International Journal of Science, Environment and Technology, Vol. 5, No 5, 2016, 2769 – 2778

ISSN 2278-3687 (O)
2277-663X (P)

FLUORIDE CONTENT IN CULTIVATED SOILS OF NARKATPALLY MANDAL OF NALGONDA DISTRICT, TELANGANA

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Abstract: Fluoride content of soil samples assessed in 26 villages of Narkatpally Mandal of Nalgonda District, Telangana during *kharif* and *rabi* seasons of 2012-13. The mean values of available F present in the soil samples of Narkatpalli mandal were 1.18 ppm in *kharif* season and 1.66 ppm, respectively in *rabi* season. All the values obtained are well within the range of 2.57 to 16.44 ppm soil available F stipulated by 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 soils was 310 ppm in *kharif* season and 338 ppm in *rabi* season. Nearly 7.7 % 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 fluoride bioavailability controlled by physical and chemical characteristics of the soil. Clay, soil pH and P_2O_5 in soil control fluoride content in the soil solution. 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.

Keywords: Available Fluoride, Total Fluoride, Seasonal Variations, Cultivated Soils, Nalgonda.

INTRODUCTION

Fluorine belongs to the halogen group of element in the periodic table and is a natural constituent of the environment and is one of 92 naturally occurring elements. Despite being the thirteenth most abundant element with an average concentration of 0.032% by weight in the earth's crust, it is not an essential nutrient for any living thing. The main natural sources of inorganic F in soil are weathering and dissolution of rocks and minerals, emissions from volcanoes and marine aerosols. Natural contamination of groundwater sources of F are derived by the solvent action of water on the rocks and the soil of the earth crust as dissolved salts is a major constraint mainly in regions characterized by arid and semiarid climates (Rao and Mamatha, 2004). The average content of total F for "world soils" amounts to 320 mg kg^{-1}. The lowest amounts are found in sandy soils in humid climate, while the highest ones are

*Received Aug 1, 2016 * Published Oct 2, 2016 * www.ijset.net*

found in soils with high clay content and soils formed on igneous rocks. For most soils, the content of total F ranges from 150 to 400 mg kg^{-1} (Pendias and Pendias, 1984).

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 a series of metabolic pathway (Miller, 1993).

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 (Fig. 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 30ºC to 46.5ºC, and in winter (November–January), it varies between 14°C and 29°C. The average annual rainfall in this area is about 1,000 mm, occurring mostly during south-west monsoon (June–September).

A survey was carried out in Narkatpalli mandal of Nalgonda district by covering all the villages, with a view to assess characterization of soil during two seasons *i.e*. *kharif* (2012) and *rabi* (2012-13). As per the objectives laid down for 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 pollution can be done and also soil F status maps can be prepared by depicting the element in soil at village level. Totally 26 benchmark sites were fixed depending on the number of villages in the mandal 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 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 (Subbiah 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 (Watanabe and Olsen, 1965), available potassium was extracted by using neutral normal ammonium acetate (Jackson, 1973) and determined by flame photometer. Available micronutrients (DTPA extractable) 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).

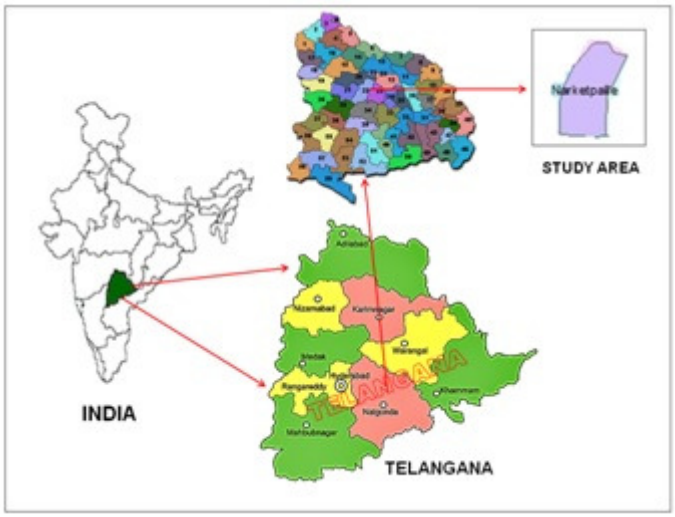

Fig 1: Location map of the study area

RESULTS AND DISCUSSION

Available Fluoride

Fluoride content of surface soil samples collected in the villages of Narkatpally mandal of Nalgonda district during *kharif* and *rabi* are presented in Table 1. Fluoride present in the soil samples collected during *kharif* and *rabi* varied from 0.26 to 2.64 and 0.53 to 2.64, with average of 1.18 and 1.66 ppm, respectively. Lowest content of F was recorded in Pothinenipalli village (0.26 and 0.53 ppm during *kharif* and *rabi*, respectively) while the highest was recorded in Yedavalli village (2.64 and 2.64 ppm during *kharif* and *rabi*, respectively). Soil fluoride status map during *kharif* and *rabi* are shown in figures 2 and 3.

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.

Total Fluoride

The content of total F distributed in soil during *kharif* and *rabi* varied from 195 to 481, and 246 to 485 ppm, with average values of 310 and 338 ppm, respectively. Of all the soils collected, highest total F (481 ppm) was found in Brahmanavellemla village while the lowest (195 ppm) value found in Indiranagar village. Total F of normal soils is usually in the range from 150 to 400 mg kg^{-1} as prescribed by Newman (1984). Nearly 7.7% 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 95-98% of the F deposited in soil surface is not available for plant uptake because of its conversion to unavailable form.

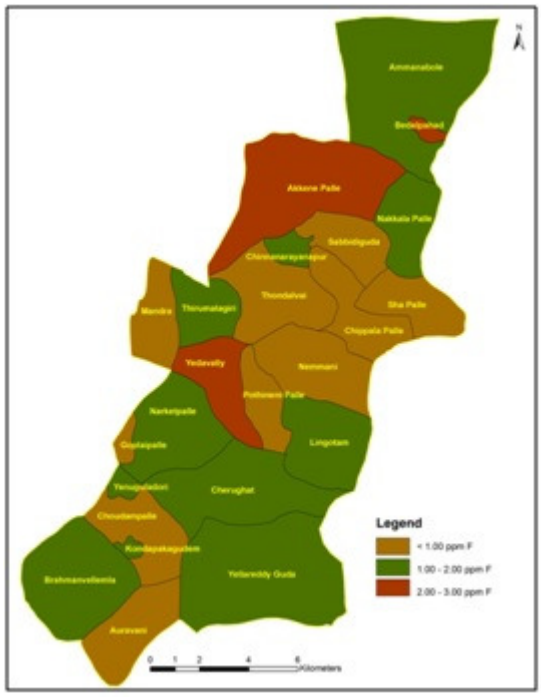

Figure 2: Soil available fluoride status map of Narkatpalli mandal (*Kharif,* 2012)

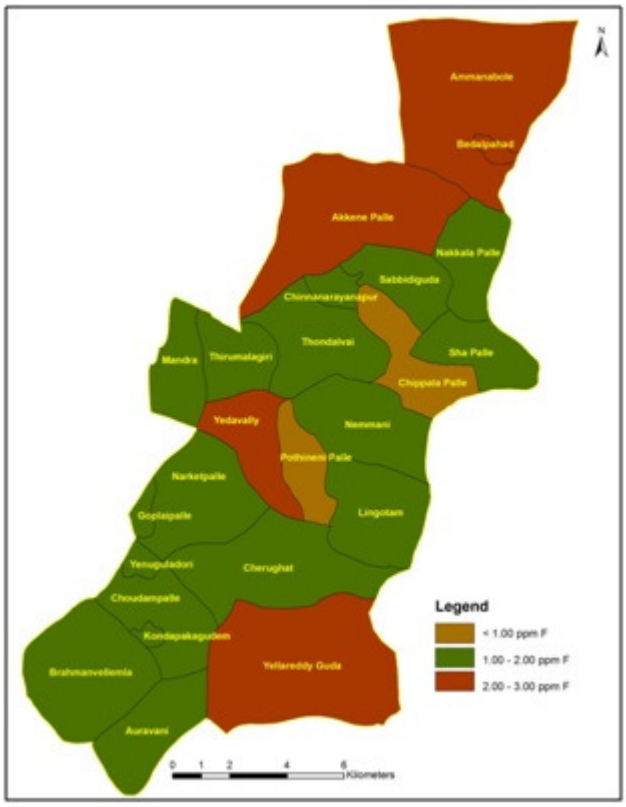

Figure 3: Soil available fluoride status map of Narkatpalli mandal (*Rabi,* 2012- 13)

Table 1: Fluoride content of the soils in different villages of Narkatpalli mandal of Nalgonda district during *Kharif* and *Rabi* seasons of 2012-13.

S. No	Name of the Village	*Kharif*		*Rabi*	
		Available F	Total F	Available F	Total F
		(ppm)		(ppm)	
1	Anuguladori	1.46	324	1.58	331
2	Brahmanavelleml	1.17	481	1.25	485
3	Auravani	0.48	249	1.73	256
4	Choudhampalli	0.41	386	1.88	392
5	Kondapakagudem	1.08	345	1.98	346
6	Yellareddygudem	1.12	278	2.32	329
7	Chervugattu	1.19	346	1.78	357
8	Lingotam	1.38	294	1.82	348
9	Narkatpalli	1.28	289	1.98	305
10	Yedavalli	2.64	367	2.64	359
11	Naibai	1.87	312	2.12	378
12	Pothinenipalli	0.26	245	0.53	251
13	Nemmani	0.98	356	1.02	368
14	Juvvagudem	0.87	278	0.87	297
15	Shapalli	0.78	332	1.74	345
16	Tirumalagiri	1.05	289	1.2	297
17	Mandra	0.98	245	1.54	309

18	Thondlavai	0.32	278	1.05	393
19	Indiranagar	1.09	195	2.17	334
20	Chippalapalli	0.41	245	0.84	262
21	Chinanarayanpur	1.2	267	1.12	274
22	Nakkalapalli	1.24	356	1.52	375
23	Akkenapalli	2.21	425	2.38	452
24	Ammanabolu	1.93	245	2.33	246
25	Bendalpahad	2.47	342	2.55	378
26	Gopalaipally	0.68	297	1.28	319
Range		**0.26-2.64**	**195-481**	**0.53-2.64**	**246-485**
Mean		**1.18**	**310**	**1.66**	**338**

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 Narkatpalli mandal varied as sandy loam, sandy clay and sandy clay 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, 10 (38.5%) samples in *kharif* and 14 (53.8%) 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, 16 samples in *kharif* and 7 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 13 samples in *kharif* and about 18 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 2).

Table 2: Range and mean values of physical, physico-chemical and chemical characteristics of the soil samples collected from different villages of Narkatpalli mandal of Nalgonda district during *kharif* and *rabi* seasons of 2012-13

Characteristics	*Kharif*		*Rabi*	
	Range	**Mean**	**Range**	**Mean**
Sand (%)	44.0-70.8	57.0	-	-
Silt (%)	7.5-17.8	12.3	-	-
Clay (%)	12.8-41.4	30.8	-	-
pH	7.25-8.52	7.76	7.26-8.66	7.95

E.C (dS m^{-1})	0.12-0.32	0.20	0.14-0.62	0.30
CEC (c mol(p^+) kg^{-1})	8.98-24.64	15.32	0.25-0.70	0.46
OC (%)	0.27-0.70	0.48	8.52-23.86	14.15
N (kg ha^{-1})	144-296	203	159-314	215
P_2O_5 (kg ha^{-1})	9.36-25.36	19.50	8.03-35.42	16.86
K_2O (kg ha^{-1})	158-325	255	159-325	254
S (mg kg^{-1})	5.98-25.56	13.23	5.50-29.50	10.99
Zn (mg kg^{-1})	0.22-2.02	0.84	0.29-1.25	0.70
Mn (mg kg^{-1})	2.42-14.56	8.18	4.02-39.72	12.63
Fe (mg kg^{-1})	2.02-18.69	8.28	2.53-16.08	7.84
Cu (mg kg^{-1})	0.24-3.12	1.13	0.18-1.44	0.73
B (mg kg^{-1})	0.22-1.23	0.64	0.12-0.75	0.36
Cd (mg kg^{-1})	0-0.24	0.07	0-0.32	0.04
Cr (mg kg^{-1})	0-0.09	0.02	0-0.89	0.20
Ni (mg kg^{-1})	0.09-0.38	0.20	0.04-1.23	0.45
Pb (mg kg^{-1})	0-1.44	0.42	0.12-1.25	0.64
Co (mg kg^{-1})	0.07-1.2	0.49	0.12-0.65	0.30

Correlation Between Fluoride and other Chemical Constituents of Soil

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). 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	*0.398	*0.464
2	Available Fluoride vs EC	-0.259	-0.213
3	Available Fluoride vs CEC	-0.353	-0.384
4	Available Fluoride vs Available P_2O_5	-0.562	-0.694
5	Available Fluoride vs Available K_2O	0.074	0.041
6	Available Fluoride vs Available Cu	-0.020	0.164
7	Available Fluoride vs Available Mn	0.202	0.186
8	Available Fluoride vs Available Iron	-0.033	-0.091
9	Available Fluoride vs Available Zinc	-0.157	-0.039
10	Available Fluoride vs Total fluoride	0.340	0.271
*5 % (0.3889) **1 % (0.4994)			

Seasonal Variations of Fluoride Content

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 (1.66 ppm) compared to *kharif* season (1.18 ppm). Seasonal distribution of fluoride is dependent on a variety of factors such as amount of soluble and insoluble fluoride source in

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 Narkatpally 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.

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