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Assessment of physico-chemical properties of soil in selected areas of Khambhat taluka, Gujarat

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ABSTRACT

The present study was carried out in Khambhat, Gujarat, to study the different soil properties affected by salinity. The effects of soil salinity comprise low agricultural productivity, low economic returns, soil erosion or desertification. The assessment of this type soil is important to adopt appropriate management practices for reducing salinity from the soil. Soil samples were collected seasonally from different villages of Khambhat taluka. Soil samples were assessed for the physico-chemical parameters such as moisture content, pH, electric conductivity (EC), water holding capacity (WHC), soil texture, organic carbon (OC), organic matter (OM),nitrogen, phosphorus, potassium and micronutrients such as Cu, Zn, Fe, Mn. As observed in the results of pH (9.88), EC (9.45 dSm^{-1}) and sodium (8565.15 μgkg^{-1}) which is found higher in winter season. The available potassium, magnesium and calcium ranged from 315.17-1567 $kgha^{-1}$, 1207.56-3120.37 $mgkg^{-1}$ and 2346-4567.65 $mgkg^{-1}$, respectively. The concentrations of micro-nutrients (Cu, Zn & Fe) were lower or limited in the soils of Khambhat taluka. Seasonal variations in soil properties are also important for future work. This present study helps to identify the soil nutrient availability and limiting factors for the crop production in these villages of Khambhat.

Keywords: Soil salinity, properties of soil, micronutrients of soil, physico-chemical parameters

INTRODUCTION

Soil plays an important role in environment. The growth of plants and their nutrients such as N, P, K, Ca, Mg, Zn, Cu, Sulphur etc. depends on soil. Soil is a natural mixture of mineral and organic material which is differentiated by their morphology, physical properties, chemical properties and biological nature (Solanki and Chavda, 2012). Analysis of physico-chemical properties of water is very common but for the soil it is not so common but analyzing soil properties is found very rare. These days a large amount of chemical fertilizers are used instead of manures for the crop productivity which deteriorates the quality of soil. So, it is necessary to analyze soil parameters to control real time adverse effect of chemical fertilizers on soil, plants and humans. Khambhat is situated on seashore of Gujarat in Anand district. It has a warm and humid climate. The relative humidity ranges between 65 to 86% which is offering semi-arid to sub humid condition in Khambhat. The soils in the arid and semi-arid regions are salt affected where evapo-transpiration processes greatly exceeds precipitation which is accumulates ions causing salinity. In India, an area of about 6.74 Mha suffers from the problem of salt accumulation, out of which 2.96 Mha are saline soils. Amongst them, the state of Gujarat has the largest area under salt affected soils and it is 2.20 Mha which is followed by the Uttar Pradesh (1.37 Mha).A lot of research work is being done for the physico-chemical properties of soil in the world. Seasonal impact on physico-chemical properties of soils of north and south Gujarat has been reported (Patel *et al.* 2015). A change of physico-chemical properties of soil after crop yield was reported in Valsad district (Kapur, *et al.* 2016). Amrine *et al.* (2020) reported seasonal changes of physico-chemical properties of soil from Gautala reserve forest. Another report from Nagpur, Maharashtra showed physico-chemical properties of soil seasonally (Watkar, 2020). The soils from Kamrej in Surat district were studied for morphological, physical and chemical properties (Jangir *et al.* 2020). Soil physico-chemical properties and enzymatic activity were studied by Seema *et al.* (2020). The information of the soil quality from Khambhat taluka is very important as no such work has been carried out for this taluka, thus the present investigation was an attempt to analyse and document the seasonal changes of the soil properties in Khambhat taluka. It is hoped that the study will

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provide useful knowledge for the future research work or farmers to improve soil quality for better crop production.

MATERIALS AND METHODS

The soil samples were collected from Khambhat for analyzing physical and chemical parameters of soil during the period 2019-2020. The standard method was used for determination of collected soil samples and their parameters. The soil parameters included: pH, EC (electrical conductivity), soil texture, water holding capacity (WHC), moisture content, organic carbon, organic matter, N,P,K and micronutrients, were analyzed using ICP-OES (Inductively coupled plasma-optical emission spectrometry) instrument using soil digestion methods (GOI, 2011; Chaurasiya *et al.* 2014).

The study was carried out during the period 2019-2020. The soil samples were collected from different places between Khambhat to Tarapur road, Taluka-Khambhat, District-Anand. The entire study area was divided into 10 locations for soil collection. These locations are Port road (S1), Akhol (S2), Paladi (S3), Bhimtalav (S4), Vaninaj (S5), Vadgam (S6), Daheda (S7), Gudel (S8), Navagam Bara (S9) and Lunej (S10). Study was being focused on soil quality of Khambhat area. Season wise sampling was done i.e. summer, rainy and winter (N=30 samples). Each sample was placed in different zip lock bags. The soil samples were collected from surface to 20 cm depth.

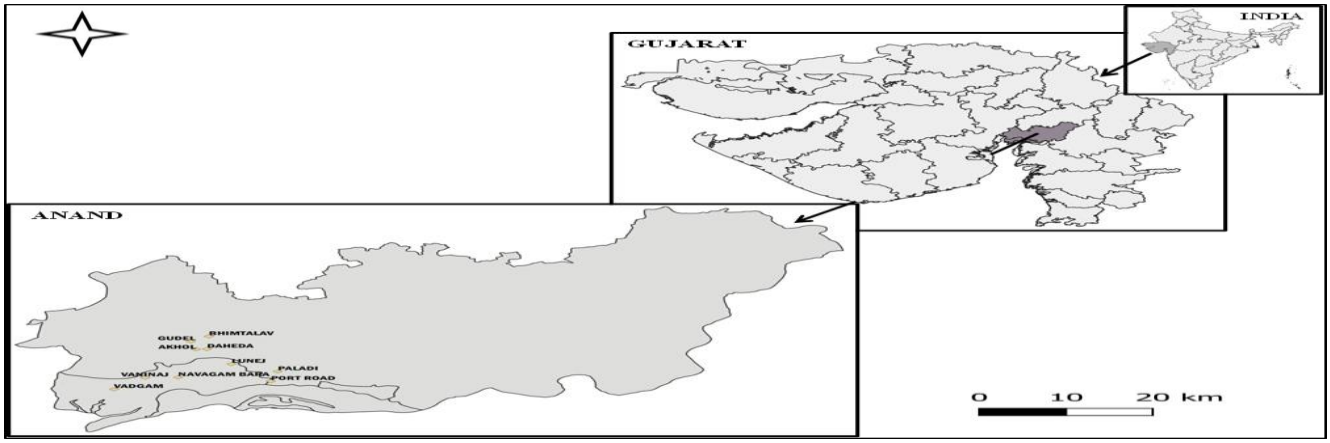

Figure 1: Location of soil sample collection

Soil pH was measured aftercalibration of the pH meter by using standard buffer solution. Record the pH of soil sample by using calibrated digital pH meter. Electrical Conductivity was measured after calibrating the conductivity meter by using 0.01 M potassium chloride (KCl). Moisture content was determined using gravimetric method. Required quantity of soil was taken as specimen in the petri plate and it was weighed and kept in oven at 105°C for 24 hours. After drying petri plate was taken from the oven and allowed to cool in desiccator. After cooling, the petri plate was weighted. For determination of water holding capacity,Keen Raczkowski box method was used capacity (Bandyopadhyay *et al.* 2012). Walkley and Black method was used to determine organic carbon content and organic matter content from the soil. Soil texture was analysed using hydrometer method**.**

RESULTS AND DISCUSSION

The objective behind examining season wise physico-chemical parameters of soil collected from Khambhat was to check soil condition for the agricultural purposes. Soil physical and chemical properties are dependent on climate i.e. precipitation and temperature. The observation of various parameters of analyzed soil is tabulated in table 1 and table 2. Soil pH is a very important physical property of soil which encourages the plant nutrient accessibility and shows the absorption capacity of soil. The pH ranges between 7.12 to 8.80, 7.12 to 8.89 and 7.37 to 9.88 in summer, rainy and winter seasons, respectively. So in these results, winter season observed highest pH (Table 1). Similarly, rise of pH in winter season was observed by Xiao Guoju *et al.* (2012).According to results, soils were found to be normal to alkaline in

reaction and changes occurred with changing seasonas. But in winter, the soils showed highly alkaline reaction. Globally, precipitation and potential evapo-transpiration control soil pH variations. The effect of climate factors on soil pH variations are also observed at regional level (Brady *et al.* 2002, Slessarev *et al.* 2016). The electrical conductivity (EC) is one of the most important indicators of soil health. It also affects crop production, plant nutrient availability and activity of soil microorganisms which influence key soil processes. Presence of salt content in to the soil is commonly expressed by measuring EC in the soil. The EC ranged from 3.92 dSm^{-1} to 9.45 dSm^{-1} (Table1). As per the soil salinity classification by NSSH and NRCS soil survey handbook, those soil samples were moderately saline in nature. The water holding capacity (%) ranged from 40.78 to 65.58% and the moisture content (%) between 3.92 to 20.3%. Water holding capacity is important for soil health. Soils that can retain a stable amount of water are able to nourish crops and keep soil organic matter active. Poor water supply is one of the most harmful conditions. Conditions like droughts and dryness of soil cause decrease in soil health and crop productivity. Dry soils cannot provide good foundation for crops. Prompting research into new technologies that will enable soil to store water more efficiently for longer period is required. Soil texture is an indicator of soil fertility. So, it is also an important property of soil to study. Sandy clay loam texture was observed most abundantly in soil samples during summer and winter season whereas clay loam and clay texture was observed in rainy season. Precipitation in the rainy season and insufficient irrigation might be a reason for changes in soil texture. White layers on soil at the time of sampling might be because of presence of salts of Mg, Ca, Na, Cl etc.

Organic carbon and organic matter

In the analysed soil samples, organic carbon (%) ranged between 0.98 and 2.99. The highest OC% was observed in S3 during summer, whereas lowest OC% was observed in S8 soil samples during winter (Table1). Organic matter (%) varied from 1.69 to 5.16. The OM is the most important part of soil because it consists of partially decayed organic matter. It makes the soil porous, thereby increasing its air and water holding capacity and also it is rich in nutrients that promote plant growth.

Soil nutrients

Macronutrients (N, P, K) and micronutrients such as Cu, Zn, Fe, Mn etc. are very important for the soil because the growth of plants depends on the nutrients. The results of soil nutrients are tabulated in Table 2. Nitrogen is very important for the soil system. Nitrogen content increased in the winter season and it ranged between 150 to 278 $kgha^{-1}$ in soil. Nitrogen content of the soil varied because of its mobility with rain and irrigation water. Further, the availability of N in salt affected soils is also poor as it contain low organic matter and the organic matter decomposition and transformation to nitrogenous compounds is also less due to high EC and pH. After nitrogen, phosphorus is one of the most essential macronutrient for soil. Availability of phosphorus for plants is required for early plant growth and maturity. The minimum range of phosphorus was recorded during the summer season (0.60 to 3.48 $kgha^{-1}$). It ranged between 1.70 to 6.77 $kgha^{-1}$in monsoon and winter seasons. Phosphate ions are very strongly absorbed by the soil (McAuliffe *et al.* 1948). The concentration of phosphorus ions depends on the absorption and assimilation process.

Potassium is also important nutrient for plant growth and it is also involved in plant metabolism reactions, overall plant health. Presence of potassium in soil also allows plant to grow rapidly without plant diseases and protects against winter freeze and insect damage. Potassium is strongly attached with the clay particles in to the soil due to the opposite nature of both particles (potassium and clay). They attract each other. All the soil samples recorded high concentration of potassium ion in the soil. And it ranged between 315 to 1567 $kgha^{-1}$. High concentration of potassium ion in soil might be due to the salinity of soil because saline soil possess higher concentration of it (Imadi *et al.* 2016).There was remarkable variation in the concentration of Zn, Cu, Fe and Mn in soil with changing season. The presence of micronutrients concentration was Mn > Fe > Zn > Cu in soil samples. Zinc ranged between 0.14 and 2.45 $mgkg^{-1}$ with 0.47-0.72 SD in soil samples. The concentration of Zn in soilwas very limited.. Especially in rainy and winter seasons, the amount of Zn was lower than the critical limit. Iron deficiency is most common for saline/alkaline soils of the arid regions. Fe is very sensitive to oxidation-reduction status of the soil. The soil samples also recorded lower amount of

Table 1: Assessment of soil parameters of Khambhat taluka using descriptive statistics SPSS

Parameters	Season	Soil Samples												
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Mean	Std. Deviation	Std. Error
Soil texture	Summer	Sandy clay loam	Sandy clay loam	Sandy clay loam	Clay loam	Clay loam	Clay	Sandy clay loam	Sandy clay loam	Clay loam	Sandy clay loam			
	Rainy	Clay loam	Clay loam	Clay loam	Clay loam	Clay	Clay loam	Sandy clay loam	Clay loam	Clay	Clay			
	Winter	Sandy clay loam	Sandy clay loam	Sandy clay loam	Clay loam	Clay	Sandy clay loam	Sandy clay loam	Clay loam	Clay loam	Clay loam			
Ph	Summer	7.87	7.6	8.18	7.57	7.12	8.8	7.39	7.54	8.45	8.72	7.92	0.58	0.18
	Rainy	8.02	7.43	8.06	8	7.72	8.52	7.12	8.15	7.78	8.89	7.97	0.51	0.16
	Winter	9.74	8.68	9.88	8.4	7.37	8.6	8.08	8.15	8.02	9.13	8.61	0.79	0.25
EC (dSm^{-1})	Summer	6.37	5.76	5.56	7.55	3.98	6.42	5.88	4.63	6.89	7.12	6.02	1.10	0.35
	Rainy	5.97	3.92	5.56	7.38	4.2	6.02	5.57	4.87	6.78	6.98	5.73	1.15	0.36
	Winter	9.45	5.52	5.56	7.4	4.2	6.1	5.26	5.32	6.72	7.05	6.26	1.47	0.47
Moisture Content (%)	Summer	6.05	6	5.8	15.34	15.9	11.8	4.5	9.3	6.5	9	9.02	4.08	1.29
	Rainy	11.2	20.03	10.5	18.7	16.65	19.04	3.92	11.08	8.45	13.25	13.28	5.24	1.66
	Winter	8.87	6.09	11.74	17	15.89	12.55	4.5	13.36	10.43	18.6	11.90	4.59	1.45
Water holding capacity (%)	Summer	64.67	46.78	49.62	65.43	43.34	54.87	50.03	50.72	41.38	60.75	52.76	8.47	2.68
	Rainy	64.12	45.65	52.43	65.58	48.27	54.24	52.33	49.54	42.09	64.22	53.85	8.23	2.60
	Winter	64.4	46.33	51.87	64.62	45.83	54.98	51.25	50.72	40.56	65.43	53.60	8.69	2.75
Organic Carbon (%)	Summer	2.34	1.98	2.99	2.33	1.24	2.5	2.64	1.75	2.14	1.92	2.18	0.49	0.16
	Rainy	2.15	1.76	2.87	2.15	2.12	2.65	2.09	1.63	2	2.15	2.16	0.37	0.12
	Winter	2.5	1.88	2.93	2.27	1.89	2	2.09	0.98	2.32	2.18	2.10	0.50	0.16
Organic matter (%)	Summer	4.04	3.41	5.16	4.02	2.14	4.31	4.55	3.02	3.69	3.31	3.77	0.85	0.27
	Rainy	3.71	3.03	4.95	3.71	3.65	4.57	3.6	2.81	3.45	3.71	3.72	0.64	0.20
	Winter	4.31	3.24	5.05	3.91	3.26	3.45	3.6	1.69	4	3.76	3.63	0.87	0.27

**Port road (S1), Akhol (S2), Paladi (S3), Bhimtalav (S4), Vaninaj (S5), Vadgam (S6), Daheda (S7), Gudel (S8), Navagam Bara (S9) and Lunej (S10)*

Table 2: Presence of nutrients in collected soil samples from Khambhat

Parameters	Season	Soil Samples												
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Mean	Std. Deviation	Std. Error
Nitrogen ($kgha^{-1}$)	Summer	105.49	116.67	136.08	102.56	208.77	185	142.28	115	170.55	133.4	141.58	35.73	11.30
	Rainy	247	210.56	176.5	230.28	245.1	200.04	165.2	187.59	203.6	197.6	206.34	27.50	8.70
	Winter	232.06	255.9	265.93	225.69	250.98	193.23	150.77	278.67	218.54	240	231.18	37.48	11.85
Phosphorus ($kgha^{-1}$)	Summer	3.48	2.94	3.21	1.69	3.32	0.6	3.25	2.11	2.04	2.64	2.53	0.91	0.29
	Rainy	2.16	2.3	6.77	4.11	3.87	1.76	4.78	3.56	2.48	3.86	3.57	1.50	0.47
	Winter	3.92	3.12	5.98	3.8	4.6	2.9	5.11	2.05	1.7	3.45	3.66	1.33	0.42
Potassium ($kgha^{-1}$)	Summer	895	1140.28	350.9	455.89	876.45	654.78	1198.7	498	768.43	315.2	715.36	313.83	99.24
	Rainy	780.56	1567.87	467.45	348	913.06	717.97	1234.3	614.52	825	367.9	783.66	384.71	121.66
	Winter	785.03	1210.98	415.71	436.09	987.7	830	1225.4	687.19	862.89	402.4	784.33	305.27	96.53
Zinc ($mg\ kg^{-1}$)	Summer	0.97	1.34	0.3	0.15	1.69	2.45	0.9	0.82	0.86	0.14	0.96	0.72	0.23
	Rainy	0.4	0.78	0.22	0.67	0.56	1.2	1.79	0.5	1.23	0.8	0.82	0.47	0.15
	Winter	0.49	0.28	0.22	1.05	1.73	1.57	2.08	0.63	0.95	0.8	0.98	0.63	0.20
Iron ($mg\ kg^{-1}$)	Summer	0.23	1.62	0.37	1.33	0.87	0.63	0.39	1.45	0.88	0.56	0.83	0.49	0.15
	Rainy	0.6	2.1	0.88	1.62	0.91	1.3	0.46	1.87	0.53	0.98	1.13	0.58	0.18
	Winter	0.64	1.97	0.84	2.24	0.9	1.8	1.37	2.16	0.67	1.43	1.40	0.62	0.20
Manganese ($mg\ kg^{-1}$)	Summer	8.62	7.9	11	3.08	14.2	8.9	5.89	6.5	14.98	3.19	8.43	4.08	1.29
	Rainy	8.56	7.32	12.75	5.88	16.36	9.04	6.28	7.68	14.25	4.15	9.23	3.95	1.25
	Winter	8.27	6.69	13.83	4.69	16.54	9.4	6.33	7.11	15.08	5.26	9.32	4.29	1.36
Copper ($mg\ kg^{-1}$)	Summer	0.1	0.58	0.02	0.26	0.46	0	0.17	0.2	0.06	0.11	0.20	0.19	0.06
	Rainy	0.34	0.2	0.12	0.22	0.28	0.1	0.26	0.13	0.1	0.18	0.19	0.08	0.03
	Winter	0.21	0.2	0.14	0.26	0.3	0.07	0.35	0.24	0.17	0.09	0.20	0.09	0.03
Magnesium (mg/ha)	Summer	2167.73	1640.86	2078.7	1856.9	1542.6	2252.3	2494.2	2084	3120.4	1728	2096.60	464.72	146.96
	Rainy	1530.27	1478.32	1934.8	1710.6	1375.4	2389.3	2500	1911	2672.8	1363	1886.60	484.19	153.11
	Winter	1478.44	1320	2196	1735	1207.6	2456.7	2515	1932.3	2890	1458	1918.90	574.40	181.64
Sodium (mg/ha)	Summer	7975.32	7924.45	8610.8	5931	7887.9	5642	6689.3	6225.8	5521.9	8634	7104.30	1230.10	388.99
	Rainy	8093.07	7781.68	8560.2	6289.6	8110.6	5798.1	6945.7	6457.4	5746.5	8124	7190.70	1064.06	336.49
	Winter	8008.25	7627.7	8565.2	6054.3	8078.3	5723.6	7058.9	6386.4	5579.8	8268	7135.00	1123.93	355.42
Calcium (mg/ha)	Summer	4276.12	4567.65	3003	3560.4	3418.2	2346.2	3957.3	4348.7	3646	2800	3592.40	721.58	228.18
	Rainy	3989.54	4230.83	2805.6	3476.3	3587.1	2552.5	3747.8	3921.8	3256.7	2756	3432.40	574.27	181.60
	Winter	3917.72	4163.65	2833.4	3310	3452	2500.1	3885.5	4057.2	3049.3	2955	3412.40	575.44	181.97

Fe and it ranged from 0.23 to 2.24 $mgkg^{-1}$. The concentration of magnesium and calcium salt are similar in range but the high level of sodium was observed in the soil samples, that ranged from 5642 to 8565 mg/kg in soil. Sodium is the most dominant ion particularly in saline soil.During the rainy season and the post-monsoon seasons, i.e. winter showed highest nutrient uptake. This might be due to addition of clay particles along with rain in the soil which is having great capacity to attach with the salt particles.

Present study indicated that all physico-chemical properties of the soil health was not in normal criteria. The soil samples were having moderate to highly saline characteristics that might affectcrop cultivation. High salinity will ultimately lead to desertification of land in future if appropriate measures are not taken for reducing soil salinity. The higher concentration of salts i.e., sodium affect the crop production. Physical properties as well as chemical properties of soil samples are useful for reducing soil salinity and improving soil fertility for plants growth. The recordedparameters of soil will be helpful to establish a relation among the soil and plant growth which can be used by farmers to identify and plan necessary measures required for sustainable agriculture.

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