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Assessment of Soil Physico-chemical Properties in Sugarcane Cultivation Areas of Navsari District, Gujarat, India

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Authors' contributions

This work was carried out in collaboration among all authors. Authors BJK and VJZ designed the study, Author BJK performed the analysis, wrote the protocol and wrote the first draft of the manuscript. Author BJK managed the analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

Sentinel 2 satellite data from the year 2021 were acquired from the Copernicus site to identify the sugarcane producing area in the Navsari district. Hybrid classification approach *i.e.,* supervised and unsupervised with ground truth data were applied using ERDAS IMAGINE software. After image classification, 2.5 km x 2.5 km grid was prepared in Q-GIS software which along with classified sugarcane area were overlapped for site identification. Then, random soil surface and sub-surface samples were collected with reference from grid of intensive sugarcane growing area. The particle

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density (2.10 to 2.76 g cm^{-3} with the mean value of 2.58 g cm^{-3}) and bulk density (1.10 to 1.68 g cm^{-3} with the mean value of 1.33 g cm^{-3}) of surface soil were found to be lower than sub-surface soil (2.18 to 2.79 g cm^{-3} and 1.15 to 1.68 g cm^{-3} with the mean value of 2.62 g cm^{-3} and 1.42 g cm^{-3} respectively) while porosity (31.60 to 59.26% with the mean value of 48.39%) and maximum water holding capacity (22.77 to 51.92% with the mean value of 39.60%) of surface soil were found to be higher than sub-surface soil (29.54 to 57.71% and 20.98 to 48.91% with the mean value of 45.60% and 36.81% respectively). The pH of soil surface showed range from 6.08 to 8.37 while pH of soil sub-surface noted range of 6.00 to 8.50. The electrical conductivity of surface and sub-surface soil showed the range of 0.011 to 1.580 dS m^{-1} and 0.010 to 1.586 dS m^{-1}. The soil organic carbon of surface soil ranged from 0.06 to 0.89% while that of sub-surface soil varied from 0.02 to 0.85%.

Keywords: Surface soil; sub-surface soil; physical properties; chemical properties; particle density (PD); bulk density (BD); porosity; maximum water holding capacity (MWHC); pH; electrical conductivity (EC); organic carbon (OC).

1. INTRODUCTION

The declining scenario in agricultural land and the growing food demand needs attention to optimized use of soil resources. The systematic soil survey provides an understanding of the nature and type of soil, its limitations, potential and sustainability for different land uses. The evaluation of characteristics and classification of soil provides information on the various morphological, physical, chemical and mineralogical properties of the soil [1]. These properties show complexity, spatial and temporal variety across the landscape and are very important for developing an effective land-use system for sustainable increase of agricultural production [2].

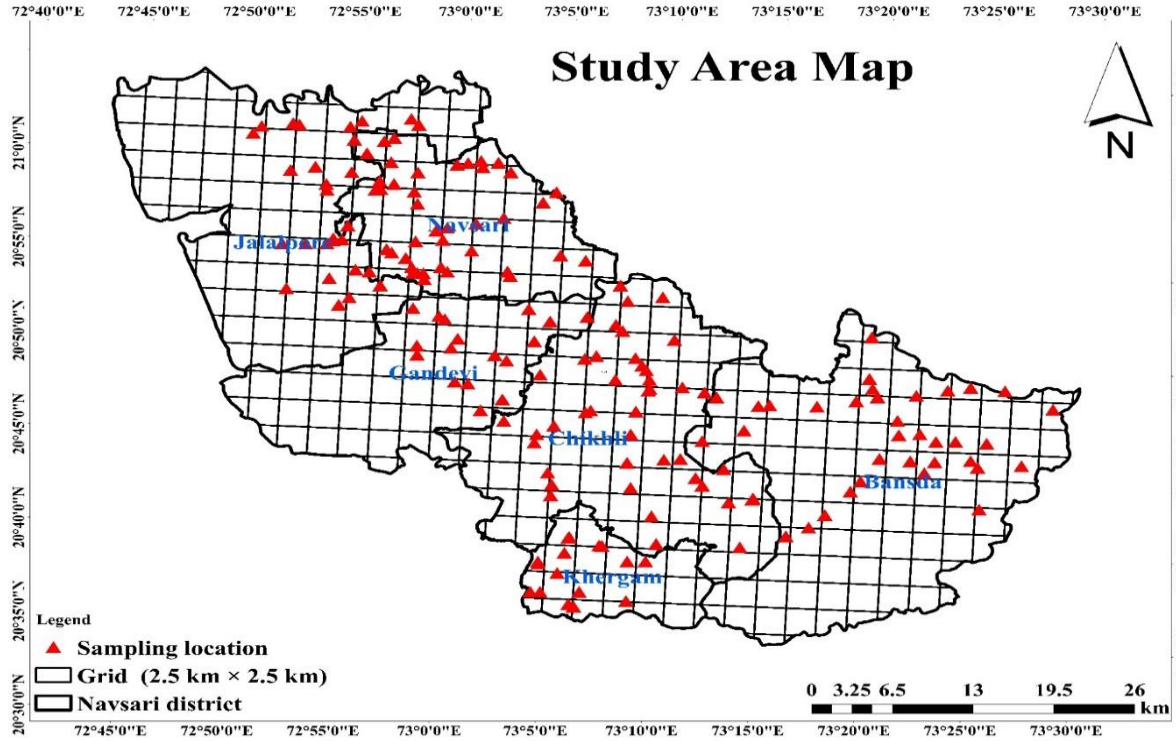
Sugarcane (*Saccharum officinarum*) is a vital crop that serves as a primary source of sugar and bioenergy production globally. Sugarcane is a widely cultivated crop in India and also an important cash crop of South Gujarat. India is the second largest producer of sugarcane contributing 306 million tons production and occupies about 4.4 million ha area [3]. In the agricultural and industrial economy of the country, it plays a crucial role. India is one of the biggest sugar producers and close competition with Brazil for its first place. Sugarcane is cultivated in 222,960 hectares in Gujarat [4].

Navsari district in the vibrant state of Gujarat, India, stands as a pivotal region for sugarcane cultivation, contributing significantly to the nation's sugar and agro-industry. The success of sugarcane farming in this area is intricately tied to the unique characteristics of its soils. The characterization and classification of soils in Navsari district play a crucial role in optimizing agricultural practices, ensuring sustainable sugarcane yield and fostering informed land management decisions tailored to the specific needs of this region. Navsari district comes under south Gujarat heavy rainfall agro-climatic zone. Navsari district consist of six talukas. These talukas are Navsari, Khergam, Jalalpore, Chikhli, Vansada and Gandevi. Sugarcane was cultivated in Navsari district in 15,194 ha in 2019-20 which slightly reduced to 15,026 ha in 2020-21 with production of 9.68 lakh MT and 9.58 lakh MT respectively [4]. For sustainable sugarcane production, it is very important to select sites with favourable soil fertility and physical properties.

Soils, in general, are degrading day by day due to poor management and faulty land-use practices at a rate faster than their natural degeneration becomes crucial to protect them from further degradation as there is a concomitant decline in soil quality to produce healthy crops. Physical properties, such as bulk density (BD), porosity and maximum water holding capacity provide insights into the soil's mechanical behavior, while chemical properties, including pH, electrical conductivity (EC) and organic carbon (OC) influence its fertility and suitability for different land uses. The soils in Navsari district exhibit a diverse range of properties influenced by the local climate, topography and geological history. Understanding interactions between physical and chemical soil properties can significantly affect soil function and productivity. By studying this, we can develop more effective soil management practices and it would be helpful in enhancing agricultural productivity, sustainable land use and preservation of soil health.

2. MATERIALS AND METHODS

The study was conducted in Navsari district of south Gujarat during the year 2022-2023. Monsoon generally commences from the second fortnight of June and retreats by middle of September to end of September with an average annual rainfall of 1767.3 mm, which is released entirely from south-west monsoon currents. July and August are the months of heavy precipitation. The total numbers of rainy days are around 58 (average of last ten years). In general, rainfall does not occur in the winter and summer seasons almost in all the parts of Gujarat. The data indicated that the maximum temperature ranged between 26.4 to 39.5 ˚C while the minimum temperature ranged between 10.9 to 27.7 ˚C during the experiment season December-2021 to February-2023 respectively. The maximum relative humidity was between 68 and 98% while the minimum relative



Map 1. Location of collection of soil samples of sugarcane growing area of Navsari district

humidity was between 20% and 97% during the experiment season December-2021 to February-2023 while bright sunshine hoursday^{-1} was between 0.0 to 10.2 hours.

Sentinel 2 satellite data from the year 2021 were acquired from the Copernicus site to identify the sugarcane producing area in the Navsari district. Hybrid classification approach *i.e.,* supervised and unsupervised with ground truth data were applied using ERDAS IMAGINE software. After image classification, 2.5 km X 2.5 km grid was prepared in Q-GIS software. Classified sugarcane area and 2.5 X 2.5 km grid were overlapped for site identification. Then, random soil samples were collected with reference from grid of intensive sugarcane growing area. From each grid soil samples were collected at a depth of 0-22.5 and 22.5-45 cm by adopting standard procedure [3]. In order to characterize soil resource of the selected sugarcane growing area from which soil samples were collected, it was marked. Similarly, the latitude and longitude were also recorded for each sample point with the help of portable Global Positioning System (GPS). 179 surface and 179 sub-surface soil samples were collected from all over Navsari district of sugarcane growing area. Out of 179 grids from which soil samples were collected, 19, 24, 40, 41, 16 and 39 grids were from Gandevi, Jalalpore, Navsari, Vansda, Khergam and Chikhli taluka respectively.

Soil particle density was determined by using the pycnometer method [5]. Soil bulk density was determined by using the core method [6]. Soil porosity was determined from soil particle and bulk density. Soil maximum water holding capacity was determined by using brass cup method as suggested by Jackson [5]. Soil pH and electrical conductivity were measured in 1:2.5 soil: water suspension by using glass electrode electric pH-meter and electrical conductivity meter respectively [7]. Soil organic carbon was determined by following the Walkley and Black rapid titration method [7].

3. RESULTS AND DISCUSSION

3.1 Soil Physical Parameters

3.1.1 Particle density (PD)

The particle density of the surface soil samples varied from 2.10 g cm^{-3} observed in Ghodmal village of Vansda Taluka to 2.76 g cm^{-3} observed in Achhavani, Rankua and Pardi village of Khergam, Chikhli and Navsari taluka with an average of 2.58 g cm^{-3} while particle density of the sub-surface soil samples varied from 2.18 g cm^{-3} observed in Pipalkhed village of Vansda taluka to 2.79 g cm^{-3} observed in Chikhli, Rumla, Rankua, Khudvel, Sadadvel, Sisodra, Jalalpore, Mirjapor and Tavdi village of Chikhli, Chikhli, Chikhli, Chikhli, Chikhli, Navsari, Jalalpore, Jalalpore and Jalalpore taluka with an average of 2.62 g cm^{-3}.

3.1.2 Bulk density (BD)

The bulk density of the surface soil samples ranged from 1.10 g cm^{-3} observed in Mirjapor village of

Jalalpore taluka to 1.68 g cm^{-3} observed in Saraiya village of Chikhli taluka with an average of 1.33 g cm^{-3} while bulk density of the sub-surface soil samples varied from 1.15 g cm^{-3} observed in Khundh village of Chikhli taluka to 1.68 g cm^{-3} observed in Surkhai, Saraiya, Kachhol and Bamanvel village of Chikhli, Chikhli, Navsari and Chikhli taluka with an average of 1.42 g cm^{-3}.

The variation in soil bulk density might be attributed to high amount of expanding clay minerals as reported by Sekhar et al*.* [8]. They also noted that higher soil bulk density in sub-surface soil than surface soil might be due to compaction of finer particle in deeper layer caused by over head weight of surface layers, high clay content in swelling soil, low organic matter and plant root concentration in lower layers. They also enumerated that lower bulk density in surface soil might be due to continuous cultivation, high organic matter content and high biotic activities. The higher amount of soil bulk density in sub-surface soil may be due to clogging of pores by dispersed clay in sub-surface soil and reduction of organic carbon as found by Prasad et al*.* [9] and Panwar et al*.* [10]. The compaction and reduction of organic matter results in increase bulk density of soil as enumerated by Singh and Agrawal [11] and Sahoo et al. [12].

3.1.3 Porosity

The porosity of the surface soil samples ranged from 31.60% observed in Peladi Bhervi and Khergam village of Khergam taluka to 59.26% observed in Mirjapor village of Jalalpore taluka with an average of 48.39% while porosity of the sub-surface soil samples varied from 29.54% observed in Peladi Bhervi village of Khergam taluka to 57.71% observed in Sisodra village of Navsari taluka with an average of 45.60%.

3.1.4 Maximum water holding capacity (MWHC)

The maximum water holding capacity of the surface soil samples varied from 22.77% observed in Khergam village of Khergam taluka to 51.92% observed in Rankua village of Chikhli taluka with an average of 39.60% while maximum water holding capacity of the sub-surface soil samples varied from 20.98% observed in Peladi Bhervi village of Khergam taluka to 48.91% observed in Khergam village of Khergam taluka with an average of 36.81%.

The variation in maximum water holding capacity might be due to differences in soil texture and organic carbon as reported by Sekhar et al. [8] and Prasad et al. [9]. The decrease in maximum water with increase in soil depth might be due to variation in finer and coarser fraction of soil as noted by Prasad et al. [9].

The findings of particle density, bulk density and porosity of soil was consistent with Narsaiah et al. [13], Prasad et al. [9], Sahoo et al. [12] and Supriya et al. [14]. Similar line of work of maximum water holding capacity was noted by Kumar and Desai [15], Sekhar et al. [16], Prasad et al. [9] and Supriya et al. [14].

3.2 Soil Chemical Parameters

3.2.1 pH

It was observed that the pH of surface soils in Kheragm, Vansda, Chikhli, Navsari, Jalalpore and Gandevi taluka ranged from 6.20 to 7.90, 6.08 to 8.03, 6.10 to 8.37, 6.10 to 8.26, 6.12 to 7.95 and 6.20 to 8.12 with a mean value of 7.00, 6.89, 7.20, 7.14, 6.93 and 6.95 respectively. It was noted that the pH of sub-surface soils in Kheragm, Vansda, Chikhli, Navsari, Jalalpore and Gandevi taluka ranged from 6.61 to 8.22, 7.08 to 8.40, 7.04 to 8.50, 6.00 to 8.50, 6.48 to 8.25 and 6.21 to 8.35 with a mean value of 7.35, 7.85, 7.72, 7.65, 7.66 and 7.67 respectively. The pH of surface soil samples were acidic to slightly alkaline while sub-surface soil samples were slightly acidic to strongly alkaline.

From 179 surface soil samples, 22.19 per cent of soil samples were categorized as slightly acidic, 62.19 percent samples were classified as having a normal soil reaction and 15.61 per cent of the soil samples exhibited a slightly alkaline soil reaction while from 179 sub-surface soil samples, 1.99, 41.65 and 56.36 percent were categorized as slightly acidic, normal and slightly alkaline respectively. In general, soil pH value tends to be increasing with increasing soil depth. The result of mostly increased pH in sub-surface soil may be due to leaching of bases from upper surface to lower sub-surface and due to free drainage which favours removal of bases by percolating water as reported by Prasad and Govardhan [17] and Supriya et al. [14] respectively. In the present investigation, soil pH were acidic to strongly alkaline and more in sub-surface soil than in surface soil may be attributed to nature of parent material and leaching. Similar results of pH also *reported by* Jangir et al. [18], Narsaiah et al. [13], Sahoo et al. [12] and Jangir et al. [19].

3.2.2 Electrical Conductivity (EC)

The electrical conductivity of the samples were observed to differ. The electrical conductivity of the surface soil samples ranged from 0.011 dS m^{-1} observed in Kolva village of Gandevi taluka to 1.580 dS m^{-1} observed in Natvad village of Vansda taluka with an average of 0.483 dS m^{-1} while electrical conductivity of the sub-surface soil samples varied from 0.010 dS m^{-1} observed in Panaj village of Khergam taluka to 1.586 dS m^{-1} observed in Mirjapor village of Jalalpore taluka with an average of 0.511 dS m^{-1}. The electrical conductivity of surface and sub-surface soils were non saline to mild saline.

Regarding soil salinity, the majority of both surface and sub-surface soils were observed to be non-saline, indicating that soil salinity is not a significant issue in the study area. However, a few surface soils as well as sub-surface in Khergam and Chikhli taluka were reported to be slightly saline. Given the soil salinity levels in the study area are all below the threshold limit of EC < 2 dSm^{-1}, it reveals that there are no significant salinity issues affecting the soil.

The result of the present investigation showed significantly increased electrical conductivity from surface to sub-surface soil. Similar lines of work were reported by Sekhar et al. [16], Jangir et al. [18], Narsaiah et al. [13], and Supriya et al. [14]. The reason of increased electrical conductivity in sub-surface soil may be accumulation and excess leaching of salts in sub-surface as noted by Prasad and Govardhan [17] and Narsaiah et al. [13]. Another reason may be free drainage conditions which favour the removal of salts by percolation and drainage as found by Sekhar et al. [8].

3.2.3 Organic Carbon (OC)

The status of organic carbon indicated wide variability in content of soil organic carbon in surface soils which was ranging from 0.06 per cent to 0.89 per cent with an overall mean value of 0.56 per cent. Sub-surface soil organic carbon content recorded was ranging from 0.02 per cent to 0.85 per cent in the area of with an overall mean value of 0.34 per cent. Regardless of the variations observed, 38.72 per cent surface soils samples were low, 41.95 per cent in medium and 19.34 per cent samples were in high categories. In case of sub-surface SOC content, 82.52 per cent samples were in low category, 14.94 per cent into the medium category and 2.54 per cent were in high category. The lowest organic carbon content was recorded in the surface and subsurface soils of Chikhli taluka compared to the other talukas. In contrast, the soils of Gandevi taluka had slightly higher organic carbon content in both surface and sub-surface layers.

The organic carbon of the samples were noted to be diverse. The organic carbon of the surface soil samples ranged from 0.06% observed in Chikhli village of Chikhli taluka to 0.89% observed in Ganghor village of Gandevi taluka with an average of 0.56%

Table 1. Range and mean of particle density (PD) at surface and sub-surface soil samples in sugarcane growing area

		PD (g cm^{-3})			
Taluka	**No. of Samples**	**0-22.5 cm depth**		**22.5-45 cm depth**	
		Range	**Mean**	**Range**	**Mean**
Khergam	16	2.31-2.76	2.54	2.37-2.77	2.60
Vansda	41	2.10-2.71	2.49	2.18-2.77	2.56
Chikhli	39	2.30-2.76	2.60	2.35-2.79	2.64
Navsari	40	2.41-2.76	2.62	2.44-2.79	2.65
Jalalpore	24	2.46-2.75	2.63	2.44-2.79	2.67
Gandevi	19	2.40-2.74	2.57	2.40-2.78	2.61
OVERALL	**179**	**2.10-2.76**	**2.58**	**2.18-2.79**	**2.62**

Table 2. Range and mean of bulk density (BD) at surface and sub-surface soil samples in sugarcane growing area

		BD (g cm^{-3})			
Taluka	**No. of Samples**	**0-22.5 cm depth**		**22.5-45 cm depth**	
		Range	**Mean**	**Range**	**Mean**
Khergam	16	1.22-1.58	1.37	1.21-1.67	1.42
Vansda	41	1.16-1.63	1.38	1.19-1.67	1.45
Chikhli	39	1.12-1.68	1.30	1.15-1.68	1.43
Navsari	40	1.12-1.48	1.31	1.18-1.68	1.43
Jalalpore	24	1.10-1.36	1.28	1.18-1.56	1.38
Gandevi	19	1.16-1.48	1.29	1.23-1.52	1.38
OVERALL	**179**	**1.10-1.68**	**1.33**	**1.15-1.68**	**1.42**

Table 3. Range and mean of porosity at surface and sub-surface soil samples in sugarcane growing area

		Porosity (%)			
Taluka	**No. of Samples**	**0-22.5 cm depth**		**22.5-45 cm depth**	
		Range	**Mean**	**Range**	**Mean**
Khergam	16	31.60-55.47	45.85	29.54-56.16	44.96
Vansda	41	35.06-52.40	44.49	36.24-51.63	43.31
Chikhli	39	36.12-58.67	49.77	36.60-55.91	45.73
Navsari	40	41.87-58.97	49.72	36.84-57.71	45.80
Jalalpore	24	45.93-59.26	51.09	36.48-56.30	48.33
Gandevi	19	41.04-56.62	49.88	42.41-55.76	46.98
OVERALL	**179**	**31.60-59.26**	**48.39**	**29.54-57.71**	**45.60**

while organic carbon of the sub-surface soil samples varied from 0.02% observed in Gandeva village of Gandvei taluka to 0.85% observed in Kachholi village of Gandevi taluka with an average of 0.34%. The organic carbon of surface and sub-surface soils were low to high.

Table 4. Range and mean of maximum water holding capacity at surface and sub-surface soil samples in sugarcane growing area

Taluka	No. of Samples	Maximum Water Holding Capacity (%)			
		Surface (0-22.5 cm)		Sub-Surface (22.5-45 cm)	
		Range	Mean	Range	Mean
Khergam	16	22.77-46.06	36.92	20.98-48.91	36.12
Vansda	41	26.48-43.79	35.48	27.42-42.79	34.29
Chikhli	39	27.02-51.92	41.20	27.60-48.53	37.13
Navsari	40	32.97-49.10	40.95	27.90-48.26	37.07
Jalalpore	24	36.58-51.66	42.26	27.14-48.78	39.51
Gandevi	19	32.49-49.91	41.23	33.53-48.44	38.22
OVERALL	**179**	**22.77-51.92**	**39.60**	**20.98-48.91**	**36.81**

Table 5. Range, mean and category wise distribution of $pH_{(1:2.5)}$ at surface and sub-surface soil samples in sugarcane growing area

Taluka	No. of samples	$pH_{(1:2.5)}$		$pH_{(1:2.5)}$ Distribution (%)			
		Range	Mean	Slightly acidic	Normal	Slightly Alkaline	Moderately Alkaline
0-22.5 cm depth							
Khergam	16	6.20-7.90	7.00	12.50	75.00	12.50	0.00
Vansda	41	6.08-8.03	6.89	26.83	68.29	4.88	0.00
Chikhli	39	6.10-8.37	7.20	12.82	66.67	20.51	0.00
Navsari	40	6.10-8.26	7.14	15.00	57.50	27.50	0.00
Jalalpore	24	6.12-7.95	6.93	29.17	58.33	12.50	0.00
Gandevi	19	6.20-8.12	6.95	36.84	47.37	15.79	0.00
OVERALL	**179**	**6.08-8.37**	**7.03**	**22.19**	**62.19**	**15.61**	**0.00**
22.5-45 cm depth							
Khergam	16	6.61-8.22	7.35	0.00	75.00	25.00	0.00
Vansda	41	7.08-8.40	7.85	0.00	19.51	80.49	0.00
Chikhli	39	7.04-8.50	7.72	0.00	41.03	58.97	0.00
Navsari	40	6.00-8.50	7.65	2.50	40.00	57.50	0.00
Jalalpore	24	6.48-8.25	7.66	4.17	37.50	58.33	0.00
Gandevi	19	6.21-8.35	7.67	5.26	36.84	57.89	0.00
OVERALL	**179**	**6.00-8.50**	**7.69**	**1.99**	**41.65**	**56.36**	**0.00**

Table 6. Range, mean and category wise distribution of electrical conductivity ($EC_{1:2.5}$) at surface and sub-surface soil samples in sugarcane growing area

Taluka	No. of Samples	$EC_{(1:2.5)}$(dS m^{-1})		$EC_{(1:2.5)}$Distribution (%)			
		Range	Mean	Non Saline	Slightly Saline	Moderately Saline	Highly Saline
0-22.5 cm depth							
Khergam	16	0.015-1.477	0.661	50.00	50.00	0.00	0.00
Vansda	41	0.052-1.580	0.337	92.68	7.32	0.00	0.00
Chikhli	39	0.050-1.524	0.739	58.97	41.03	0.00	0.00
Navsari	40	0.014-1.220	0.368	87.50	12.50	0.00	0.00
Jalalpore	24	0.020-1.190	0.383	87.50	12.50	0.00	0.00
Gandevi	19	0.011-1.565	0.487	84.21	15.79	0.00	0.00
OVERALL	**179**	**0.011-1.580**	**0.483**	**76.81**	**23.19**	**0.00**	**0.00**
22.5-45 cm depth							
Khergam	16	0.010-1.421	0.68	50.00	50.00	0.00	0.00
Vansda	41	0.044-1.330	0.309	95.12	4.88	0.00	0.00
Chikhli	39	0.014-1.510	0.791	51.28	48.72	0.00	0.00
Navsari	40	0.030-1.400	0.371	95.00	5.00	0.00	0.00
Jalalpore	24	0.013-1.586	0.486	87.50	12.50	0.00	0.00
Gandevi	19	0.041-1.584	0.558	78.95	21.05	0.00	0.00
OVERALL	**179**	**0.010-1.586**	**0.511**	**76.31**	**23.69**	**0.00**	**0.00**

Table 7. Range, mean and category wise distribution of organic carbon (OC) at surface and sub-surface soil samples in sugarcane growing area

Taluka	No. of Samples	OC (%)		OC Distribution (%)		
		Range	Mean	Low	Medium	High
0-22.5 cm depth						
Khergam	16	0.21-0.82	0.56	43.75	25.00	31.25
Vansda	41	0.16-0.88	0.58	24.39	60.98	14.63
Chikhli	39	0.06-0.86	0.49	48.72	43.59	7.69
Navsari	40	0.18-0.88	0.62	27.50	42.50	30.00
Jalalpore	24	0.08-0.87	0.54	45.83	37.50	16.67
Gandevi	19	0.18-0.89	0.52	42.11	42.11	15.79
OVERALL	**179**	**0.06-0.89**	**0.56**	**38.72**	**41.95**	**19.34**
22.5-45 cm depth						
Khergam	16	0.09-0.56	0.31	87.50	12.50	0.00
Vansda	41	0.05-0.82	0.37	73.17	24.39	2.44
Chikhli	39	0.06-0.82	0.29	87.18	10.26	2.56
Navsari	40	0.10-0.81	0.40	72.50	22.50	5.00
Jalalpore	24	0.07-0.64	0.32	95.83	4.17	0.00
Gandevi	19	0.02-0.85	0.34	78.95	15.79	5.26
OVERALL	**179**	**0.02-0.85**	**0.34**	**82.52**	**14.94**	**2.54**

This higher organic carbon content may be attributed to extensive sugarcane cultivation, which contributes organic matter from sugarcane crop residues. The variation of soil organic carbon from place to place under study area might be ascribed to addition of varying quantity of organic matters / manures / biocomposts by the farmers in plant and ratoon sugarcane and also due to difference in rate of decomposition of added organic matter. Similar findings were reported by Gaikwad et al. [20] during GIS mapping of major sugarcane-growing soils in south Gujarat. Bhalawe et al. [21] also found increased soil organic carbon content in sugarcane-growing soils compared to soils under paddy and banana cultivation in south Gujarat.

In the present survey, soil organic carbon decreased in sub-surface soil than in surface soil. Similar results were noted by Sekhar et al. [16], Narsaiah et al. [13], Supriya et al. [14] and Jangir et al. [19]. The wide variation and distribution of soil organic carbon is mainly associated with physiography and land use as enumerated by Prasad and Govardhan [17]. The decreased soil organic carbon in sub-surface soil and somewhat low soil organic carbon may be attributed to degradation of organic matter which occurred at faster rate coupled with low vegetation cover as found by Sekhar et al. [8] and Jangir et al. [19]. Another reason is increasing rate of oxidation of organic matter as reported by Kumar et al. [22].

4. CONCLUSION

The soils of sugarcane growing area of Navsari district was characterized with higher bulk density, slightly acidic to slightly alkaline, non-saline to slightly saline and low organic carbon for sugarcane cultivation. Soil bulk density is one of the main direct indicators of soil health and is an important aspect of for determining agro-ecosystem potentiality. Soil bulk density used for topsoil carbon stock estimation as well as others soil quality indicator classification. Unconscious irrigation and old irrigation techniques extremely damage fertile land and accelerate water logging and salt accumulation in soil reduced productivity and damaged soil health. Soil organic carbon Soil organic carbon (SOC) regulates terrestrial ecosystem functioning, provides diverse energy sources for soil microorganisms, governs soil structure and regulates the availability of organically bound nutrients. Therefore it's necessary to identified soil related problems like salinity, alkalinity, higher bulk density or low organic carbon statuses covered under study and concern to scientists as well as farmers to predict and monitor continuously in order to take protective measures against further deterioration of the soil and managed soil fertility, productivity and sustainability for sugarcane growing area.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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