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Study of soil quality parameters along vertical direction of an agricultural field and variation with depth

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Abstract

The study involves the analysis of soil quality of an agricultural land of village Salarpur. Tehsil Tijara, District Alwar, Rajasthan, India.The village is surrounded by industrial area. The soil quality is expected to be affected by industrial pollutants.The soil quality analysis is a necessity before the crop is irrigated to meet the necessary requirements. The present study involves the analysis of soil quality of an agricultural land by collecting the samples at a fixed distance from each other in vertical direction of the field and also from different depths i.e. 0 to 1 cm and 1 to 5 cm. IS and APHA methods are followed for testing and estimation of soil quality parameters such as pH, electrical conductivity, available N, P, K, organic carbon, C/N ratio and fluoride. The study indicates thatall of the soil samples are alkaline soils. With the depth of soil the mean values of parameters such as pH, EC, mean of concentration of available N, available P, Organic Carbon, Carbon Nitrogen ratio and Fluoride tend to increase but the increase is slight. Mean concentration of Potassium slightly decreases with the soil depth.Few parameters are differently correlated with each other at different depths and others show similar correlation at different depths.

Key words: Soil quality, Salarpur, vertical direction, different depths, correlation

Introduction

Sustainability of crops and hence animals and humans is dependent on soil health. Capability of soil to work within environmental limits is necessary to maintain sustainable environment, plant and human health. Soil health is affected due to anthropogenic activities, novel agricultural practices and rigorous land use management [1]. Soil quality management is essential for sustainability of agriculture, preservation of crops, animals, human health and maintaining the quality of climate [2]. Soil productivity relies upon soil quality. Therefore assessment of soil is prerequisite for sustainable management of soil [3]. Anthropogenic activities and distresses in soil continuously disturb physical, chemical and biological parameters of soil. These parameters are indicators to assess soil quality

[4]. Physicochemical characteristics of the soils belonging to different areas are influenced accordingly. N-P-K fertilizers play an effective role in enhancing fertility of soil and its sustainable management [5]. Nutrients availability in soil is affected by pH [6]. EC of Soil determines soil quality, nutrient cycle, available nitrate-Nand crop [7]. Although fertilizers provide minerals to the soil but their excess use contaminates the soil due to production of pollutants affecting sustainability [8]. Nitrogen and Potassium are macronutrients which are required by plants in larger amounts [9]. The soil quality analysis is a necessity before the crop is irrigated to meet the necessary requirements. The present study involves the analysis of soil quality of an agricultural land by collecting the samples at a fixed distance from each other and also from different depths.

Study Area

The soil samples were taken from agricultural field of village Salarpur (latitude 27.9824217 and longitude 76.8519159), Tehsil Tijara, District Alwar, Rajasthan, India. The village is surrounded by industrial area of Dharuhera, Bhiwadi, Khushkhera and Tapukara. The Industrial area is a hub of a number of industries such as automobiles, chemical industries, metal (Zinc and Copper) smelting, dyes, vegetable oils, textiles, electronics etc. As per communication with the villagers, the quality of water and soil was very poor due to improper disposal of industrial effluents from adjoining industries.

Materials and Methods

Total ten samples of soil were collected from an agricultural field of about 2500 square meters area in the month of April 2022. Five soil samples were taken from a depth from 0 to 1cm in a vertical direction of the agricultural field and five samples were taken from the depth of 1 to 5 cm from the same location. Sampling locations were separated by ten meters from each other. About one kilogram of soil sample was collected from each location. Labelled polythene bags were used to collect soil samples and transported to laboratory. Testing of soil samples was done at the laboratories of **VardanEnviroLab, Manesar, Gurugram, Haryana, India approved by** MoEF& CC, NABL, and HSPCB.

IS and APHA methods are followed for testing and estimation of soil quality parameters. pH is measured by Electrometric method, Electrical conductivity by conductivity meter, Available Nitrogen by Kjeldahl method, Available Phosphorous by Colorimetric method, Available Potassium by Flame photometer, Organic Carbon by Titrimetric method

(Methods of Analysis of Soils, Plants, Waters, Fertilizers & Organic Manures- A Book by HLS Tandon), Carbon Nitrogen ratio by calculation method and Fluoride by Ion selective electrode method**[10]**. Statistical analysis was performed using MS-Excel.

Results and Discussion

Table 1and Table 2 represent various parameters studied along with their values. In Table 1, the parameters studied correspond to five soil samples (VS-1, VS-3, VS-5, VS7, VS-9) taken from the depth of 0 to 1 cm along vertical direction in the field. pH varies from 7.91 to 8.31 with mean value 8.072 and Standard deviation of 0.18553. All soil samples depict alkaline nature. Electrical conductivityvaries from 0.252to0.298 with mean value 0.2768and Standard deviation of0.01907. Available Nitrogen varies from163.1to179.09with mean value171.416and Standard deviation of6.632287. Available Phosphorous varies from27.85to33.22 with mean value30.616and Standard deviation of2.16982257. Available Potassium varies from176.92to189.8with mean value185.21and Standard deviation of5.0479402. Organic Carbon varies from0.29to0.33with mean value0.314and Standard deviation of0.01817. Carbon Nitrogen ratio varies from37.18to43.83with mean value41.132and Standard deviation of2.56163.Fluoridevaries from0.43 to0.57with mean value0.508 and Standard deviation of0.05762.

In Table 2, the parameters studied correspond to five soil samples (VS-2, VS-4, VS-6, VS8, VS-10) taken from the depth of 1 to 5 cm along vertical direction in the field from the same locations as was in case of 1cm depth. pH value varies from 7.88 to 8.31 with mean 8.132 and standard deviation 0.18472. Electrical conductivity ranges from 0.269 to 0.391mS/cm with mean 0.3224 and standard deviation 0.05244. Available nitrogen varies from 156.7 to 182.29kg/hec with mean 173.336 and standard deviation 9.9634574. Values of available Phosphorous varies from 29.27 to 34.86 kg/hec with mean 32.448 and standard deviation 2.0187298. Available Potassium from 169.08 to 193.72 kg/hec with mean 181.648 and standard deviation 10.167599. Organic Carbon varies from 0.31 to 0.35 %with mean 0.326 and standard deviation 0.1517. Carbon Nitrogen ratio ranges from 38.75 to 47.14 with mean 42.336 and standard deviation 3.12393. Nitrogen is released for uptake by plants on rapid mineralisation if an organic substrate has a C/N ratio between 1 and 15.If the C/ N ratio is lesser, nitrogen will be released into the soilmore speedily for instant useby crop. 24 is found to be best C/N ratio for microorganisms in soil**[11]**.

Concentration of Fluoride varies from 0.51 to 0.56 mg/kg with mean 0.534 and standard deviation 0.02074.

	pH	EC	Available Nitrogen (as N)	Available Phosphorous	Available Potassium	Organic Carbon	C/N ratio	Fluoride
VS-1	7.92	0.287	166.3	31.58	176.92	0.3	40.54	0.56
VS-3	7.99	0.262	163.1	28.96	185.32	0.32	43.83	0.57
VS-5	8.23	0.252	172.69	31.47	189.8	0.33	42.86	0.49
VS-7	7.91	0.298	179.09	33.22	185.32	0.33	41.25	0.43
VS-9	8.31	0.285	175.9	27.85	188.69	0.29	37.18	0.49
Min.	7.91	0.252	163.1	27.85	176.92	0.29	37.18	0.43
Max.	8.31	0.298	179.09	33.22	189.8	0.33	43.83	0.57
Mean	8.072	0.2768	171.416	30.616	185.21	0.314	41.132	0.508
SD	0.18553	0.01907	6.632287	2.16982257	5.0479402	0.01817	2.56163	0.05762

Table 1. The parameters of soil samples collected from 0 to 1 cm depth

	pH	EC	Available Nitrogen (as N)	Available Phosphorous	Available Potassium	Organic Carbon	C/N ratio	Fluoride
VS-2	8.31	0.391	156.7	32.9	169.08	0.33	47.14	0.52
VS-4	7.88	0.269	182.29	34.86	193.72	0.35	43.21	0.55
VS-6	8.17	0.359	175.89	32.35	173.66	0.32	41.02	0.53
VS-8	8.29	0.277	179.1	32.86	188.13	0.31	38.75	0.51
VS-10	8.01	0.316	172.7	29.27	183.65	0.32	41.56	0.56
Min.	7.88	0.269	156.7	29.27	169.08	0.31	38.75	0.51
Max.	8.31	0.391	182.29	34.86	193.72	0.35	47.14	0.56
Mean.	8.132	0.3224	173.336	32.448	181.648	0.326	42.336	0.534
SD	0.18472	0.05244	9.9634547	2.0187298	10.167599	0.01517	3.12393	0.02074

Table 2. The parameters of soil samples collected from 1to 5 cm depth

Abbreviations: VS- vertical soil, EC- Electrical Conductivity, C/N- Carbon Nitrogen ratio, VS- Vertical soil, Min. - Minimum, Max. - Maximum, SD- Standard deviation

Units: pH-unit less, EC-mS/cm, Available Nitrogen, Available Phosphorous, Available Potassium- kg/hec. Organic Carbon- %, Fluoride- mg/kg

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Comparative Study (Fig. 1 to Fig.8)

Except available Potassium, mean values of all of the parameters such as pH, EC, available N, available P, Organic Carbon, Carbon Nitrogen ratio and Fluoride are found to be greater in the soil samples taken from the depth of 1 to 5 cm than mean values of parameters in the soil samples taken from 0 to 1 cm. Mean value of available Potassium from 0 to 1 cm depth of soil is greater than that from 1 to 5 cm depth. Properties of soil affect the availability of Potassium to the plants **[12]**. Forms of Potassium present in the soil are: solution, exchangeable, nonexchangeable or fixed and mineral form. Equilibrium and kinetic reactions among these forms affect the level of solution Potassium in soil. Solution Potassium is the most available form for the plants **[13] [14] [15]**. In a study the available potassiumin soil was significantly positively correlated with the depth and clay content, but significantly negatively correlated with the sand content**[16]**.

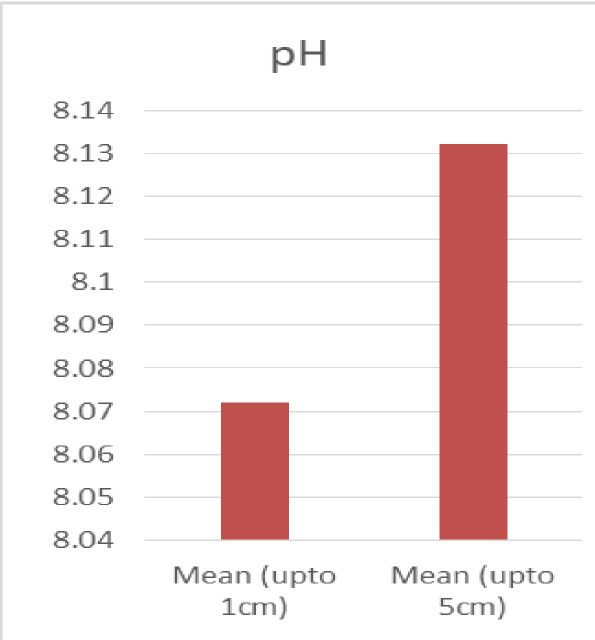

Fig. 1 Comparison of pH

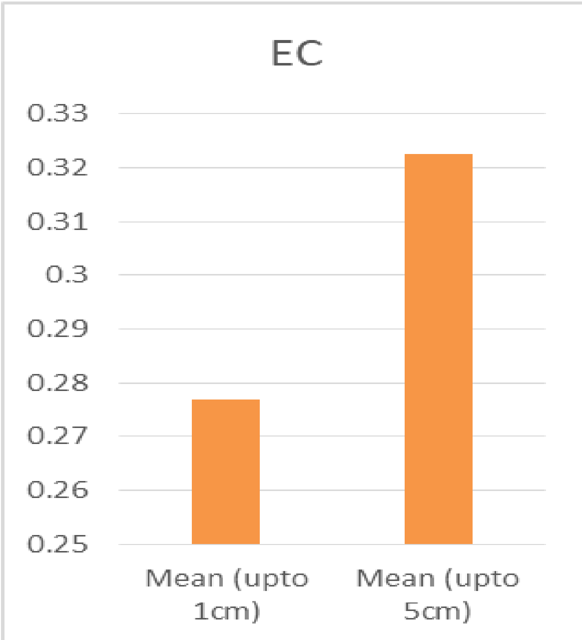

Fig. 2 Comparison of EC

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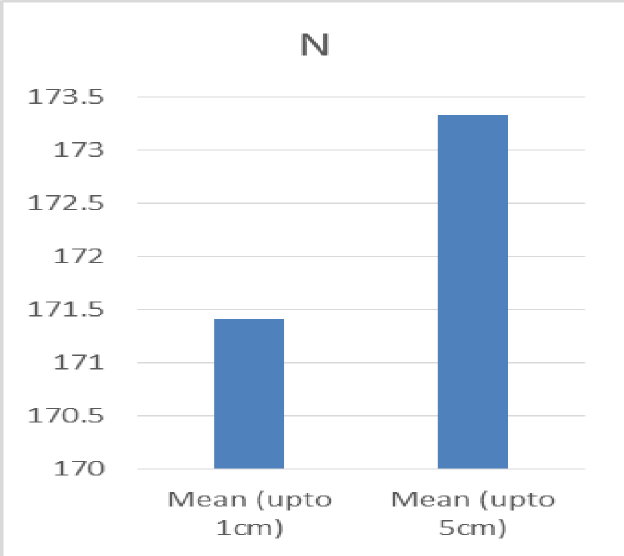

Fig. 3 Comparison of Available N

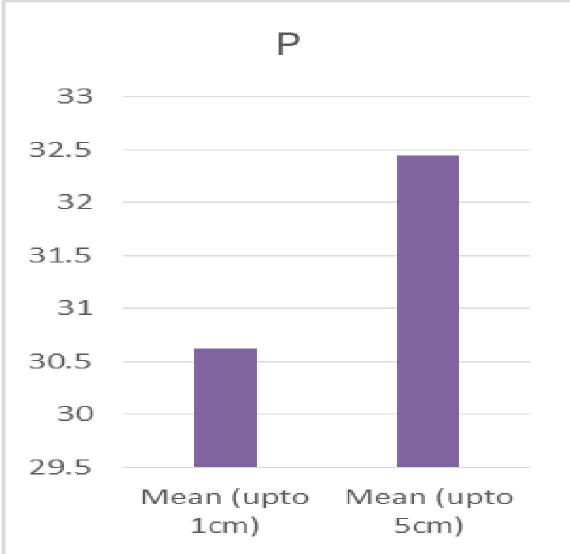

Fig. 4 Comparison of Available P

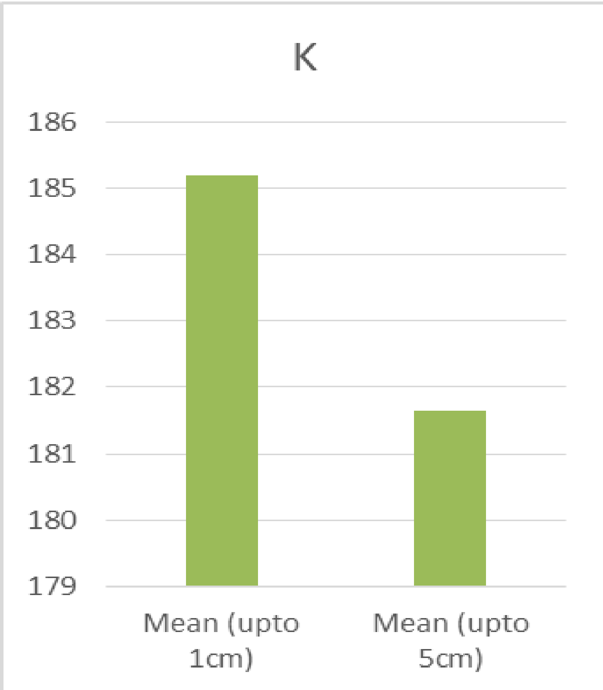

Fig. 5 Comparison of Available K

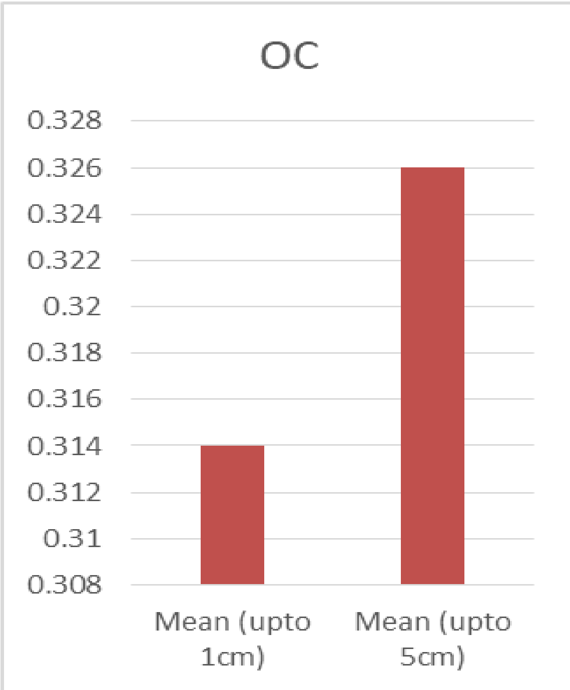

Fig. 6 Comparison of Organic Carbon

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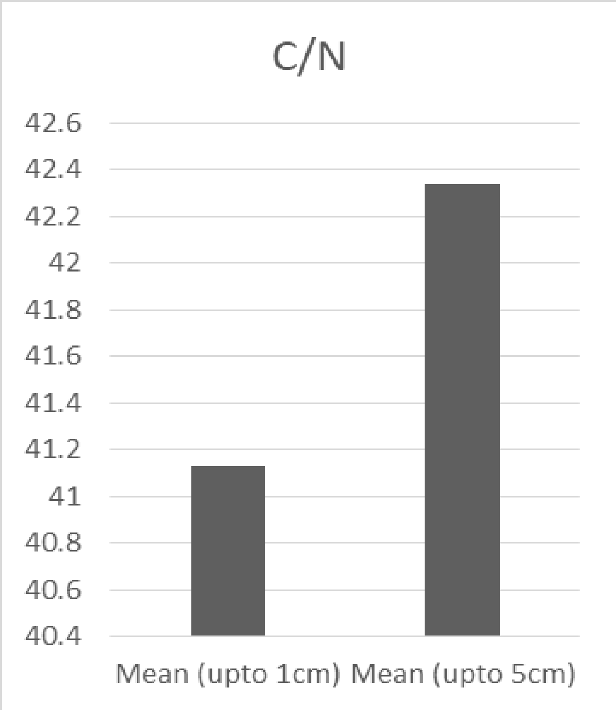

Fig. 7 Comparison of C/N ratio

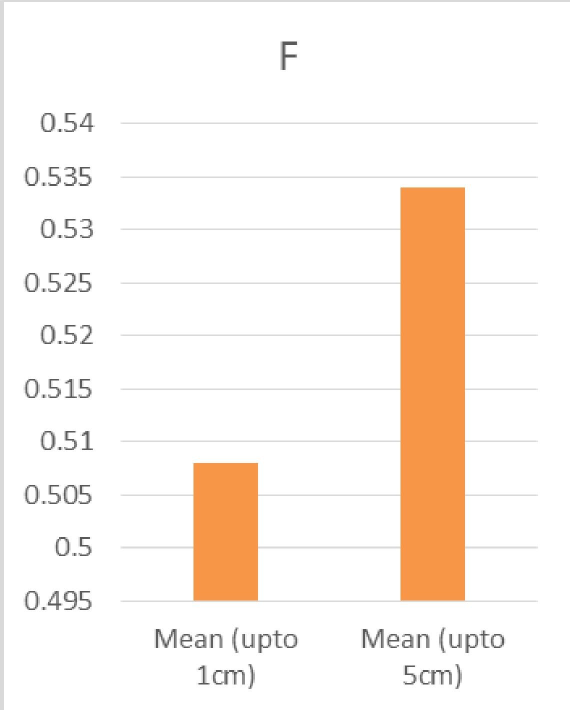

Fig. 8 Comparison of Fluoride

Correlation Studies(Table 3)

1.As per Table 3 pH, EC, organic carbon at 0-1 cm are negatively correlated with pH, EC and organic carbon respectively at 1-5 cm. More the alkaline soil lesser will be the amount of soluble salt. It shows that lower the soil pH value i.e. acidic soil, higher the soluble salt content and therefore high electrical conductivity**[17]** [A].Whereas available Nitrogen, available Phosphorous, available Potassium and Fluoride at 0-1 cm depth are positively correlated with available Nitrogen, available Phosphorous, available Potassium and Fluoride respectively at 15 cm.

2. OC and pH,available P and pH, Fluoride and pH, available K and EC, OC and EC,Fluoride and EC,available N and C/N ratio, available P and Fluoride,K and C/N ratio, are negatively correlated respectively with each other in both the depths i.e. 0-1cm as well as 1-5 cm. another study reveals that organic carbon density of soil increases over the pH range of 4.2– 6.5, decreasing sharply in the range of 6.5–9.2. It may be because of microbial activity that is likely be greatest at intermediate soil pH levels i.e. pH 6–7**[18].**The negative correlation between soil pH and available phosphorus may be due to conversion of soluble phosphorus to insoluble phosphates of calcium and magnesium thus reducing its availability with the rise in soil pH **[19][20]**. According to a research the Fluoride is primarily located in the colloid or clay fraction of the soil, and the movement of Fluoride is intensely affected by the sorption capacity

of the soil, which is affected by pH, the type of soil sorbent present, and the salinity **[21]**. One more study confirms negative correlation of available fluoride concentration with EC **[22]**.

3. Available N and available P, available N and available K, available N and OC, available P and OC, available K and OC, OC and C/N ratio are positively correlated respectively with each other in both the depths i.e. 0-1cm as well as 1-5 cm. The positive correlation between available nitrogen and organic carbon might be due to release of mineralizable nitrogen from soil organic matter in equivalent amounts **[23]** and adsorption of NH4-N by humus complexes in soil. **[24]**.

4. EC and pH, C/N ratio and pH, C/N ratio and EC, available N and Fluoride, available P and available K, available K and Fluoride, OC and Fluoride are negatively correlated with each other at 0-1 cm depth but are positively correlated with each other at 1-5 cm depth. In another study also, Organic carbon, nitrogen and the C/N ratio are negatively correlated with soil pH, indicating that relatively low pH benefits the accumulation of organic matter **[25]**.

5. Available N and pH, available K with pH, available N and EC,availableP and EC are positively correlated with each other at 0-1 cm depth but negatively correlated with each other at 1-5 cm depth. The negative correlation between soil pH and available nitrogen shows that increase in soil pH decreases available nitrogen. It might be due to loss of nitrogen because of volatilization with the rise in pH of soil. **[19] [20] [26].** Another study reflects nonsignificant but positive relationship of Electrical Conductivity with available phosphorus andnonsignificant and negative correlation of EC with available Nitrogen **[19].**

6. Significant positive linear correlation (Corr. Coefficient ≥ 8) is shown by the following pairs-

OC and C/N ratio at 0-1 cm depth **correl.coefficient= 0.8**,available P (0-1cm) and pH (15cm) **correl.coefficient= 0.85**,C/N ratio (0-1cm) and available P (1-5cm) **correl.coefficient= 0.903**, Fluoride (0-1cm) and OC (1-5cm) **correl.coefficient= 0.9**, Fluoride (0-1cm) and C/N (1-5cm) **correl.coefficient= 0.86**, available N (1-5cm) and available K (1-5cm) **correl.coefficient= 0.82**

7. Highly negative correlation (Corr. Coefficient= - 8 or -9) has been observed in the following pairs-

Available N (0-1cm) and Fluoride (0-1cm)**correl.coefficient= -0.97**, available N (0-1cm) and OC (1-5cm) **correl.coefficient= -0.94**, pH (1-5cm) and Fluoride (1-5cm) **correl.coefficient=**

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0.89, EC (1-5cm) and available N (1-5cm) **correl.coefficient= -0.85**, EC (1-5cm) and available K (1-5cm) **correl.coefficient= -0.99.**

	pH (01)	EC(01)	Av. N (0-1)	Av.P(0-1)	Av. K(0-1)	O C(0-1)	C/N (01)	Fluoride(0-1)	**pH (15)**	**EC(15)**	**Av. N (1-5)**	**Av. P(1-5)**	**Av.K (1-5)**	**OC(15)**	**C/N (1-5)**	**Fluoride (1-5)**
pH (0-1)	1															
EC(0-1)	-0.41	1														
Av. N (0-1)	0.302	0.47	1													
Av.P(0-1)	-0.59	0.28	0.3	1												
Av. K(0-1)	0.744	-0.4	0.48	-0.31	1											
O C(0-1)	-0.31	-0.4	0.12	0.62	0.3	1										
C/N (0-1)	-0.43	-0.6	-0.5	0.35	-0.01	**0.8**	1									
Fluoride(0-1)	-0.17	-0.4	**-0.97**	-0.44	-0.5	-0.3	0.283	1								
pH (1-5)	-0.4	0.49	0.39	**0.85**	-0.47	0.15	-0.116	-0.4	1							
EC(1-5)	0.143	-0.1	-0.17	0.19	-0.41	-0.3	-0.189	0.27	0.53	1						
Av. N (1-5)	0.151	-0.3	0.21	-0.14	0.74	0.6	0.408	-0.35	-0.56	**-0.85**	1					
Av. P(1-5)	-0.74	-0.3	-0.63	0.36	-0.37	0.61	**0.903**	0.43	-0.05	-0.24	0.23	1				
Av.K (1-5)	-0.12	0.06	0.05	-0.31	0.37	0.24	0.183	-0.13	-0.64	**-0.99**	**0.82**	0.25	1			
OC(1-5)	-0.21	-0.5	**-0.94**	-0.5	-0.26	-0.1	0.475	**0.9**	-0.66	-0.15	0.07	0.594	0.28	1		
C/N (1-5)	-0.26	-0.1	-0.78	-0.19	-0.77	-0.5	-0.004	**0.86**	0.05	0.614	-0.8	0.214	-0.5	0.58	1	
Fluoride(1-5)	0.667	-0.4	-0.24	-0.99	0.45	-0.5	-0.287	0.36	**-0.89**	-0.24	0.26	-0.36	0.35	0.46	0.07	1

Table 3 Correlation matrix presenting correlation among parameters of soil (0-1cm) and (15cm) depth

Conclusion

The agricultural land under study indicates that

1. All of the soil samples indicate alkaline soils. With depth of soil the mean values of parameters such as pH, EC, mean of concentration of available N, available P, Organic Carbon, Carbon Nitrogen ratio and Fluoride tend to increase but increase is slight.
2. Concentration of available N, P, K and C/N ratio show high standard deviations.
3. Mean concentration of Potassium slightly decreases with soil depth.
4. Parameters such as pH, EC, organic carbon at 0-1 cm are negatively correlated with pH, EC and organic carbon respectively at 1-5 cm.
5. Parameters such as available Nitrogen, available Phosphorous, available Potassium and Fluoride at 0-1 cm depth are positively correlated with available Nitrogen, available Phosphorous, available Potassium and Fluoride respectively at 1-5 cm.

6. Few parameters are differently correlated with each other at different depths and others show similar correlation at different depths.
7. Soil quality analysis is must before irrigation to make an agricultural land fertile so that the nutrients are readily available for crops.

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