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Monitoring of Fluoride Content in Surface Soils used for Crop Cultivation in Ramannapet Mandal of Nalgonda District, Telangana, India

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Abstract

A study was carried out to assess the fluoride content of soil in Ramannapet Mandal of Nalgonda District, Telangana during *kharif* and *rabi* seasons of 2012-13. The mean values of available F present in the 30 soil samples of Ramannapet mandal were 1.17 and 1.41 ppm in *kharif* and *rabi* seasons, respectively. All the values obtained are well within the range of 2.57 to 16.44 ppm soil available F stipulated by EPA, FAO and WHO standard limit for fluoride, so it could be indicated that there was no danger from F accumulation in the plants. The average content of total F distributed in soil was 279 ppm in *kharif* season and 289 ppm in *rabi* season. Nearly 3.3% of soil samples in both *kharif* and *rabi* seasons recorded higher total F content than the usual range and remaining samples were within its normal range. The available F concentration in soils negatively correlated with clay content and available P_2O_5 content of soil whereas the correlation coefficient between F and soil pH was positive. The *kharif* season soil sample had lower values of fluoride because of leaching of fluoride to lower layers by rain water.

Introduction

The study and monitoring of fluorine and fluorides has been of interest to scientists for a long time. This is because of the reactivity and ready availability of fluorine in many forms. The main natural source of inorganic fluorides in soil is the parent rock. It is the 13th most abundant element of the earth's crust representing about 0.3 g kg^{-1} (Rakshit, 2004). The world average of total fluoride concentration in granitic rocks was found to be 810 ppm (Wedepohl 1969), while fluoride content of granitic rocks from Nalgonda district was found to be in the range of 325 to 3,200 ppm, with a mean of

1,440 ppm (Ramamohana Rao *et al*. 1993). Thus, the granitic rocks of Nalgonda possess the highest fluoride content than in any other parts of the world. Assessment of the granite gneisses from Nalgonda showed the presence of fluoride containing minerals such as fluorite (0–3.3%), biotite (0.1–1.7%), and hornblende (0.1–1.1%) (Reddy *et al*., 2009).

The fluoride bioavailability controlled by physical and chemical characteristics of the soil. The clay and organic carbon content as well as the pH of soil are primarily responsible for the origin and/or retention of F in soils. F in soil is primarily associated with the soil colloid or clay (Omueti and Jones, 1977). Fluoride at high concentration in soils can cause various forms of toxicity to plants. The common symptoms of fluoride toxicity include chlorosis of the tips and margins of older leaves followed by necrosis of the same areas, sometimes called burnt tips. Fluoride is phytotoxic to most plants influencing negative effect on crop production (Miller, 1993). So periodical measurement and control of the concentration of fluoride is very important to avoid both biological and environmental damage. Hence, keeping in view the above facts a survey was conducted to identify the fluoride content in surface soils used for crop cultivation in Ramannapet mandal of Nalgonda district, Telangana.

Materials and Methods

The study area forms a part of Nalgonda district, Telangana, which is located at a distance of 90 km away from Hyderabad (Figure 1). This area experiences arid to semiarid climate. The study area goes through hot climate during the summer (March–May) with a temperature range from 30°C to 46.5°C, and in winter (November–January), it varies between 14°C and 29°C. The average annual rainfall in this area is about 1000 mm, occurring mostly during south-west monsoon (June–September). A survey was carried out in Ramannapet mandal of Nalgonda district by covering all the villages, with a view to assess soil properties with special emphasis on fluoride during two seasons i.e. *kharif* (2012) and *rabi* (2012-13). As per the objectives of this study, from each village one soil sample was collected with the help of a handheld Global Positioning System (GPS). Geographical information *viz*., latitude and longitude of the benchmark sites were recorded, so that the delineation of the areas having F contamination can be done and also soil F status maps can be prepared by depicting the element in soil at village level. Totally 30 benchmark sites were fixed depending on the number of villages for collection of soil samples at each site in each season.

The samples were collected at 0-15 cm depth by adopting the standard procedures of soil sample collection. The collected soil samples were air dried, gently pounded in wooden mortar and pestle, sieved (2 mm sieve) and preserved in polythene bags for further analysis. The samples were analyzed for physico-chemical properties like pH, EC, OC and chemical properties like available F, Total F, N, P_2O_5, K_2O, S, CEC and micronutrients. The samples were analyzed for pH, EC and OC as per the standard procedure outlined by Jackson (1973). Available nitrogen was estimated by alkaline potassium permanganate method (Subbaiah and Asija, 1956). Available phosphorus content was estimated by Olsen's reagent as described by Olsen *et al*. (1956) and determined by ascorbic acid method, available potassium was extracted by using neutral

normal ammonium acetate (Jackson, 1973) and determined by flame photometer. Available micronutrients (DTPA extractable) like Fe, Mn, Cu and Zn were analyzed by DTPA method using atomic absorption spectrophotometer (Lindsay and Norvell, 1978). The samples total fluoride was analyzed by NaOH fusion technique using Fluoride Ion Selective Electrode (FISE) method given by McQuaker and Gurney (1977). Available fluoride in soil samples analyzed by Potentiometric method (McQuaker and Gurney, 1977).

Results and Discussion

Available Fluoride

Fluoride present of the soil samples collected in the villages of Ramannapet mandal of Nalgonda district during *kharif* and *rabi* varied from 0.41 to 2.32 and 0.77 to 2.39, with average of 1.17 and 1.41 ppm, respectively (Table 1). Lowest content of F was recorded in Venkatapuram village (0.41 ppm during *kharif*) and Kakkireni village (0.77 ppm during *rabi*), while the highest was recorded in Rontakolla village (2.32 and 2.39 ppm during *kharif* and *rabi*, respectively). Soil fluoride status map during *kharif* and *rabi* are shown in figures 1 and 2.

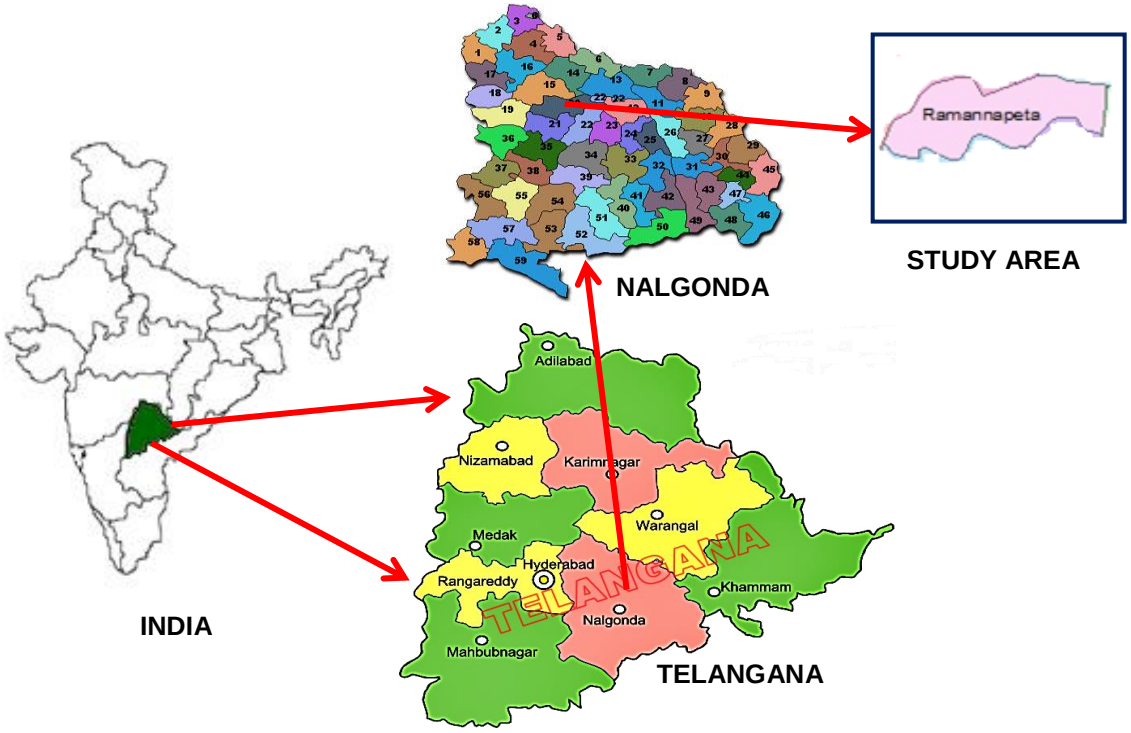

Figure 1: Location map of the study area

All the values obtained are well within the range of 2.57 to 16.44 ppm soil available F stipulated by EPA, FAO and WHO standard limit for fluoride, so it could be

concluded that there was no danger from F accumulation in the plants. Similarly, F content in soil between 0.02 and 1.00 mg kg^{-1} as reported by Davidson (1983) and between 0.075 and 0.200 mg kg^{-1} as obtained by Okibe *et al*. (2010). The content of available F in the soil samples is very low indicating that major part of deposited F had transformed itself in to insoluble compounds like CaF_2 (Blagojevic *et al*. 2002). These results are in conformation with the findings of Jakovljevic *et al.* (2002). Unfortunately there is no Indian standard available prescribing a limit to the F in soil and biological tissue.

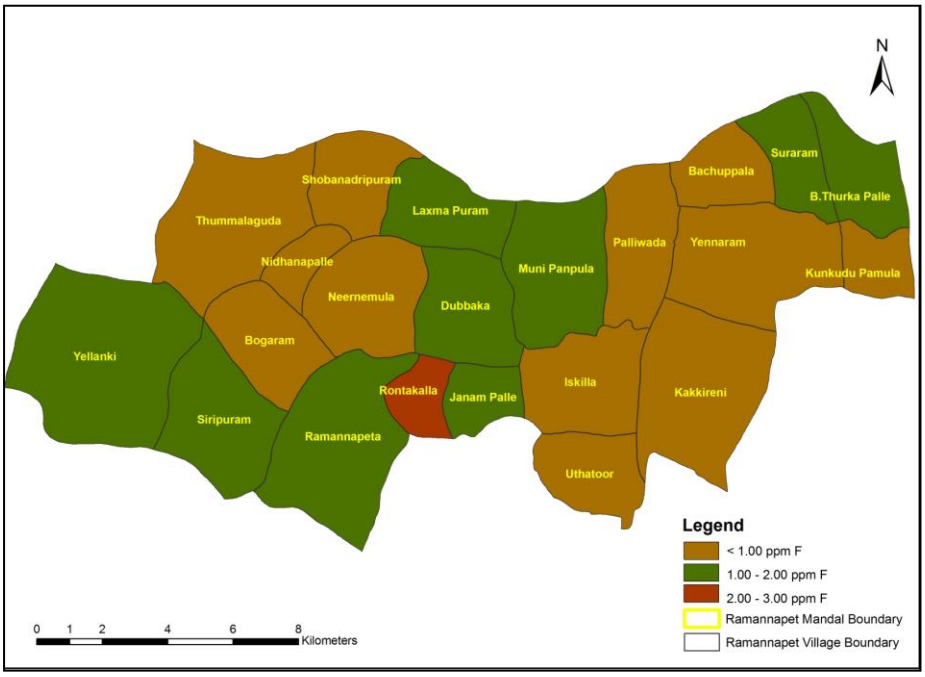

Figure 2: Soil available fluoride status map of Ramannapet mandal (*Kharif*, 2012)

Total Fluoride

The content of total F distributed in soil during *kharif* and *rabi* varied from 178 to 451, and 186 to 456 ppm, with average values of 279 and 289 ppm, respectively. Of all the soils collected, highest total F (451 ppm) was found in Janampalli village while the lowest (178 ppm) value found in Ramannapet village. Total F of normal soils is usually in the range from 150 to 400 mg kg^{-1} as prescribed by Newman (1984). Nearly 3.3% of soil samples recorded higher than the usual range and remaining samples were within its normal range indicates its geo-chemical origin without any form of artificial contamination. So, a danger from F accumulation in plants and its toxicity to human and animals are not to be expected. The results are in conformity with the findings of Jakovljevic *et al.,* 2002. The percentage of available F from its total fluoride content ranges from 0.10 to 0.82. The available F content was very low (< 3 mg kg^{-1}), being mostly less than 2% from its total amount. It is indicating that 95% of the F deposited in

soil surface is not available for plant uptake because of its conversion to unavailable form.

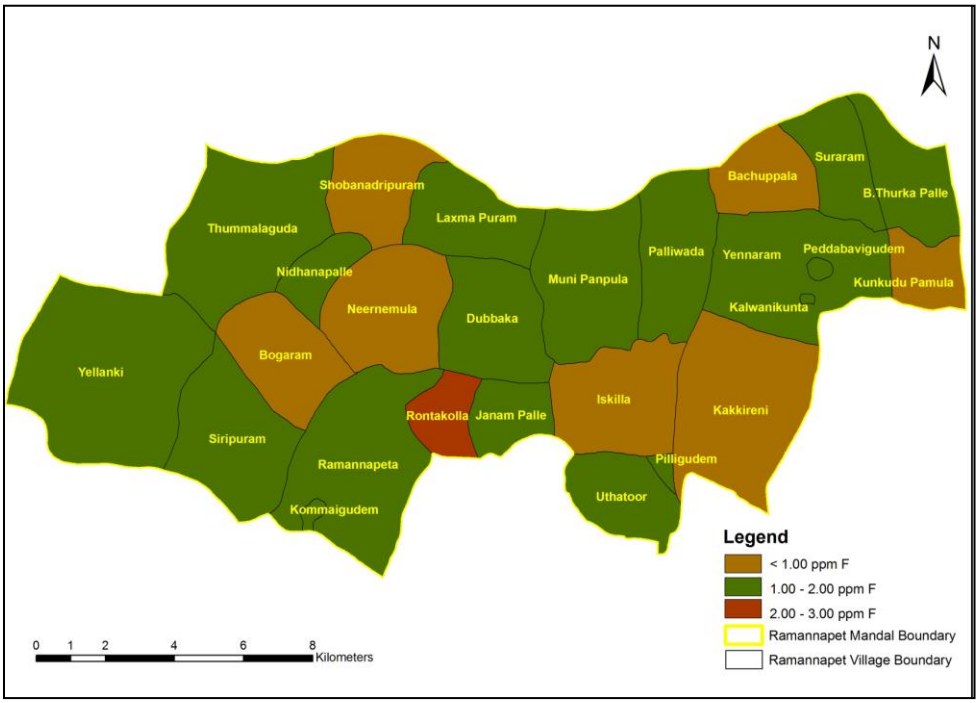

Figure 3: Soil available fluoride status map of Ramannapet mandal (*Rabi*, 2012-13)

Soil Physico-Chemical and Chemical Properties

The results indicated that the soils are neutral to alkaline in reaction, non saline in nature, low to medium in organic carbon (OC) content and cation exchange capacity (CEC). The texture of the soils collected in different villages of Ramannapet mandal varied as sandy loam (Table 2). The information regarding contents of available N, P_2O_5 and K_2O content in both the *kharif* and *rabi* seasons were categorized from very low to medium. With respect to available Zn, 18 (60%) samples in *kharif* and 15 (50%) samples in *rabi* were deficient, while remaining samples were found above critical limit (0.6 mg kg^{-1}) of available Zn. The results on available Fe revealed that, 8 (27%) samples in *kharif* and 9 (30%) samples in *rabi* were below critical limit (<4.5 mg kg^{-1}) of available Fe. The available Mn, Cu content of soils in both the *kharif* and *rabi* seasons are found to be above critical limit. Considering the critical limit for available B as 0.45 mg kg^{-1}, about 11 (37%) samples in *kharif* and about 21 (70%) samples in *rabi* were found to be deficient. The results revealed that, all the heavy metals viz., Cd, Cr, Ni, Pb and Co analyzed during *kharif* and *rabi* seasons were within the permissible limits.

Table 1: Fluoride content of the soils in different villages of Ramnnapet mandal of Nalgonda district during *Kharif* and *rabi* season.

S. No	Name of the Village	*Kharif*		*Rabi*	
		Available F	Total F	Available F	Total F
		(ppm)		(ppm)	
1	Ramannapet	1.12	178	1.16	186
2	Neernemula	0.62	214	0.81	232
3	Shobanadripuram	0.82	289	0.83	289
4	Laxmapuram	1.28	281	1.42	323
5	Nidhanpalle	0.66	289	1.02	295
6	Bogaram	0.87	236	0.87	267
7	Thummalagudem	0.88	205	1.63	214
8	Yellanki	1.75	356	1.78	356
9	Siripuram	1.58	245	1.61	243
10	Dubbaka	1.95	334	1.98	367
11	Rontakolla	2.32	308	2.39	249
12	Munipampula	1.63	302	1.65	318
13	Palliwada	0.47	287	1.74	259
14	Nagulanchagudem	0.79	288	1.89	291
15	Bachuppala	0.93	332	0.98	298
16	Suraram	1.82	279	1.83	336
17	Thurkapalle	1.75	213	1.78	296
18	Venkatapuram	0.41	275	0.78	278
19	Kunkudupamula	0.93	315	0.98	221
20	Peddabavigudem	1.56	224	1.69	237
21	Yennaram	0.94	256	1.38	265
22	Kallonikunta	1.19	298	1.52	305
23	Kakkireni	0.65	235	0.77	315
24	Pilligudem	1.82	297	1.92	301
25	Uttatoor	0.44	229	1.1	231
26	Iskilla	0.75	265	0.78	271
27	Lacchigudem	1.34	214	1.76	352
28	Janampalle	1.74	451	1.88	456
29	Sanjeevaiahnagar	0.63	357	0.94	253
30	Kommaigudem	1.47	319	1.51	360
Range		**0.41-2.32**	**178-451**	**0.77-2.39**	**186-456**
Mean		**1.17**	**279**	**1.41**	**289**

Correlation between Fluoride Content and Other Chemical Constituents of Soil

Simple correlation co-efficient have been worked out between the available fluoride and other properties of soils. The ‘r’ values are presented in the Table 3. The positive correlation of available fluoride with soil pH, suggesting that the pH of the soil is more important in determining the concentration of fluoride, in agreement with earlier observation made by Blagojevic *et al*. (2002).

Table 2: Range and mean values of physical, physico-chemical and chemical characteristics of the soil samples collected from Ramannapet mandal of Nalgonda district during *Kharif* and *rabi* (2012-13).

Characteristics	***Kharif***		***Rabi***	
	Range	**Mean**	**Range**	**Mean**
Sand (%)	46.0-66.6	56.8	-	-
Silt (%)	7.4-20.5	13.1	-	-
Clay (%)	19.8-41.4	30.1	-	-
pH	7.14-8.64	7.97	7.18-8.65	8.08
E.C (dS m^{-1})	0.14-0.29	0.21	0.15-0.98	0.49
CEC (c mol(p^{+}) kg^{-1})	9.86-22.31	15.18	0.23-0.71	0.47
OC (%)	0.23-1.04	0.50	7.82-21.58	13.45
N (kg ha^{-1})	110-289	191	153-364	218
P_2O_5 (kg ha^{-1})	8.55-32.12	19.49	12.21-32.65	21.86
K_2O (kg ha^{-1})	125-312	229	171-312	260
S (mg kg^{-1})	5.78-28.21	12.73	4.58-34.00	11.39
Available F (ppm)	0.41-2.32	1.17	0.77-2.39	1.41
Total F (ppm)	178-451	279	186-456	289
Zn (mg kg^{-1})	0.23-2.17	0.68	0.24-2.14	0.66
Mn (mg kg^{-1})	2.56-17.68	8.39	2.61-29.55	8.62
Fe (mg kg^{-1})	2.52-13.56	6.99	2.22-25.23	8.58
Cu (mg kg^{-1})	0.24-2.99	1.06	0.18-2.71	0.82
B (mg kg^{-1})	0.18-0.89	0.53	0.35-0.55	0.42
Cd (mg kg^{-1})	0-0.21	0.05	0-0.47	0.07
Cr (mg kg^{-1})	0-0.18	0.03	0-0.3	0.09
Ni (mg kg^{-1})	0.02-0.32	0.20	0.24-1.2	0.71
Pb (mg kg^{-1})	0.25-1.4	0.71	0.24-3.01	1.12
Co (mg kg^{-1})	0.02-1.28	0.28	0.12-1.02	0.35

The available fluoride concentration in soils negatively correlated with EC, CEC and P_2O_5 content of soil whereas the correlation coefficient between fluoride and other ions is very poor during both seasons. Increasing fluoride content in soil decreases the available P_2O_5 content of the soil. The reduction of P_2O_5 content in soil due to F addition can be attributed to formation of insoluble phosphorus compounds in the soils. Positive correlation coefficients between available fluoride and the content of some micronutrients metals (Cu, Mn and Zn) were also found, which indicated their mutual geochemical origin. Similar results reported by Jakovljevic *et a*l, (2002).

It is interesting to note that, fluoride is negatively correlated with clay percent of soils and positively correlated with sand percent of soils during both seasons but no significant correlation was observed. Clay, soil pH and P_2O_5 in soil control fluoride content in the soil solution. Most of the fluoride in the soil is insoluble and, therefore, less available to plants. However, high soil fluoride concentrations or clay can increase

fluoride levels in soil solution, increasing uptake via the plant root. The relationship between available fluoride and total fluoride was positive but no significant correlation was observed.

Table 3: Correlation coefficients (r) between available fluoride content and other chemical constituents of soils

S. No.	Correlation Among	r value in	
		Khari	***Rabi***
1	Available Fluoride vs pH	0.685**	0.382*
2	Available Fluoride vs EC	-0.289	-0.105
3	Available Fluoride vs CEC	-0.415	-0.241
4	Available Fluoride vs Available P_2O_5	-0.394	-0.423
5	Available Fluoride vs Available K_2O	-0.014	0.101
6	Available Fluoride vs Available Cu	-0.046	0.056
7	Available Fluoride vs Available Mn	0.049	-0.029
8	Available Fluoride vs Available Iron	-0.167	-0.108
9	Available Fluoride vs Available Zinc	-0.049	-0.122
10	Available Fluoride vs Total fluoride	0.276	0.349
*5 % (0.3730)			
**1 % (0.4774)			

Seasonal Variations of Fluoride Content

Generally, a high rate of evapo-transpiration and over-exploitation of groundwater resources for agricultural and drinking water purposes during *rabi* season causes a low freshwater exchange and results in precipitation of salts, including F rich salts, temporarily in the top layers of the soil. During *kharif* season, the infiltrating waters leach these soils and replenishment of the groundwater by rainfall indicated a clean recharge from external sources. Hence, the concentration of fluoride is observed to be greater in the *rabi* season soil than in *kharif* season. As a result, mean fluoride content in surface soil was higher in *rabi* season (1.41 ppm) compared to *kharif* season (1.17 ppm). Seasonal distribution of fluoride is dependent on a variety of factors such as amount of soluble and insoluble fluoride in source rocks, the duration of contact of water with rocks and soil temperature, rainfall and oxidation- reduction process (Mahapatra *et al*., 2005 and Paya and Bhatt, 2010).

Conclusion:

In conclusion, results show that the surface soils of the Ramannapet mandal Nalgonda district has no deleterious effects on crop cultivation. The most predominant factors that control the amount of fluoride in soil are the quantity of clay minerals, soil pH and the concentration of Ca and P in soils.

Authors' contributions: *Dr. D. Vijaya Lakshmi (Ph.D. Research Scholar) performed the Ph.D research experiment, wrote the manuscript and is the corresponding author of manuscript. Dr. K. Jeevan Rao (Professor&University Head) was chairman of the Advisory Committee, Dr. T. Ramprakash (Scientist) and Dr. A. Pratap Kumar Reddy (Principal Scientist) was members of advisory committee.*

References

Blagojevic, S., Jakovljevic, M. and Radulovic, M. 2002. Content of fluorine in soils in the vicinity of aluminium plant in Podgorica. *Journal of Agricultural Sciences.* 47(1): 1-8.

Davidson, A., 1983. The effects of fluoride on plant growth and forage quality in effect of gaseous air pollution in agriculture and horticulture. Edited by *M.H. Unsworth and D.P. Ormord, London butter worth.* 267-291.

Jakovljevic, M., Blagojevic, S. and Mladenovic, S.A. 2002. Fluorine content in soils of Northern Pomoravlje. *Journal of Agricultural Sciences*. 47(2): 121-128.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Printice Hall of India Private Limited, New Delhi.

Lindsay, W.L. and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*. 42: 421-428.

Mahapatra, M.K., Mishra, A and Das, B.P. 2005. Fluorosis first reported in Naupada district of Orissa India. *Ecology, Environment and Conservation*. 11(2): 277-280.

McQuaker, N.. and Gurney, M. 1977. Determination of total fluoride in soil and vegetation using an alkali fusion selective ion electrode technique. *Analytical Chemistry*. 49:53-56.

Miller, G.W. 1993. Effect of fluoride on physiological and biochemical disorders in plants. *Fluoride*. 26: 3-22.

Newman., J.R. 1984. Fluoride standards and predicting wildlife effects. *Journal of the International Society for Fluoride Research.* 17: 41-47.

Okibe, F.G., Ekanem, E.J., Paul, E.D., Shallangwa, G.A., Ekwumemgbo, P.A., Sallau, M.S. and Abanka, O.C. 2010. Fluoride content of soil and vegetables from irrigation farms on the bank of river Galma, Zaria, Nigeria. *Australian Journal of Basic and Applied Sciences*. 4(5): 779-784.

Olsen, S.R., Cole, C.V., Watanabe, F.S and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *US Department of Agriculture Circular*.

Omueti, J.A.I. and Jones, R.L. 1977. Fluoride adsorption by Illinois soils. *Journal of Soil Science.* 28: 564-572.

Paya, P. and Bhatt, S.A. 2010. Fluoride contamination in groundwater of Patan district, Gujarat, India. *International Journal of Engineering Studies*. 2(2): 171-177.

Pendias, A. and Pendias, H. 1984. Elements of group VII in: *Trace elements in soils and plants*. CRC, Boca Raton USA. 473-482.

Rao, M.S. and Mamatha, P. 2004. Water quality in sustainable water management. *Current Science*. 87(7): 942-947.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure of the estimation of available nitrogen in soils. *Current Science*. 25: 259-260.

Watanabe F.S. and Olsen S R 1965 Test for ascorbic acid method for determining phosphorus in water and sodium bicarbonate extracts of soil. Soil Science Society of America Proceedings 29: 677-678.