1				
NO_3	0.134	0.107	-0.392	-0.289	-0.254	-0.265	-0.077	1			
TDS	-0.358	0.211	0.006	0.116	-0.123	-0.05	.571**	0.134	1		
EC	0.114	0.253	0.038	0.17	-0.141	0.179	-0.052	0.009	-0.003	1	
ALK	-0.31	0.264	0.069	0.294	-0.228	-0.058	0.252	0.066	.449*	0.392	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The range of fluoride concentration in water sample in the study area varied from minimum 0.17 mg/l in sample station S-3 in June 2010 in monsoon season to maximum 1.28 mg/l in pre monsoon March, 2011 at sample station S-24. The sample station S-3 monsoon is minimum located at Lanjipali and S-24 exhibited maximum in March, 2011. The average fluoride content during 2009-10 is shown in figure-4.

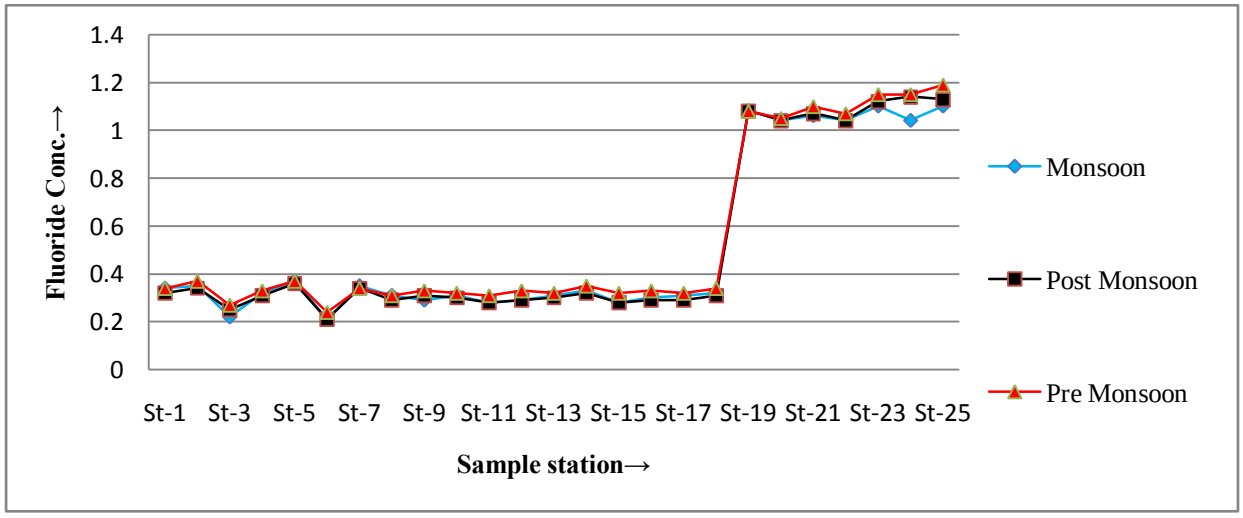

Fig 4: Fluoride concentration of ground water sample during - 2010-11

Total Hardness(TH) has good +ve correlation with Calcium (r = 0.760), magnesium (r = 0.566), Chloride (r = 0.730) and has slight +ve correlation with TDS (r = 0.053). Calcium has good +ve correlation with Mg (r = 0.126), Cl (r = 0.752), No_3 (r= 0.082), TDS (r = 0.067) & slight +ve correlation with Alkalinity (r = 0.010).Mg has a good +ve correlation with Cl^- (r = 0.223) and TDS (r = 0.143).Cl has a +ve correlation with NO_3 (r = 0.046) and TDS (r = 0.061).Fluoride has a good +ve correlation with NO_3(r = 0.421), TDS (r= 0.164) & slightly +ve correlation with alkalinity (r = 0.108).NO_3hasa +ve correlation with TDS (r = 0.511).TDS has a +ve correlation with alkalinity (r =0.236) and slightly +ve correlation with EC (r = 0.031).EC has a +ve correlation with Alkalinity (r = 0.337).B.O.D has good +ve correlation with C.O.D (r = 0.874), Do(r = 0.548), ca^{2+} (r = 0.424) PH has good +ve correlation with DO(r=0.490), the values are identified from table-4.

TABLE 4: Correlation coefficient of ground water quality parameters in Berhampur town during- 2010-11

	pH	Turb	TH	Ca	Mg	Cl	F	NO3	TDS	EC	ALK	DO	COD	BOD
pH	1													
Turb	-0.338	1												
TH	-0.292	.485*	1											
Ca	-0.051	.468*	.760**	1										
Mg	-.451*	0.11	.555**	0.126	1									
Cl	-0.246	.458*	.730**	.752**	0.223	1								
F	0.168	0.171	-0.118	-0.215	-0.176	-0.341	1							
NO3	-0.055	0.223	-0.099	0.082	-0.307	0.046	.421*	1						
TDS	-0.307	0.11	0.053	0.067	0.143	0.061	0.164	.511**	1					
EC	0.261	-0.325	-0.133	-0.016	-0.129	-0.132	-0.351	-0.123	0.031	1				
ALK	0.178	-0.18	-0.052	0.01	-0.139	-0.16	0.108	-0.168	0.236	0.337	1			
DO	.490*	0.029	-0.11	0.075	-0.386	-0.147	0.212	-0.058	-0.023	0.069	0.199	1		
COD	0.319	0.123	-0.121	0.177	-0.323	-0.063	0.015	-0.031	-0.166	-0.094	0.052	.548**	1	
BOD	0.238	0.212	0.148	.424*	-0.224	0.178	0.053	-0.006	-0.122	-0.239	0.187	.427*	.874**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The range of fluoride concentration in water sample in the study area varied from minimum 0.10 mg/l at sample station S-3 November 2011 to maximum 1.25 mg/l in July, 2012 at sample station S-20. The sample station S-3 is at Lanjipali and S-20 at Auto Nagar.

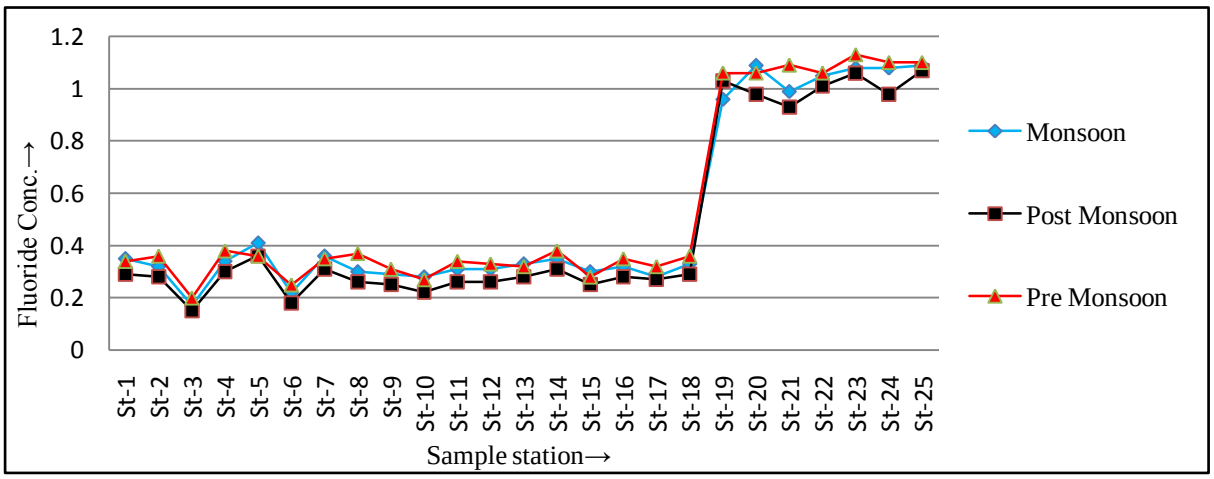

Fig 5: Fluoride concentration of ground water sample during - 2011-12

Total Hardness has good +ve correlation with Calcium (r = 0.760), Mg (r = 0.720), Chloride(r = 0.680), EC (r=0.426), TDS (r = 227), and has slight +ve correlation with Alkalinity(r = 0.025).Calcium has a good +ve correlation with Cl^- (r = 0.665), EC (r = 0.318), TDS(r=0.119), Mg (r = 0.105) and slight +ve correlation with NO_3^- (r = 0.018) and Alk (r =0.045).Mg has a good +ve correlation with Cl^- (r = 0.341), EC (r =0.335) and TDS (r = 0.256). Cl^- has good +ve correlation with TDS (r = 0.284), EC (r=0.197) &Cl^- (r = 0.144).F^- has a +ve correlation with NO_3^- (r =0.389) and slightly correlation with Alkalinity (r = 0.092).No_3^- has a good +ve correlation with TDS (r = 0.455) and slightly correlation with Alkalinity (r = 0.012).TDS has a good +ve correlation with Alkalinity (r = 0.316) and EC(r = 0.124).EC has a correlation with Alkalinity (r = 0.255).Turbidity has a good +ve correlation with Fluoride (r = 0.921).DO has a good +ve correlation with Calcium (r = 0.401)Potassium has a good +ve correlation with Magnesium (r = 0.556), Chloride (r = 0.446), Sodium (r = 0.456), shown in table-5 & the correlation chart is given in table-6.

TABLE 5: Correlation coefficient of ground water quality parameters in Berhampur town during- 2011-12

	pH	Turb	TH	Ca	Mg	Cl	F	NO_3	TDS	EC	ALK	DO	Na	K
pH	1													
Turb	-.428*	1												
TH	-.424*	-0.158	1											
Ca	-0.252	-0.02	.760**	1										
Mg	-0.367	-0.254	.720**	0.101	1									
Cl	-0.32	-0.18	.680**	.665**	0.341	1								
F	-0.261	.921**	-0.235	-0.076	-0.306	-0.316	1							
NO_3	-0.051	0.31	-0.094	0.018	-0.143	0.143	0.388	1						
TDS	-0.201	-0.092	0.227	0.119	0.256	0.284	-0.033	.455*	1					
EC	0.181	-.562**	.426*	0.318	0.335	0.197	-.458*	-0.087	0.124	1				
ALK	-0.206	-0.021	0.025	0.045	-0.018	-0.099	0.095	0.012	0.316	0.255	1			
DO	-0.205	0.361	0.159	.401*	-0.18	-0.078	0.297	-0.149	-0.076	0.094	-0.058	1		
Na	0.012	-0.206	0.07	0.022	0.066	0.044	-0.374	-.481*	-.549**	-0.068	-0.217	-0.131	1	
K	-0.395	-0.226	.490*	0.198	.556**	.446*	-0.289	0.278	0.243	.417*	0.045	-0.346	.456*	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

TABLE 6: Chart of Correlation

Results	Degree of correlation
± 1	Perfect correlation
± 0.90 or more	Very high degree of correlation
≥ ± 0.75 and ≤ ± 0.90	Fairly high degree of correlation
≥ ± 0.50 and ≤ ± 0.75	Moderate degree of correlation
≥ ± 0.25 and ≤ ± 0.50	Low degree of correlation
< ± 0.25	Very low degree of correlation
0	No correlation

IV. CONCLUSION

The fluoride value varied from 0.09 mg/l to 1.7 mg/l in the years 2009-2010 and 0.17 mg/l to 1.28 mg/l in the year 2010-2011 and 0.1 mg/l to 1.25 mg/l in the year 2011-2012.The maximum value 1.7 mg/l was obtained at sample station S-24 in April, 2010. Fluoride has a good +ve Correlation with TDS in 2009-10, a positive correlation with NO_3(r = 0.421), TDS (r= 0.164) & slightly +ve correlation with alkalinity (r = 0.108) in 2010-11 and has a +ve correlation with NO_3^- (r =0.389) and slightly correlation with Alkalinity (r = 0.092) during 2011-12. Hence, from the results it shows that the ground water of Berhampur, Ganjam (Odisha) is fit for drinking purpose at the time of research period. Several parameters have a good correlation factor with fluoride. However, there is the need for routine checks to find the suitability for human consumption.

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