Analysis of Soil Quality Using Physico-Chemical Parameters with Special Emphasis on Fluoride from Selected Sites of Sawai Madhopur Tehsil, ajasthan

Arshi Iram* and TI Khan

Indira Gandhi Center for Human Ecology, Environment and Population Studies, University of Rajasthan, India

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*Corresponding author: Arshi Iram, Indira Gandhi Center for Human Ecology, Environment and Population Studies, University of Rajasthan, India,
Email: arshiiram444@gmail.com

Abstract

Soil samples from were collected for analysis from the agricultural fields of Sawai Madhopur tehsil. Inhabitants, cattle and some crop species which are sensitive to fluoride toxicity of this tehsil suffer from fluorosis. Soil samples were collected from 35 villages of Sawai Madhopur Tehsil. Total 175 samples (5 samples from each village) were analyzed. Selected ion meter was used for estimation of fluoride. Fluoride ion concentration in soil samples varied from 1.0ppm to 8.23ppm. Out of 35villages 1village is in 0-1ppm, 7 villages is in 1-1.5ppm, 7 villages is in 1.5-2.5ppm ,16 villages is in 2.5- 5.0ppm and 4 villages is in 5.0-10.0ppm range .

Keywords: Fluoride; Physico-Chemical; Parameters; Subsoil Water

Introduction

Soil is a vital component, medium of unconsolidated nutrients and materials, forms the life layer of plants. Soil developed as a result of pedogenic processes through weathering of rocks, consisting of inorganic and organic constituents, possessing definite chemical, physical, mineralogical and biological properties, having variability from depth to surface of the earth, and provides a medium for plant growth Thakre [1]. Soil physic-chemical properties influence the behavior of soil and hence, knowledge of soil property is important Sumithra [2]. Soil testing is the only way to determine the available nutrient status in soil and the only way we can develop specific fertilizer recommendations. Soil properties that are sensitive to changes can be used as indicators to improve soil quality. Analysis of soil is carried out for the studies of various parameters like total Organic Carbon, Available Nitrogen (N), Phosphorus (P2O5) and Potassium [K2O], pH, Electrical conductivity, soil texture, bulk density, chloride, fluoride and % moisture content. The fertility of the soil depends on the concentration of N, P, K, organic and inorganic materials, conductivity. The physicochemical properties such as moisture content, Nitrogen, phosphorus and organic matter required for the growth of plant. Potassium is used for flowering purpose, it is also required for building of protein, photosynthesis, fruit quality and reduction of diseases and phosphate is used for growth of roots in plants.

Fluoride Distribution in Soil

The main source of fluoride in soil is Pegmatite Pneumatolitic deposits as vein deposit in rocks or Pegmatite & metamorphosed limestone, higher concentrations (1,000 g/kg) can occur in soils by anthropogenic inputs, such as phosphate fertilizers Kabata [3]. Mostly fluorine present as oxy-hydroxides, only a few parts dissolved in the soil solution. Fluoride mobility in soil soil's sorption capacity is positively correlated, and sorption capacity depends on pH and soil salinity Cronin [4]. Fluoride contaminated soil are more acidic or alkaline, the risk of fluoride toxicity in shoots of plants would increase with increasing concentration of fluoride in soil Stevens [5]. Fluoride at high concentration in soils toxic not only for plants but also for grazing animals who feed in such soils Clark, O'Hara and Cordes, Cronin Loganathan.

Study Area

Sawai Madhopur district is located in the eastern part of the Rajasthan State, it lies between 250 45' to 260 41 N latitude and 75059' to 770 0' E longitude. Administratively, the district is divided into 4 sub-divisions viz. Gangapur, Bamanwas, Bonli and Sawai Madhopur and has seven tehsils i.e. Gangapur, Bamanwas, Malarna Dungar, Bonli, Chouth Ka Barwara, Sawai Madhopur and Khandar. The total area of Sawai Madhopur tehsil is 5042.99 km2 with a population of about 1,20,998. Out of this 19.04 percent of

total population lives in towns and 80.96 percent in rural area. The climate of the district can be classified as semi-humid. It is characterized by very hot summers and very cold winters with fairly good rainfall during south-west monsoon period. Many villages contain high fluoride concentrations (Figure 1).
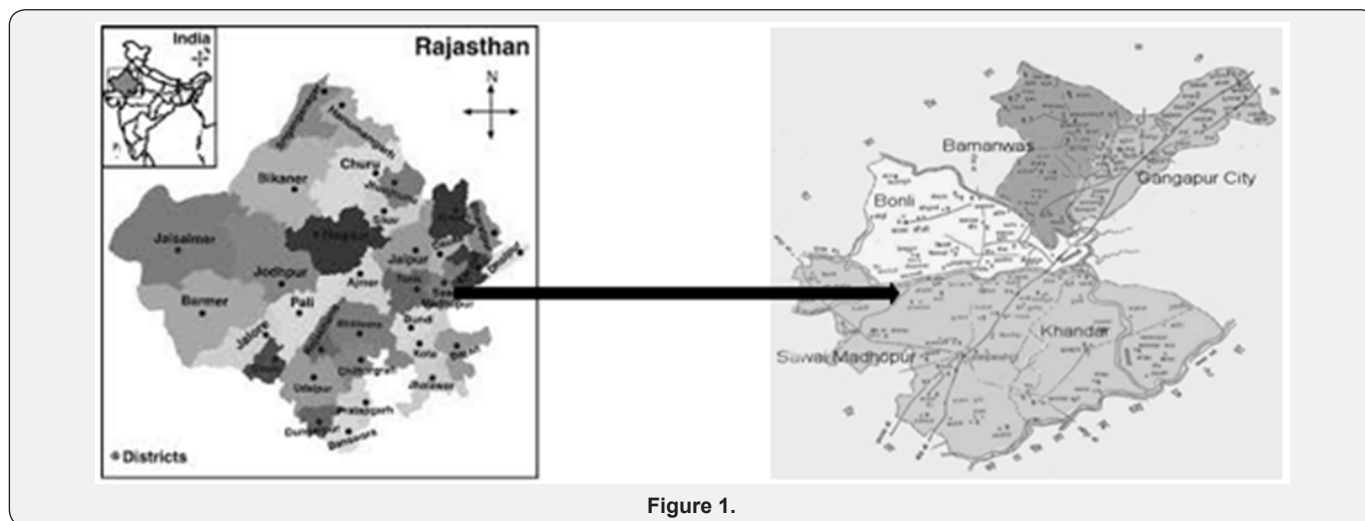

Figure 1.

Materials And Methodology

Selection of Sampling Station

For the purpose of this study soil samples were collected from various agricultural fields of the area. In total 175 samples from 35 villages were collected. Five soil samples at 0-15 cm depth were collected randomly from each village.

Sampling Procedure

In order to collect soil samples (0-15 cm depth) first removed grasses, litter and other plant residues from soil surface and collect soil samples by using soil collection tools. In each case, a triangular block was marked and soil samples were collected in plastic bags, which were sealed, and labeled properly. Soil samples were brought to the laboratory for analysis. Before analysis, the samples were hot air dried and homogenized, sieved through a 2mm sieve to ensure homogeneity. The samples were preserved in clean sealed polythene bags for analysis (Table 1).

Table 1: Soil Properties under Study with Their Methods of Measurement.

Sr. N.	Soil Property	Analysis Method	Unit
1	Bulk density	Core sampling method	Gm/cm^3
2	Texture	Robinson's pipette method	-
3	Temperature	Soil thermometer	
4	Moisture content	Oven drying method	In Percantage
5	pH	pH meter	-
6	Organic matter	Titrimetric method (Walkley and Black, 1934). % Soil organic matter =% organic carbon x 1.724	In Percantage
7	Available Nitrogen	Micro Kjeldhal Method	Kg/ha
8	Available phosphorus	Spectrophotometric method	Kg/ha
9	Available otassium	Flame photometer method (1986)	Kg/ha
10	EC	Digital portable water analyzer kit (Model 161 E)	m mhos
11	Chloride	Volumetric titration	mg/100gm
12	Fluoride	Selective Ion meter	ppm

Soil Quality Parameters and Methodology

For analysis of physicochemical parameters of the soil samples first we prepared soil suspension in distilled water (1:4 w/v) and allowed to settle down the particles. Main focus was on those soil quality parameters which influence the movement and retention of water that contribute to store and supply of nutrients. In this study some selected physical and chemical parameters were determined.

Physical Parameters: Temperature, Texture, Bulk density, Moisture content.

Chemical Parameters: pH, Organic matter, Available Nitrogen, Available Phosphorus, Potassium, Electrical Conductivity, Chloride, Fluoride.

Fluoride Estimation: Fluoride estimated by ion selective meter (Mettler Toledo MA 235 pH /ion analyzer), Standard procedure was followed APHA [6] to get satisfactory results; total Ionic strength adjustment buffer (TISAB) was used to maintain a suitable ionic strength and also to avoid complex formation (Figure 2).
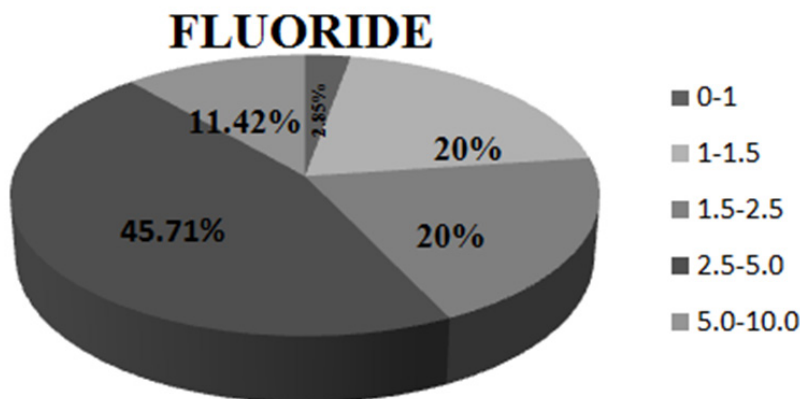

Figure 2: Fluoride Distribution Percentage in Different Villages.

Statistical Analysis

In the present study Mean and Standard Deviation have been calculated for each pair of soil quality parameters by using Excel spreadsheet (Table 2). The standard formulae were used in the calculation for statistical parameters are as follows:

$$Mean(\mu) = \sum X \div N$$

x = Value of Observation

N = Number of Observation

$$Standard\ Deviation = \sqrt{n\Sigma \times 2 - (\Sigma x)2 / n(n-1)}$$

x = Values of Parameter

n = Number of Observations

Table 2: Standard Soil Classification.

Soil Test	Range	Classification
pH	<4.5	Extremely acidic
	4.51-5.50	Very strongly acidic
	5.51-6.00	Moderately acidic
	6.01-6.50	Slightly acidic
	6.51-7.30	Neutral
	7.31-8.50	Moderately alkaline
	8.51-9.00	Strong alkaline
	>9.01	Very strong alkaline
Salinity, Electrical conductivity (mmhos)	Upto 1	Average
	1.01-2.00	Harmful to germination
	2.01-3.00	Harmful to sensitive crop
Organic Carbon%	Upto 0.20	Very less
	0.21-0.40	Less
	0.41-0.50	Medium
	0.51-0.80	On an average sufficient
	0.81-1.00	Sufficient
	>1.00	More than sufficient
Nitrogen (kg/ha)	Upto 50	Very less
	51-100	Less
	101-150	Good
	151-300	Better

	>300	Sufficient
Phosphorus (kg/ha)	Upto 15	Very less
	16-30	Less
	31-50	Medium
	51-65	On an average sufficient
	66-80	Sufficient
	>80	More than sufficient
Potassium (kg/ha)	0-120	Very less
	120-180	Less
	181-240	Medium
	241-300	Average
	301-360	Better
	>360	More than sufficient

Result

The basic chemical and physical soil properties are given in Table 3. The analyzed chemical and physical properties show the wide variation range, as can be seen in the results. The pH of all soil samples were found to be ranged in between 7.04 to 8.3 which indicate the slight alkalinity of soils. Electrical conductivity of soil samples range between 0.026 to 1.967m mhos, in most of the samples except some hilly soil samples moisture content was in proportionate level between 7.02percent to 25.71 percent; moisture content varies in different season (Figure 3). Organic matter was varied widely among the various cultivated soils horizons selected for the study from 0.188 to 3.14percent. Chloride is generally mentioned as a hydrological and chemically inert substance. Chloride concentration in soil generally shows the salinity of soil, chloride concentration in soil samples ranged from 3.52 to 24.14mg/100gm. Most important factor which decide the soil productivity is N:P:K ratio. Available nitrogen found in soil samples between 13.8 to 218.60 kg/ha. Phosphorus considered as micro nutrient, is utilized by plant in the form of $H_2PO_4^-$ & HPO_4^{-2} species. Appropriate concentration of phosphorus (P) is necessary for maintaining a balance between the other plant nutrients and ensuring the normal growth of the crop. Previous researches have already reported the importance of phosphorus Leonardi [7]. Available phosphorus ranged in cultivated soil samples of study area between 54.72 to 298.4kg/ha.

Table 3: Physico-chemical Analysis of Soil Samples.

Sr. N.	Ph	EC	Soil Texture	Bulk Density	Village	Moisture Content	Chloride	Fluoride	% Carbon	% Organic Matter	N	P	K
1	7.5± 0.01	1.882± 0.003	Deep brown loamy	1.41±0.21	Sawai Madhopur	21.29	6.39± 0.926	1.5± 0.41	0.311± 0.029	0.517± 0.092	91.2± 12.08	100.4± 20.81	364.2± 9.35
2	7.1± 0.24	0.487± 0.164	Deep dark brown sandy	0.98± 0.08	Phalodi	13.47	10.65± 0.392	3.1± 1.01	0.842± 0.112	1.448± 0.261	123.0± 54.62	98.43± 34.66	402.8± 17.99
3	8.3± 0.14	0.536± 0.12	Medium brown loamy	1.02± 0.54	Charoda	12.08	14.91± 2.98	2.5± 0.97	0.948± 0.154	1.634± 0.385	151.2± 38.29	162.3± 25.04	423.1± 12.58
4	7.6± 0.23	0.24± 0.006	Rock red	0.64± 0.29	Geenapur	7.9	22.01± 3.045	3.0± 1.21	0.435± 0.023	0.749± 0.095	138.7± 47.24	120.4± 15.54	382.6± 29.02
5	7.9± 0.06	0.847± 0.431	Shallow brown loamy	1.09± 0.72	Makholi	10.47	17.75± 2.091	2.09± 0.45	0.701± 0.104	1.209± 0.189	102.4± 29.05	125.4± 21.43	310.5± 25.43
6	7.9± 0.25	0.026± 0.059	Deep black clayey	1.21± 0.38	Dondri	24.01	22.01± 2.038	6.19± 2.10	0.744± 0.029	1.282± 0.231	98.3± 42.84	97.8± 31.05	242.5± 62.01
7	7.3± 0.93	0.869± 0.073	Deep brown loamy	0.86± 0.47	Kanseer	18.52	7.1± 0.837	2.30± 1.52	0.645± 0.374	1.112± 0.137	190.5± 25.96	154.7± 10.42	528.4± 36.18

8	8.1± 0.53	0.424± 0.026	Deep dark brown sandy	0.74± 0.91	Sellu	12.15	4.26± 1.021	3.01± 1.04	0.095± 0.002	0.164± 0.056	117.2± 38.27	102.9± 21.04	374.6± 19.26
9	7.4± 0.36	0.481± 0.174	Shallow yellowish brown gravelly	0.92± 0.39	Chitara	19.21	12.07± 2.112	4.0± 2.01	1.124± 0.537	1.938± 0.118	87.5± 12.57	74.25± 32.33	251.2± 59.08
10	7.9± 0.42	1.86± 0.046	Red gravelly loam hilly	1.23± 0.24	Dobda	7.02	5.68± 0.984	8.23± 2.11	0.178± 0.097	0.307± 0.106	184.7± 9.02	196.2± 25.09	362.4± 31.55
11	7.4± 0.29	1.58± 0.095	Deep brown clayey	0.69± 0.40	Bhagw atgarh	23.12	21.3± 3.102	6.72± 1.89	0.273± 0.100	0.470± 0.142	70.2± 22.65	142.3± 24.07	217.6± 44.02
12	7.2± 0.84	1.96± 0.11	Medium brown loamy	1.05± 0.33	Behru pura	17.15	19.17± 1.292	3.12± 0.95	0.246± 0.039	0.424± 0.098	170.2± 18.09	101.4± 55.97	402.9± 17.42
13	7.8± 0.34	0.750± 0.027	Deep dark brown sandy	0.83± 0.49	Ranth ambore	9.05	7.81± 0.573	1.10± 0.45	0.560± 0.104	0.966± 0.055	99.4± 24.67	110.2± 21.48	273.5± 22.98
14	7.5± 0.93	0.920± 0.103	Shallow brown loamy	1.40± 0.12	Udha mpuri	19.17	4.97± 0.953	1.15± 0.23	0.701± 0.074	1.209± 0.564	134.5± 10.41	145.2± 32.61	504.2± 14.38
15	8.2± 0.06	0.326± 0.007	Deep black clayey	1.20± 0.98	Korwada	22.85	14.21± 2.054	2.40± 1.04	1.397± 0.153	2.41± 0.135	162.75± 13.004	114.1± 28.04	495.1± 53.22
16	8.0± 0.15	0.956± 0.012	Rock red gravelly	0.91± 0.71	Dum oda	10.55	10.59± 1.503	1.13± 0.95	0.580± 0.045	1.00± 0.04	51.8± 29.72	94.77± 37.55	145.2± 28.36
17	8.4± 0.35	0.198± 0.055	Medium brown clayey	1.24± 0.10	Vijay pur	20.09	10.24± 1.027	4.21± 1.42	1.821± 0.904	3.14± 0.034	218.6± 6.002	254.9± 51.23	641.0± 16.74
18	7.4± 0.02	0.320± 0.01	Shallow brown sandy	0.87± 0.25	Nand pura	8.75	24.14± 4.105	3.52± 1.27	0.572± 0.028	0.982± 0.421	115.2± 15.06	120.9± 23.31	357.2± 24.52
19	8.1± 0.57	0.178± 0.005	Medium brown loamy	1.01± 0.53	Panc halos	18.12	14.18± 2.406	3.72± 0.94	0.765± 0.056	1.32± 0.95	74.3± 26.04	93.73± 41.62	259.7± 53.50
20	7.6± 0.33	0.344± 0.11	Deep brown clayey	1.04± 0.73	Bhadoti	19.3	7.09± 0.307	5.1± 1.89	0.402± 0.012	0.69± 0.12	38.6± 24.09	73.48± 12.97	240.7± 26.71
21	7.9± 0.82	1.93± 0.036	Red gravelly loamy hilly	0.84± 0.21	Bansla	12.42	7.06± 1.002	4.97± 1.22	0.179± 0.054	0.31± 0.05	13.8± 7.92	122.4± 32.84	138.5± 18.63
22	8.1± 0.07	1.33± 0.092	Yellowish silt	0.94± 0.08	Retra	14.17	3.52± 0.428	4.12± 2.05	0.504± 0.096	0.87± 0.02	41.6± 14.72	125.4± 34.75	161.5± 26.44
23	7.4± 0.92	0.530± 0.152	Deep brown clayey	1.05± 0.53	Todra	23.08	8.52± 0.156	2.95± 0.44	0.222± 0.101	0.066± 0.005	34.2± 20.87	54.72± 18.22	172.9± 35.42
24	7.8± 0.21	0.390± 0.217	Deep black clayey	1.21± 0.89	Habib pur	25.43	4.97± 0.087	1.7± 0.59	0.109± 0.065	0.188± 0.042	62.8± 25.31	90.51± 27.45	209.7± 45.29
25	7.9± 0.19	0.264± 0.102	Deep dark brown sandy	0.98± 0.26	Nara yanpur	8.85	9.02± 0.229	3.5± 1.87	1.090± 0.301	1.88± 0.981	103.48± 16.21	165.6± 30.19	347.9± 346.21
26	8.2± 0.47	0.353± 0.5	Brownish sandy	1.22± 0.91	Ahm edpur	7.88	16.58± 0.065	1.5± 0.64	1.293± 0.128	2.24± 0.975	153.64± 10.24	219.8± 31.05	471.2± 53.29
27	7.8± 0.52	0.221± 0.027	Red gravelly loam hilly	1.10± 0.55	Hing otia	10.12	7.01± 0.188	2.4± 1.01	0.556± 0.057	0.96± 0.021	59.1± 21.19	150.3± 16.74	250.3± 34.97

| 28 | 8.1± 0.14 | 0.649± 0.105 | Rock red gravell | 0.79± 0.36 | Seva | 16.72 | 17.75± 0.904 | 3.0± 1.27 | 0.435± 0.021 | 0.749± 0.042 | 98.5± 14.07 | 120.6± 25.02 | 237.6± 28.88 |
29	7.5± 0.92	0.521± 0.089	Yellowish loamy clay	0.86± 0.11	Nomdya	18.81	19.17± 0.216	1.2± 0.05	0.745± 0.055	1.285± 0.487	129.4± 10.01	132.7± 42.66	389.4± 41.32
30	7.5± 0.57	0.492± 0.002	Deep brown clay	1.05± 0.74	Dibssya	22.47	4.97± 0.108	3.1± 0.53	0.880± 0.102	1.517± 0.206	134.2± 5.04	160.5± 27.25	407.2± 28.36
31	7.4± 0.83	0.580± 0.354	Shallow brown loamy	1.12± 0.67	Ladpura	21.35	12.07± 0.129	1.0± 0.02	0.597± 0.099	1.029± 0.571	87.4± 31.64	152.6± 38.03	196.4± 37.54
32	7.1± 0.75	0.501± 0.162	Deep dark brown sandy	0.97± 0.43	Berkh andi	17.55	8.52± 0.018	3.7± 0.42	0.659± 0.125	1.136± 0.583	139.2± 7.24	123.4± 29.12	386.2± 62.17
33	7.5± 0.12	0.495± 0.036	Medium brown loamy	1.03± 0.39	Goth	20.42	4.97± 0.113	1.95± 0.94	0.941± 0.048	1.622± 0.124	152.7± 4.26	210.5± 54.23	457.5± 45.08
34	7.4± 0.41	0.492± 0.372	Brownish clay	1.52± 0.12	Ajnoti	25.71	9.94± 0.375	1.5± 0.74	0.772± 0.062	1.331± 0.095	109.3± 9.65	87.42± 49.21	372.5± 32.97
35	7.2± 0.39	0.981± 0.129	Deep brown clay	1.24± 0.09	Soorwal	24.08	11.09± 0.217	1.8± 0.26	0.433± 0.108	0.747± 0.045	127.2± 13.87	298.4± 62.71	390.7± 57.09
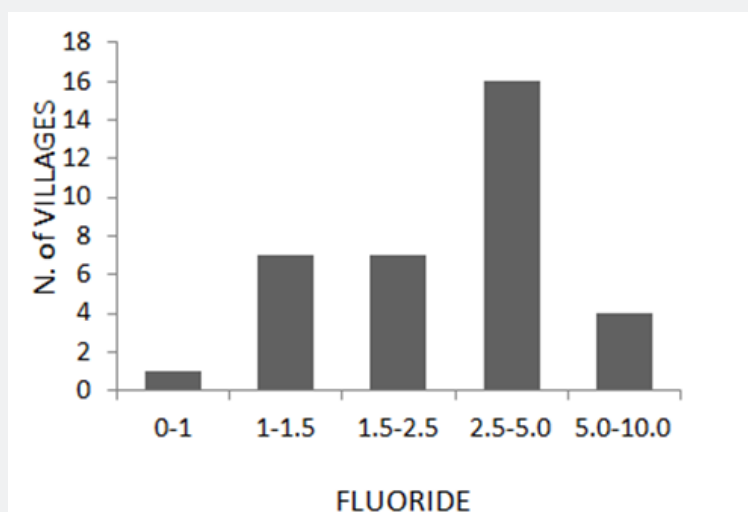
Figure 3.

Generally, fluoride concentration in soil depends on the groundwater and rocks type in the area. Previous research explained this- The first reason is its inherent availability in the soil and the gaseous fluorine in the atmosphere. Fluoride is a mobile ion and its retention in the soil correlated with the amount and rate of water percolating into the soil zone which depends on the soil permeability. High permeability leads to high water content infiltration thus causing the ion to move deeper into the water table where it is retained. Fluoride can also be absorbed by some cations, radicals and oxides of metals to form complex compound. Fluoride levels were varied widely 1.0 to 8.23ppm among the various cultivated soils horizons selected for the study (Table 4).

Table 4: Tabular Correlation Coeff.86 DF5% =0.248, Tabular Correlation Coeff.86 DF1% =0.323.

	pH	EC	Bulk Density	Moisture Content	Chloride	% Carbon	% Organic Matter	Nitrogen	Phosp horus	Potas sium	Fluoride
pH	1	-	-	-	-	-	-	-	-	-	-
EC	-0.234	1	-	-	-	-	-	-	-	-	-
Bulk Density	0.076	0.023	1	-	-	-	-	-	-	-	-

Moisture Content	-0.324	-0.075	0.276	1	-	-	-	-	-	-	-
Chloride	-0.01	-0.061	-0.006	-0.105	1	-	-	-	-	-	-
%Carbon	0.094	-0.266	0.103	-0.075	0.162	1	-	-	-	-	-
%Organic Matter	0.1	-0.258	0.099	-0.087	0.167	0.998	1	-	-	-	-
Nitrogen	-0.097	-0.026	0.119	0.041	0.104	0.363	0.374	1	-	-	-
Phosphorus	-0.185	0.223	-0.147	-0.186	0.285	0.296	0.3	0.216	1	-	-
Potassium	-0.034	-0.105	0.226	0.12	-0.139	0.278	0.283	0.732	-0.089	1	-
Fluoride	0.207	0.166	-0.12	-0.165	0.093	-0.082	-0.079	0.025	0.174	0.017	1

Discussion

pH can affect the availability of nutrients and activity of many essential micro-organisms, And most of the sample found alkaline, high alkalinity is not good for microbes. Several researchers showed that the texture of soil remain a major constraint to crop production. In this context, Nyabyenda [8] reported that the production of grain legumes had been low due to declining soil fertility as a result of soils impoverishment in organic matter content and corresponding texture. In present study variability in soil texture may contribute to the variation in nutrient storage and availability, water retention and transport and binding and stability of soil aggregates. As we can see black loamy soil has good N:P:K ratio. Soil texture directly or indirectly influences soil functions such as soil erosion, water availability Adhikari [9]. The sandy soil can quickly be recharged but its holding capacity is not good. As texture becomes heavier, the wilting point increases because fine soils with narrow pore spacing hold water more tightly than soils with wide pore spacing Thakre. In the present study most of the samples were loamy. The bulk density depends on compaction, consolidation of the soil but it is negatively correlated to the organic content. According to Micheni [10] the soil organic matter plays an important role in maintaining soil quality.

Everyday falling down of leaves may increase the soil organic carbon and thus the total organic matter. In the study area soil organic matter content varies from very less to more than sufficient and its directly influenced by soil texture and moisture content. Chloride is an undesirable content but it's unavoidable, because it is a essential micronutrient for optimal growth. Both potassium and Chloride play the main role to neutralize the charges, and as the most important inorganic osmotic active substances in plant cells and tissues. The association of potassium and Chloride is related to the opening and closing of stomata Oberg [11], Talbott [12], Fixen PE [13]. In most of site soil samples potassium content was in average range. Potassium is known to affect cell division, cell permeability formation of carbohydrates, translocation of sugars, various enzyme actions and resistance of some plants to certain diseases Miller and Turk [14]. Soils are basically categorized on behalf of soil fertility and presence of micro nutrient. In present findings site soil is less nutrient so farmers use more fertilizers and phosphate fertilizer shows the positive correlation with the presence of fluoride content in soil.

Chemical-intensive practices in agricultural fields increasing fluoride contamination and other pollution problems of a magnitude that exceeds normal limits. Plants take up fluoride through fine hair rootlets from the soil. Plants absorb more fluoride from sandy than from clay soil. The most prominent factors that dictate the amount of F in most soils are the quantity of clay minerals, the soil pH and the concentrations of Ca and P in soils Abida [15]. Same results found in the study of Larsen and Widdowson [16], Perroilt and Chhabra [17], Omueti and Jones [18] high adsorption of fluoride by soil mineral components is at about pH 6 to 8 [19-33].

Conclusion

The results of the study reveal the values or percentages of physico-chemical parameter, physicochemical study of soil is important to agricultural chemists for plants growth and soil management. Fluoride is generally present in soils in the form of cryolite (Na_3AlF_6), flurapatite (Ca_5 (PO_4)$_3$.F) and other phosphate rocks. The results of present study will help to identify the type and degree of soil related problems and to suggest appropriate reclamation measure, and also to find out suitability for growing crops. It will also help to study the soil genesis. On the basis of this study farmers can get a approx idea about the amount of which fertilizers and nutrients needed to soil for increase the percentage yield of crops.

Acknowledgement

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