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Assessment of groundwater quality with special emphasison fluoride contamination in some villages of Chandrapur district of Maharashtra, India

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Abstract: *The fluoride (F^-) concentration in ground water was determined in sixteen villages of Warora tehsil of Chandrapur district of Maharashtra state (India) where it is the only source of drinking water. Various other water quality parameters such as pH, electrical conductivity (EC), total dissolved salts (TDS), total hardness (TH), total alkalinityas well as sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), carbonate, bicarbonate, chloride (Cl^-), nitrate (NO_3^-) and sulphate (SO_4^-) concentrations were also measured. The results were compared according to the BIS standards (2003). The fluoride concentration in the underground water of these villages varied from 0.53 to 5 mg/L which is found to be above the permissible limit. Result revealed that the fluoride is main contaminant in ground water of this area and due to use of contaminated drinking water, human population affected from a variety of water borne disease. As well as the hydro-geological conditions are also responsible for causing significant variation in ground water quality. A systematic calculation of correlation coefficients among different physico-chemical parameterswas performed. The analytical results indicated considerable variations among the analyzed samples with respect to their chemical composition. Furthermore study on human population is extremely important to have a primary understanding of the current fluoride pollution status in various tehsil.*

Key words:*Fluoride, Physico- Chemical analysis, Ground water, Warora tehsil*

I. Introduction

Water is one of the most important compounds to the ecosystem (Manjare*et al.*, 2010). There are several states in India where more than 90% populations are dependent on groundwater for drinking and other purpose (Ramachandraiah, 2004).Ground water is ultimate, most suitable fresh water resource with nearly balanced concentration of the salts for human consumption (Pandey 2009).Over burden of the population pressure, unplanned urbanization, unrestricted exploration and dumping of the polluted water at inappropriate place enhance the infiltration of harmful compounds to the ground water (Pandey and Tiwari 2009). Due to use of contaminated drinking water, human population suffers from a variety of water borne diseases.

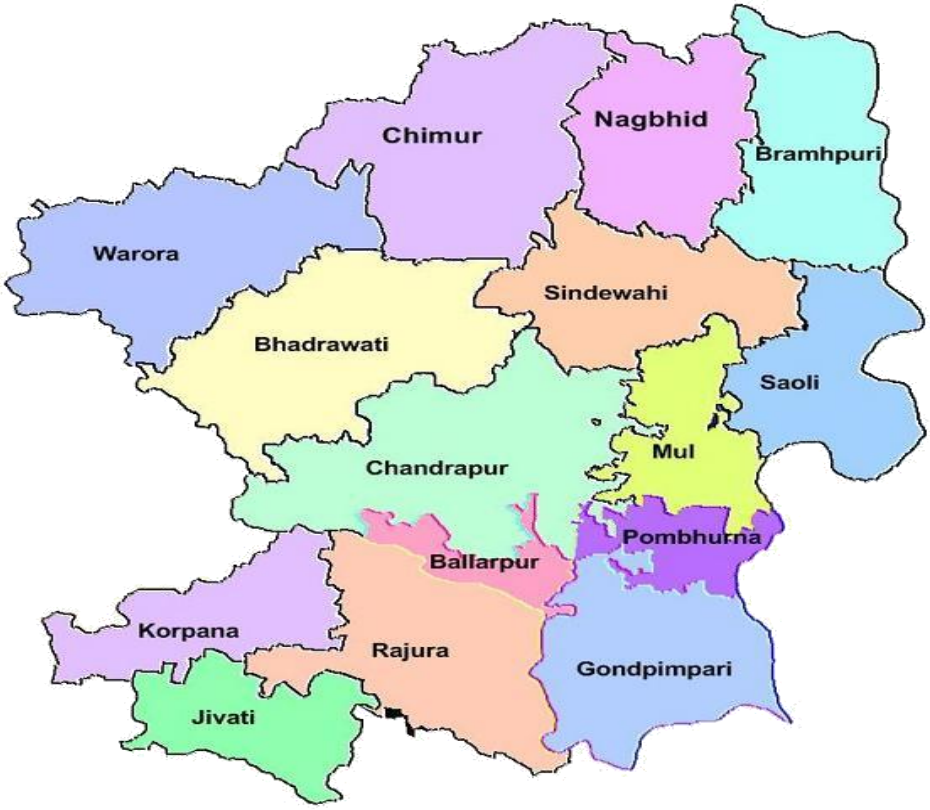
High concentration of fluoride in groundwater is a considerable health problem in several regions of the world. Considerable part of India has fairly good distribution of fluoride contamination ground water (Sinha, 1991) and according to State Maharashtra pollution control (2011), 1183 villages spread over 28 districts of Maharashtra are affected by excess fluoride. Twenty three states in India have been identified as endemic for fluorosis and Maharashtra is one of them. About 30-50% districts of Maharashtra are affected by fluorosis. Fluorosis is an endemic disease resulting from excess intake of fluoride through drinking water.

High fluoride in groundwater is present especially in peninsula and arid to semiarid region of north-western India (Jack *et al.*, 1999). The groundwater of Chandrapur district is contaminated with various pollutants including fluoride and the residing subjects affected from a variety of water borne disease. So present study, has, therefore, undertaken to analyse the quality of drinking water and for further study on human population, it is extremely important to have a primary understanding of the current fluoride pollution status of villages of Warora tehsil, Chandrapur district, Maharashtra, India.

II. Material and Methods

The area selected for present research work lies in north western part of Chandrapur district between the latitudes 19˚55’5.7”N and 20˚03’7.3”N longitudes 79˚06’28.4”E and 79˚18’34.9”E, includes 16 villages of Warora tehsil, Chandrapur district, Maharashtra, India Fig. 1.Water samples were collected in plastic bottles to

avoid unpredictable changes from different locations and sources like dug well and bore well (Table 1).



Fig, 1 Map of Chandrapur district of Maharashtra, India

Physical parameter of groundwater sample like pH, TDS and conductivity were measured in the field, whereas the chemical parameters such as Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Carbonate (CO_3^{-2}), Bicarbonate (HCO_3^{-}), Total alkalinity (TA), Nitrate (NO_3^{-}), Sulphate (SO_4^{-}), Chloride (Cl^{-}) and Fluoride (F^{-}) were analysed by using standard techniques (APHA 2007) in Table 2.

III. Resultand Discussion

In the study area maximum pH was recorded from (Do3) Dongargaon, (Blg2) Belgaon and (Jmn1) Jamni and minimum from borewell (Blg1) of Belgaon(Table2, Fig.2).pH is ranges from 6.4-7.5, with an average of 6.9 ± 0.36(Table2).A positive correlation was observed between pH–F(r= 0.064) (Table 6, Fig. 17).Data revealed that 21% locations of Warora tehsil have low pH value and 79% locations has optimum limit of pH(Table 5). pH showed positive correlation with fluoride was supported by Jain *et al.*,(2006), Daisy and Khan (2008), SubbaRao,(2009) and Gautam*et al.*,(2011).

Fluoride (F^{-}) varied from 0.53-5 mg/L with an average 1.506 ± 0.195mg/L (Table 2).Minimum (0.53ppm) and maximum (5ppm) concentration of F^{-}wasobserved from Dugwell of Dongargaon village fluoride mine of Dongargaonvillages respectively (Table 2, Fig. 3).Permissiblelimit for F- concentration is 1-1.5 ppm according toWHO (2011). The data revealed that 28% locations of villages of WaroraTehsil are affected with high concentrate onof F^{-}, whereas 31% locations of villages had lower F- content and 41% locations of villages contained optimum limit offluoride concentration (Table5).The ground water fluoride concentration above the permissible limit was reported in Andhra Pradesh (ranged from 0.6 to 2.1 mg/L) and Rajasthan (1.5 to 18.0 mg/L) by SubbaRao (2009) and Daisy and Khan (2008) respectively. Sharma *et al.,* (2011) and Gautam*et al.,* (2011) investigated the fluoride concentration in ground water of Uttar Pradesh and Rajasthan varied between 0.1 to 14.8 mg/L and 0.64 to 14.62 mg/L respectively.

Few reports on excessive fluoride in drinking water in Chandrapur district of Maharashtra was reported in Rajura Tehsil (0.4-4.8ppm) and Bhadrawati Tehsil (0.5-4.4 mg/l) by Chandekar and Kamble (2010) and Murkute and Badhan (2011)respectively.

The values of EC ranged from is 448- 2620µS with an average 1249 ± 107 µS. The maximum EC value was recorded from borewell (Amt2) of Athmurdi village and minimum was recorded from dugwell (Do3) of Dongargaon village(Table2, Fig. 3). A positive correlation was observed between EC-F(r=+0.126) (Table 6, Fig. 18).By analyzing the results, all water samples showed EC higher than permissible limit as per BIS (2003) guideline (Table 5). EC signifies the amount of TDS in water. Findings of the present study were in agreement

with the results of the survey conducted by Jain *et al.,* (2006), Meenakshi*et al.,* (2003) and Daisy and Khan (2008).

The total dissolved solids (TDS) in drinking water reveal the saline behavior of water, which indicates the organic pollution level of water. The ground water was non saline in 22 locations and slightly saline at 7 locations (Table 3). TDS ranged from 269- 1572 mg/L with an average 749 ± 64.5 mg/L (Table2). Minimum (269 mg/L) and maximum (1572 mg/L) concentration of TDS was observed from dugwell of Dongargaon village and borewell of Athmurdi villages respectively (Table 2, Fig. 5). TDS was found to be within limit in 76% locations villages, lower in 21% locations villages, whereas 3% locations villages showed TDS higher than limitas per BIS (2003) guideline(Table 5). In this study, significant positive correlation was observed between TA-F(r=+0.126) and EC and TDS (r= +0.999)(Table 6, Fig. 21).Similar results were observed by Sharma (2005) and Meenakshi*et al.,* (2003).

The range of calcium is 8- 116 mg/L, average is 39.3± 4.88 mg/L. The maximum calcium value was recorded from borewell (Atm2) of Athmurdi and minimum was recorded from borewell (Dh1) of Dahegaon village(Table 2, Fig. 6).Calcium was within permissible limit in 7% samples where as 93% samples contained calcium below than limit and no samples were out of limit as per BIS (2003) guideline (Table 5).The Magnesium in study area ranges from 21.2-115 mg/L with an average 58.79± 5.48 mg/L. The maximum magnesium value was recorded from dugwell (Mo2) of Mohbala and minimum was recorded from dugwell (Do3) of Dongargaon village(Table 1, Fig. 8).As per BIS (2003) guideline Mg^- was below than limit in 17% locations of villages and 83 % locations of villages showed within optimum limit(Table 4).A negative correlation between Ca^{2+} and F (r=-0.800) (Table 6, Fig. 22) and $Mg^{2+}$and F (r= -0.106) (Table 6). A negative correlation was observed between Ca^{2+} and F and $Mg^{2+}$and Fwhich supported by the findings of Jain *et al.,* (2006), Daisy and Khan (2008), Trivedi, (1988) and Sharma, (2003).

The groundwater in the study area is moderately hard to very hard(Table 4). The range and average of total hardness in is from 130- 762 mg/L and 389 ± 21mg/L. The maximum Hardness was recorded from borewell (Atm2) of Athmurdi and minimum was recorded from dugwell (Do3) of Dongargaon village(Table 2 and Fig. 8). In groundwater, hardness is mainly due to carbonates, bicarbonates, sulphates and chlorides of Ca and Mg. Total hardness was higher in 21%locationsofvillages, whereas 79%locations samples contained TH within optimum limit as per BIS (2003) guideline (Table 5).In this study, hardness showed negative correlation with F^-(r= - 0.0091) in Fig. 17, which supported by the findings of Jain *et al.,* (2006), Daisy and Khan (2008), Trivedi, (1988) and Sharma, (2003).

During present study, carbonate (CO_3^{-2}) ranged from 12-53 mg/L with an average 12.47 mg/L (Table 2). At some villages CO_3^{-2} concentration is negligible. Minimum (12 mg/L) and maximum (53 mg/L) content of CO_3^{-2} was observed from dugwell and borewll of Pijdura and dugwell of Athmurdi villages respectively(Table 2, Fig. 9). Bicarbonate (HCO_3) ranged from 107-610mg/L with an average 377 mg/L. Minimum bicarbonate (HCO_3^-) (107mg/L) observed from dugwell of Dongargaon village and maximum (610mg/L) was reported from borewell of Waroravillage respectively (Table 2, Fig. 10). $CO_3^{-2}$and HCO_3^-together makes total alkalinity.The Total Alkalinity ranges from 74-586mg/L with an average 339 ± 32 mg/L (Table 2). The maximum Total Alkalinityvalue was recorded from borewell (W1) of Waroravillage and minimum was recorded from dugwell (Do3) of Dongargaon village(Table 2, Fig. 11).A positive correlation was observed between TA-F(r=+0.126) (Table 6, Fig. 21). Similar observations were reported earlier by Daisy and Khan (2008), Gautam*et al.,*(2011), Jain *et al.,*(2005) and Murkute and Badhan (2011).

In the present study, chloride content ranges from 4.65- 280 mg/L with an average 88.48 ± 16.49 mg/L (Table 2). The maximum chloride value was recorded from borewell(C1) of Chikni village and minimum was recorded from borewell (Phd1) of Pijdura village(Table 2, Fig. 12).The chloride content was higher than permissible limit (200-600 mg/L) in 86% locations of villages whereas lower in 14% locations of villagesas per BIS (2003) guideline (Table 5).A positive correlation was observed between Cl^- and F(r= 0.106) (Table 6)Datta*et al.,* (2010); Chandekar and Kamble (2010) and Daisy and Khan (2008) also reported positive correlation between chloride and fluoride.

On the basis of chemical analysis of groundwater, the range of sodium content is 31- 418 mg/L with an average 130.6 ± 16.83mg/L (Table 2). The maximum sodium concentration was recorded from borewell (C1) of Chikni and dugwell (Ppl1) of Pimpalgaon(Table 2, Fig. 13).Almost all the locations of villages 69% contained higher concentration of Na^+ 21% locations of villages was below limit and 10% locations in optimum limitas per BIS (2003) guideline (Table 5).Potassium ranges from 0.05-3.06 mg/L with an average 0.508 ± 0.111mg/L (Table 2). The maximum potassium value was recorded from borewell (Blg1) of Belgaon village and minimum was recorded from borewell (Atm2) of Athmurdi village(Table 1, Fig. 14).All the water samples (100%) contained K^+ content lower than permissible limit i.e. 20 mg/L (Table 5). In the present study, Na^+showed strong positive correlation with fluoride (r= 0.178) and negative correlation was observed between K^+ and F(r= -0.104) (Table 6). The results are in agreement with the results of Jacks *et al.,* (2005), Kodate (2007) and Murkute and Badhan (2011).

In the study area, nitrate ranges between the limits 1.8- 6.9 mg/L with an average 4.3 ± 0.292 mg/L (Table 2). The maximum nitrate value was recorded from borewell (Phd1) of Pijdura village and minimum was recorded from borewell (Dh1) of Dahegaon village(Table 2, Fig. 15). As per BIS (2003) guideline 83% samples contain nitrates below the desirable range, 13% within permissible and 14 % above permissible limit(Table 5). The sulphate ranges from 12- 437 mg/L with an average 101 ± 23.37 mg/L(Table 2). The maximum sulphate value was recorded from borewell (Tbd1) of Temurda village and minimum was recorded from borewell (Chn1) of Chinora village(Table 2, Fig. 16). 83% locations of Warora Tehsil were in below the limit where as 4% locations of are above the limit. However 14% locations are in optimum limit according to Indian Standard(Table 5).In the present study, nitrate and sulphate showed negative correlation with fluoride (r= - 0.187) and (r= - 0.106) (Table 6). Fluoride show negative correlation with sulphate, both from shallow as well as deeper aquifers reported by Murkute and Badhan 2011.Saikia, (2011) and Jain *et al.*,(2006) reported a contradictory result in which the positive correlation was found between fluoride and nitrate and sulphate.

Among the cationic concentration Na^+ and Mg^{2+} are dominant ion followed by Ca^{2+} and K^+. The cationic chemistry indicated that 52% of samples are $Na^+ > Mg^{2+} > Ca^{2+} > K^+$ while 48% of samples are $Mg^{2+} > Na^+ > Ca^{2+} > K^+$. Among the anionic concentration HCO_3^- and $SO_4^{2-}$are dominant ion followed by Cl^- and NO_3^-.

IV. Conclusion

The data indicate that the groundwater of Warora Tehsil is highly deteriorated as it is polluted with high amount of fluoride. Most of the parameters were either more than permissible limit or below limit. Therefore, the drinking water of villages of Warora Tehsil is not potable-. To maintain quality of groundwater, the continuous monitoring of physic-chemical parameters should be done and can be used for cooking and drinking only after prior treatment.

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Table 1. Location of water samples collected from different water sources of villages of Warora Tehsil

Sr. No.	Code	Name of Villages	Source of water	Landmark	Latitude	Longitude	Elevation
1	Mj1	Majara	Borewell	Near Hanuman Mandir	$20^0$15'59.1N	$79^0$18'12.2"E	227m
2	Tbd1	Temurda	Borewell	Near entrance of village	$20^0$21'04.3N	$79^0$01'15.3"E	270m
3	Phd1	Pijdura	Borewell	Near gram panchayat	$20^0$21'04.2N	$79^0$01'16.2"E	280m
4	Phd2	Pijdura	Dugwell	Near Kordhane's residence	$20^0$21'35.5N	$79^0$02'03.7"E	240m
5	Phd3	Pijdura	Borewell	Near Chaudhary'sresidence	$20^0$21'34.1N	$79^0$02'10.7"E	237m
6	Phd4	Pijdura	Borewell	Near Ghagi's residence	$20^0$21'33.1N	$79^0$02'08.3"E	237m
7	Phd5	Pijdura	Borewell	Near Dhoke's residence	$20^0$21'32.2N	$79^0$02'07.4"E	237m
8	Do1	Dongargaon	Stream water	Inside the mine	$20^0$21'33.4N	$79^0$02'04.8"E	209m
9	Do2	Dongargaon	Stream water	Near the mining officer's cabin	$20^0$21'33.4N	$79^0$02'04.8"E	209m
10	Do3	Dongargaon	Dugwell	Near PHC	$20^0$21'35" N	$79^0$02'20" E	230m
11	Do4	Dongargaon	Borewell	Near Madavi's residence	$20^0$19'40" N	$78^0$57'35.7" E	264 m
12	Do5	Dongargaon	Borewell	Near Z.P. School	$20^0$19'43.6N	$78^0$29'26.2"E	269m
13	C1	Chikani	Borewell	Near Z.P. School	$20^0$21'57.4N	$78^0$55'41.1"E	252m
14	C2	Chikani	Dugwell	Near Shaikh's residence	$20^0$21'58.6N	$78^0$55'45.4"E	210m
15	Dh1	Dahegaon	Borewell	Near Highway	$20^0$18'10.7N	$78^0$54'48.2"E	204m
16	Mo1	Mohbala	Borewell	On the way	$20^0$15'47.4N	$78^0$59'38.7"E	210m
17	Mo2	Mohbala	Dugwell	On the way	$20^0$15'46.4N	$78^0$59'37.7"E	212m
18	W1	Warora	Borewell	Near Lokmanya School	$20^0$14'0.2" N	$79^0$00'8.2" E	207m
19	Chn1	Chinora	Borewell	Near Ambade'sresidance	$20^0$31'22.2N	$79^0$15'59.9"E	197m
20	Yns1	Yensa	Borewell	Near Gajabe's residence	$20^0$15'40.0N	$79^0$01'22.2"E	211m
21	Kdl1	Kondhala	Dugwell	Near Pavghan'sresidence	$20^0$18'46" N	$78^0$59'12.7"E	210m
22	Blg1	Belgaon	Borewell	On the entrance	$20^0$19'32.8N	$78^0$59'09.2"E	210m
23	Blg2	Belgaon	Dugwell	Near Turale's residence	$20^0$19'35.1N	$78^0$59'9.4" E	212m
24	Atm1	Athmurdi	Dugwell	Near Kumare's residence	$20^0$20'38.8N	$78^0$51'14" E	228m
25	Atm2	Athmurdi	Borewell	On the way	$20^0$15'34.4N	$79^0$01'14.6"E	222m
26	Jm1	Jamani	Dugwell	Near Jeurkar's residence	$20^0$19'34" N	$79^0$01'16" E	225m
27	Ppl1	Pimpalgaon	Dugwell	Near Mango field	$20^0$20'01.8N	$79^0$01'26.1"E	226m
28	Snt1	Sosati	Borewell	Near the temple	$20^0$18'36.7N	$79^0$07'8.9" E	226m
29	Brg1	Borgaon	Dugwell	In the field	$20^0$19'16.8" N	$79^0$03'20.5" E	227 m

Table 2.Chemical composition of the groundwater (all the values are in mg/L except conductivity in µSiemen's/cm)

Sr.No.	Name of village	Temp	pH	EC	TDS	TA	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^-	NO_3	F^-
1	**Majara**	31.1	6.8	942	565	442	398	24	82	33	0.18	0	435	21	16	3	0.73

2	**Temurda**	32	6.9	647	388	286	206	19	39	53	1.09	20	275	5	12	3	0.8
3	**Pijdura**	31.3	7	693	416	312	257	30	44	41	0.17	21	293	4.7	15	3	1.06
4	**Pijdura**	28.5	6.9	1510	906	472	504	44	96	115	0.28	53	487	102	44	6	0.8
5	**Pijdura**	30.7	7	843	506	276	285	30	51	62	1.09	12	338	17	40	6	1.6
6	**Pijdura**	30.8	6.8	1202	721	468	385	48	65	100	0.76	27	417	67	47	6	2.12
7	**Pijdura**	33	6.9	1923	1153	468	609	60	112	160	0.52	52	610	120	100	7	2.26
8	**Dongergaon**	34.4	6.9	1363	821	374	401	62	60	130	0.06	0	462	133	32	3	4.66
9	**Dongergaon**	36.3	7.3	1292	775	300	308	24	60	155	0.28	0	357	145	87	3	2.26
10	**Dongergaon**	34.4	7.5	448	269	74	130	17	21	43	0.29	0	107	36	63	3	0.53
11	**Dongergaon**	32.7	6.8	1364	818	420	137	11	27	250	0.28	0	467	105	65	2	5
12	**Dongergaon**	33.8	6.6	1780	1068	284	491	82	70	178	1.09	0	430	250	92	3	1.4
13	**Chikani**	33.3	6.8	2400	1440	500	297	31	53	418	0.63	22	438	280	327	3	0.93
14	**Chikani**	34	7.4	839	503	392	331	28	63	40	0.18	28	329	18	22	2	1.26
15	**Dahegaon**	33.6	6.9	1020	612	540	230	8	51	130	0.05	0	425	34	47	1.83	1.2
16	**Mohbala**	32.8	6.9	889	533	324	172	13	34	125	0.18	39	301	29	40	3.07	1.06
17	**Mohbala**	33.6	7.1	1851	1111	520	641	68	115	131	0.28	0	503	235	98	3.2	1.06
18	**Warora**	30.9	6.9	1810	1086	586	633	84	103	124	0.86	0	293	180	348	3.2	0.93
19	**Warora**	29.6	6.9	1279	767	524	295	34	51	157	0.05	0	523	53	46	6.6	0.86
20	**Chinora**	29.5	6.9	2190	1314	564	642	82	107	204	1.09	0	476	119	437	6.2	1.4
21	**Kondhala**	28.8	7.1	688	413	344	230	18	45	52	0.06	0	303	20	15	3.9	1.4
22	**Belgaon**	29.6	6.4	1050	630	320	269	24	51	115	3.06	0	199	10	299	6.2	1.13
23	**Belgaon**	30.2	7.5	1510	906	330	180	20	32	266	0.51	35	367	197	59	3.7	1.33
24	**Athmurdi**	30	7.4	1366	820	286	160	18	28	240	0.63	53	365	73	121	5.9	2.52
25	**Athmurdi**	30	6.5	2620	1572	450	762	117	115	252	0.05	0	526	271	397	6.6	0.86
26	**Jamani**	31.5	7.5	627	376	312	205	42	24	50	0.18	0	293	5	17	3.7	1
27	**Pimpalgaon**	31	6.9	498	299	284	182	35	23	31	0.29	0	226	7	15	4.05	0.66
28	**Sonati**	30.9	6.9	928	557	496	256	36	41	95	0.28	0	409	20	29	5.22	1.86
29	**Borgaon**	29.6	6.9	652	391	334	245	34	39	38	0.18	0	290	10	26	3.2	1
	Average	31.6	6.9	1249	749	339	389	39.3	58.79	130.6	0.508	12.47	377.3	88.48	101.9	4.130	1.506
	SD	1.96	0.2	578	347	176	115	26.2	29.53	90.59	0.602	18.45	111.4	88.73	125.7	1.571	1.053
	SE	0.36	0.05	107	64.5	32	21	4.88	5.488	16.83	0.111	3.429	20.72	16.49	23.37	0.292	0.195
	Maximum	36.3	7.5	2620	1572	586	762	117	115	418	3.06	53	610	280	437	6.9	5
	Minimum	28.5	6.4	448	269	74	130	8	21	31	0.05	0	107	4.65	12	1.8	0.53

Table 3. Classification of water samples on the basis of TDS

Sr. No.	Classification of Ground Water	TDS mg/L	No. of Samples
1	Non Saline	<1000	**23**
2	Slightly Saline	1000-3000	**6**
3	Moderately Saline	3000-10,000	-
4	Very Saline	>10,000	-

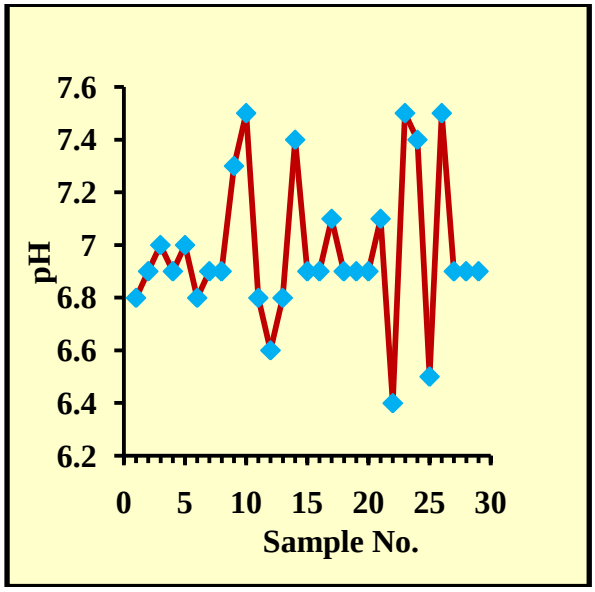
Table 4. Classification of water samples on the basis of Total Hardness

Sr. No.	Description	Hardness mg/L	No. of Samples
1	Soft	0-60	-
2	Moderately Hard	61-120	-
3	Hard	121-180	**6**
4	Very Hard	>180	**23**

Table 6.correlations among various parameters of water samples of study area

	pH	EC	TH	Ca^{2+}	Mg^{2+}	TA	TDS	Cl^-	CO_3^{-2}	HCO_3^-	Na^+	K^+	NO_3^-	SO_4^-	F^-
pH	1.000	-.012	-.005	.396	-.172	.237	-.023	.320	.157	-.640**	.950**	-.230	.500*	.573*	-.064
EC		1.000	.968**	.681**	.716**	.106	.999**	.861**	.200	.466	.777**	-.140	-.238	.762**	.126
TH			1.000	.842**	.976**	-.107	.919**	.609**	.546	.498	.502	.433	.103	-.106	-.126
Ca^{2+}				1.000	.762**	.059	.681**	.534*	.329	.231	.266	.590*	-.131	.597*	-.800**
Mg^{2+}					1.000	-.324	.713**	.534*	.950**	.286	.268	.370	-.208	.542*	-.106
TA						1.000	.123	.155	.645	.563	.245	.234	-.106	-.060	.126
TDS							1.000	.862**	.206	.467	.777**	-.160	-.242	.764**	.124
Cl^-								1.000	.113	.207	.763**	.520*	-.114	.526*	.115
CO_3^{-2}									1.000	-100	.210	-.217	-.115	.252	.287
HCO_3^-										1.000	.423	.720**	-.315	-.680**	-.106
Na^+											1.000	-.440	-.167	.568*	.178
K^+												1.000	-.210	-.690**	-.104
NO_3^-													1.000	-.123	-.187
SO_4^-														1.000	-.106
F^-															1.000

**Correlation is significant at the 0.001, *Correlation is significant at the 0.01.



Fig, 2 pH of water samples of Warora Tehsil

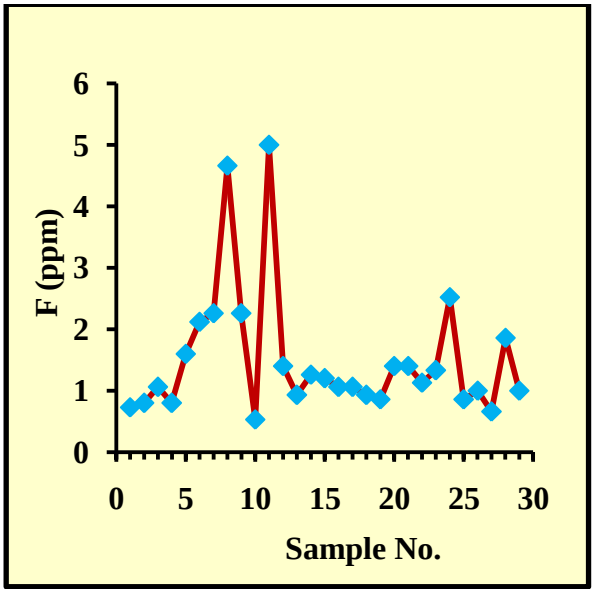


Fig. 3 Fluoride concentration of water samples of Warora Tehsil

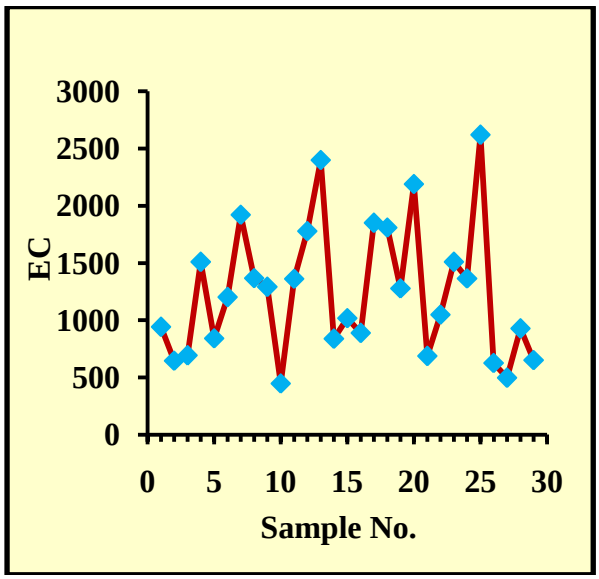


Fig. 4 Electrical conductivity of water samples of Warora Tehsil

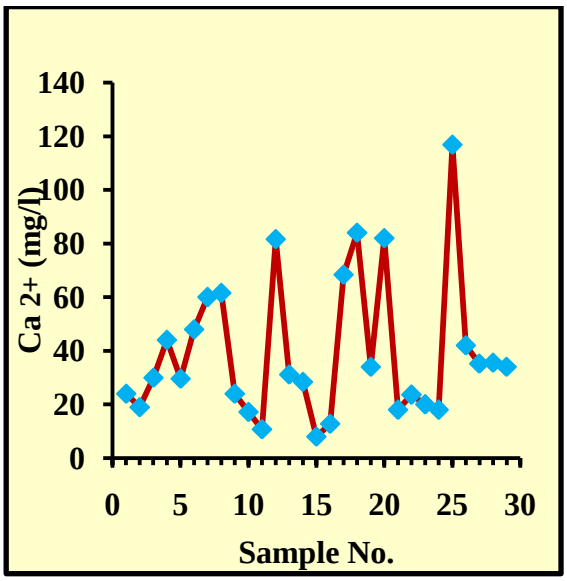


Fig.6 Calcium of water samples of Warora Tehsil

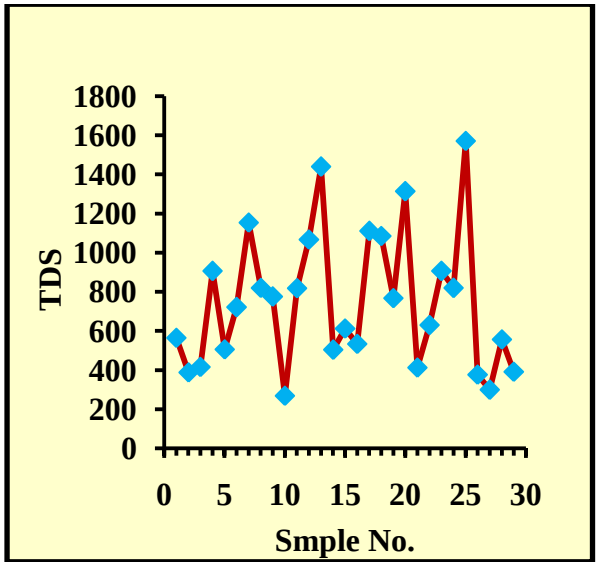


Fig. 5 Total dissolved solid of water samples of WaroraTehsil

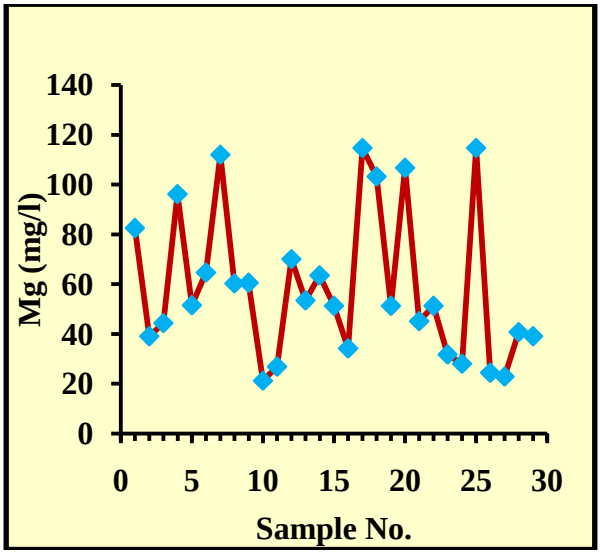


Fig.7 Magnesium of water samples of Warora Tehsil

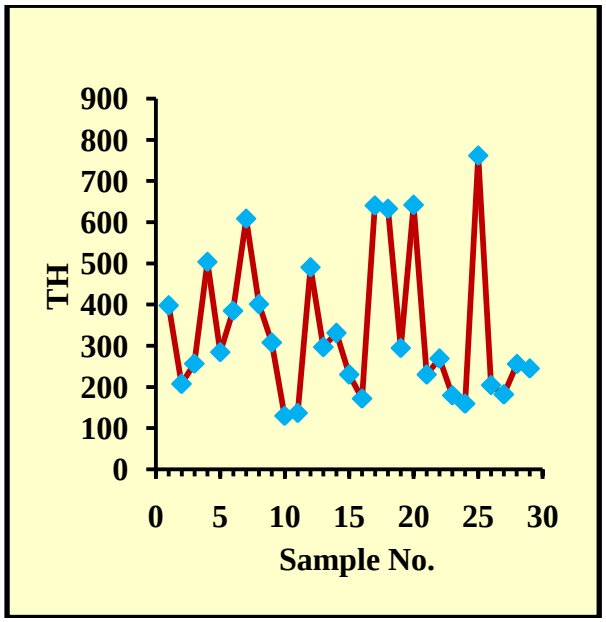


Fig. 8 Total hardness of water sample of Warora Tehsil

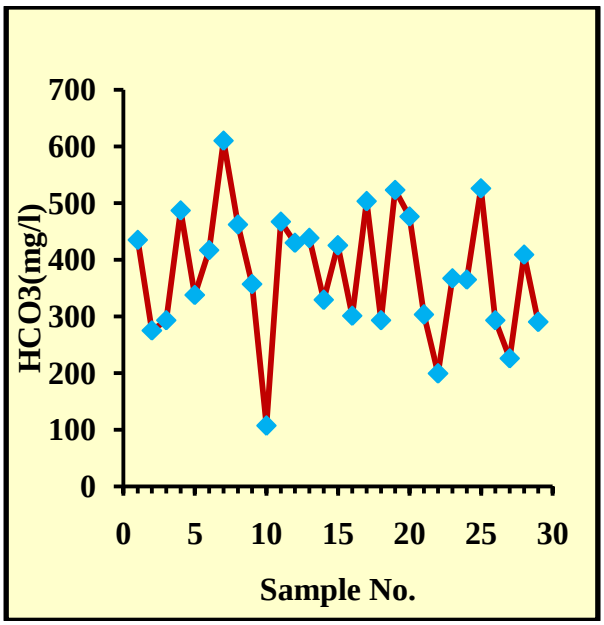


Fig. 10 Carbonate of water sample of Warora Tehsil

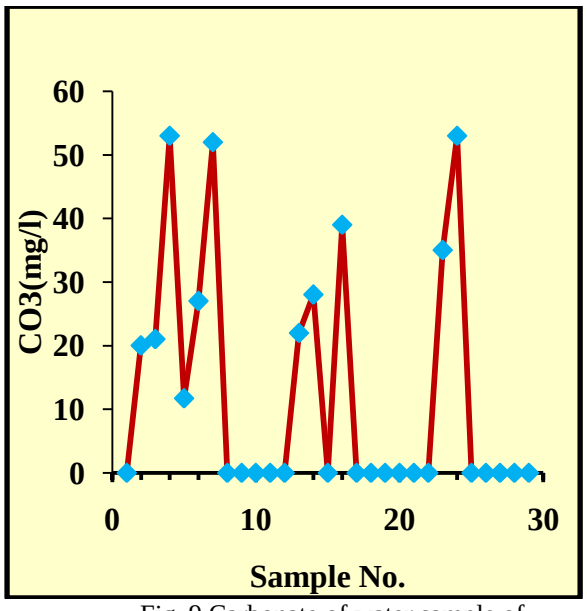


Fig. 9 Carbonate of water sample of Warora Tehsil

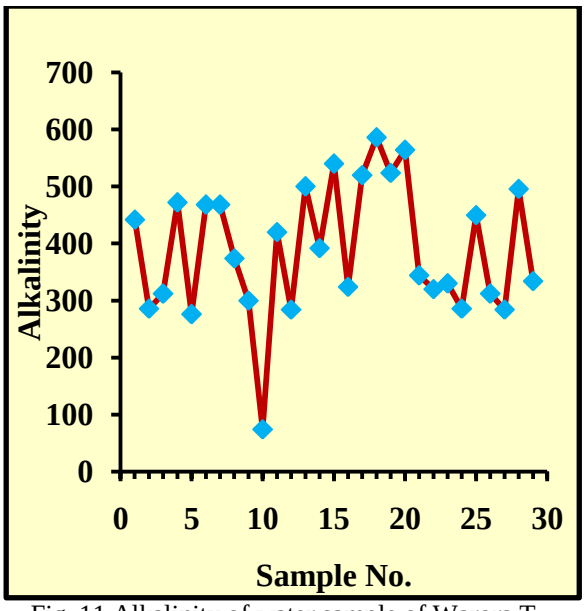


Fig. 11 Alkalinity of water sample of Warora T

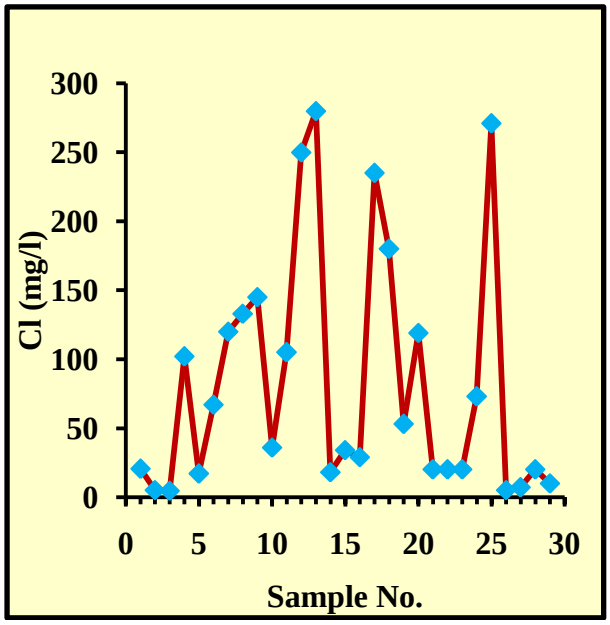


Fig. 12 Chloride of water sample of Warora Tehsil

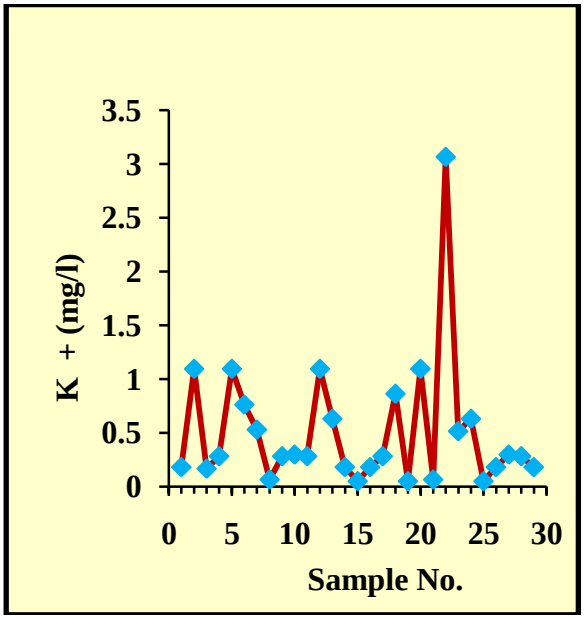


Fig. 14 Potassium of water samples of Warora Tehsil

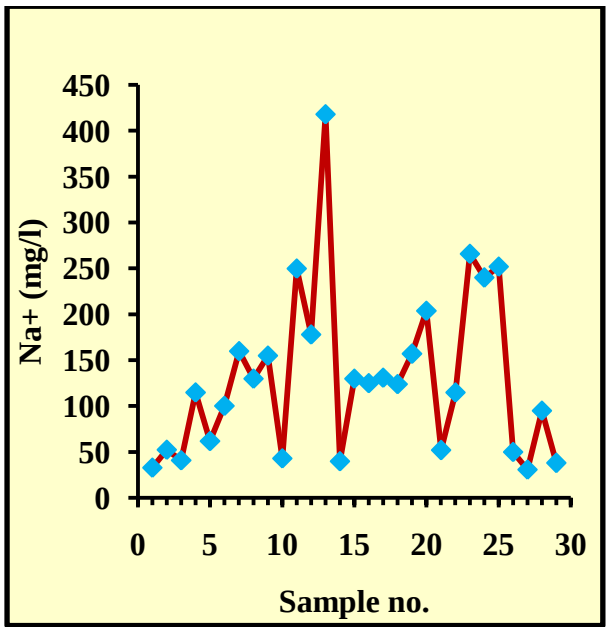


Fig. 13 Sodium of water samples of Warora Tehsil

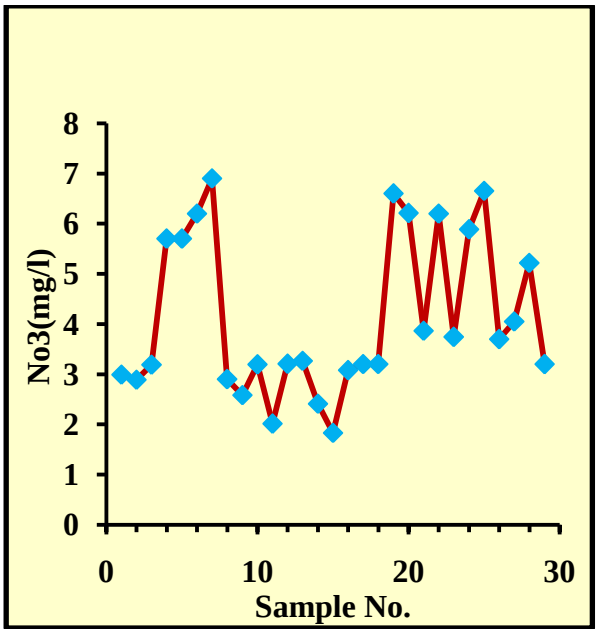


Fig. 15 Nitrate of water samples of Warora Tehsil

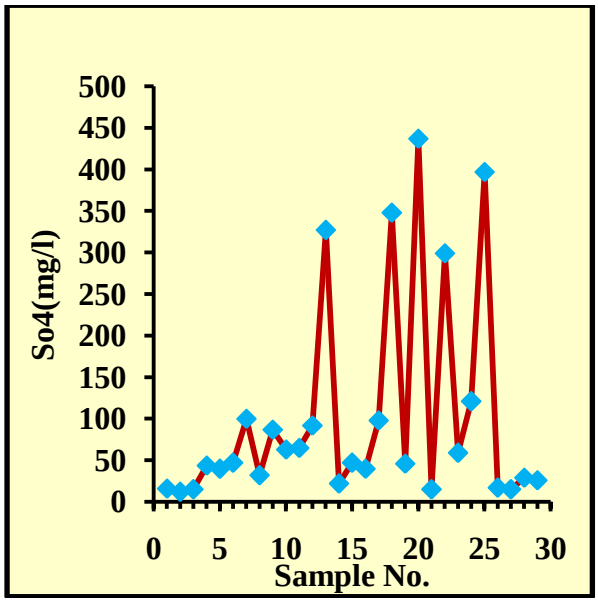


Fig. 16 Sulphate of water samples of Warora Tehsil

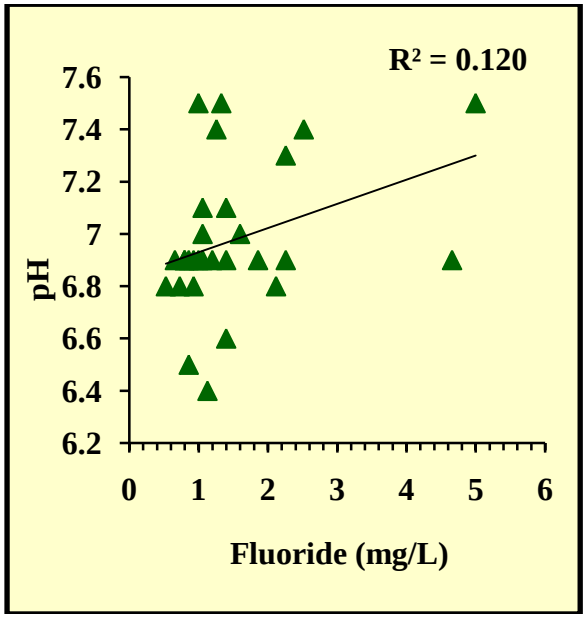


Fig. 17 Correlation of pH with fluoride of water samples of Warora Tehsil

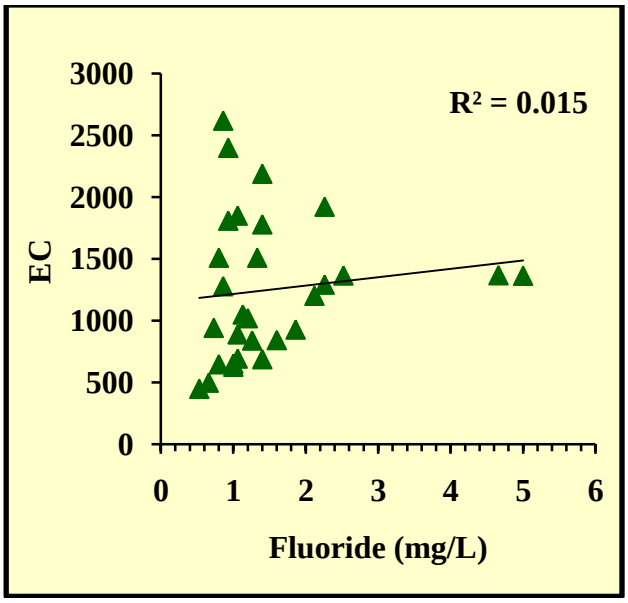


Fig. 18 Correlation of EC with fluoride of water samples of WaroraTehsi

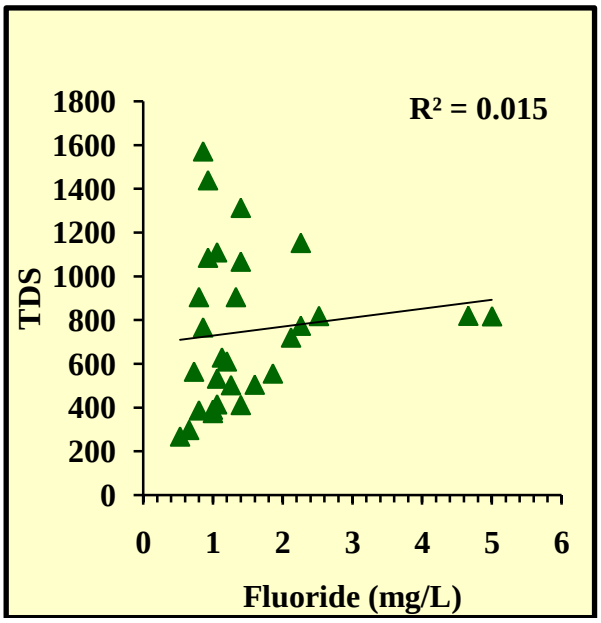


Fig. 19 Correlation of TDS with fluoride of water samples of Warora Tehsil

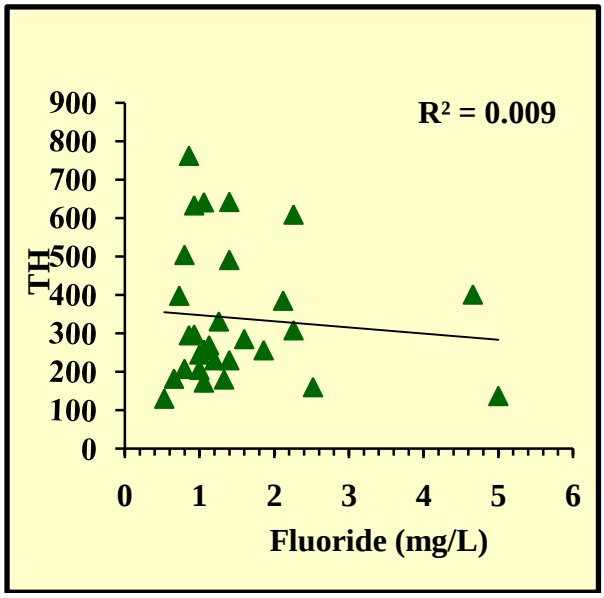


Fig. 20 Correlation of TH with fluoride of water samples of Warora Tehsil

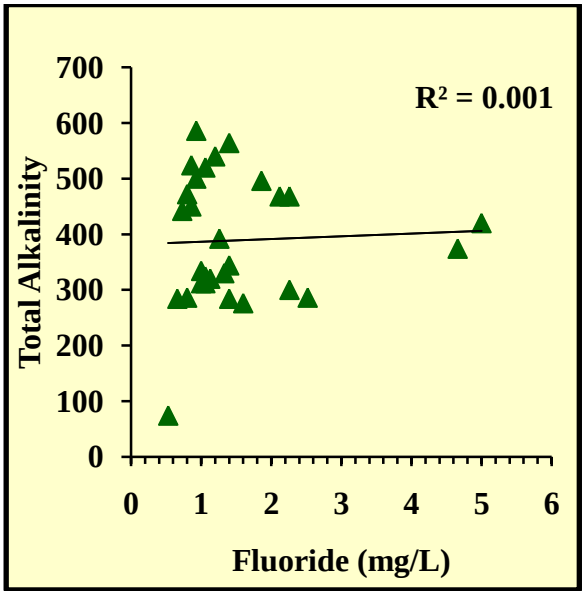


Fig. 21 Correlation of TA with fluoride of water samples of Warora Tehsil

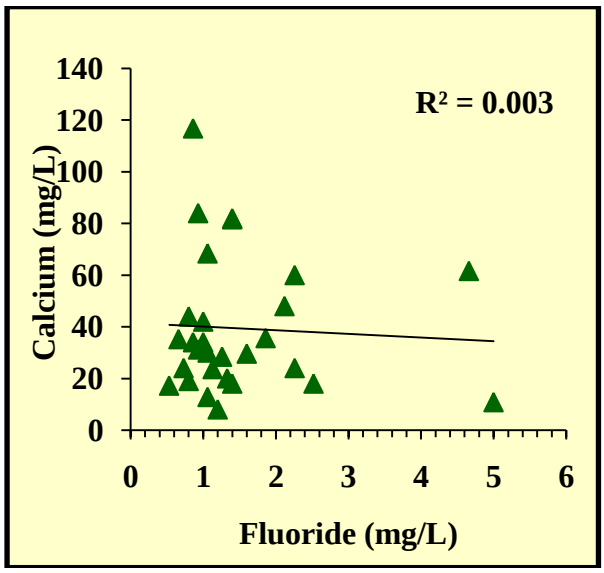


Fig. 22 Correlation of calcium with fluoride of water samples of Warora Tehsil