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## Soil salinity Patten along the distance gradient in coastal region soils of southern Saurashtra of Gujarat

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### Abstract

Grid based (GPS) surface (0-15 cm) soil samples by systematic survey were collected from 0 km of the sea coast (Bhavnagar, Amreli, Gir Somnath and Junagadh district) to 20 km towards inland. The distance between the sample locations was about 5 km from cultivated fields of different district of coastal region of South Saurashtra of Gujarat region. These soil samples were analyzed for determination of EC<sub>e</sub>, pH<sub>s</sub>, ESP, SAR and SSP to study the salinity status of soil. The value of soil EC<sub>e</sub> is comparatively higher in the 0 to 5 km distance away from the sea coast. Whereas, the lower EC<sub>e</sub> noted in the 15 to 20 km area. The soil EC<sub>e</sub> and pH<sub>s</sub> decreased with increased in distance from sea coast. The overall mean values of EC<sub>e</sub> were 5.22, 3.94, 2.93 and 2.14 dS m<sup>-1</sup> and pH<sub>s</sub> were 8.03, 7.85, 7.84 and 7.41 at 0-5, 5-10, 10-15 and 15-20 km from sea coast. The overall mean values of ESP were 17.44, 15.82, 15.53 and 14.91 at 0-5, 5-10, 10-15 and 15-20 km distance, SSP were 33.75, 35.20, 37.06 and 39.72 at 0-5, 5-10, 10-15 and 15-20 km distance and overall mean values of SAR content in soils of Southern Saurashtra coastal region were 2.28, 2.15, 2.09 and 1.96 at 0-5, 5-10, 10-15 and 15-20 km distance from seacoast, respectively. The result also revealed that the overall mean value of ESP and SAR were decreased with increased in distance from sea coast while SSP increased with increased in distance from sea coast.

**Keywords:** Sea coast, salinity, distance, Southern Sourashtra

### 1. Introduction

Soil survey provides useful information for planning proper soil and water management practices, which play important part in augmenting crop production. Among the natural resources, soil is available finite, non-elastic and non-renewable asset. In India the dwindling per capita availability of land that decreased from 0.5 to 0.15 ha in 1999-2000 because of population escalation, is likely to reduce further to 0.08 ha in 2020 AD (Yadav and Singh, 2000) [1]. Approximately 80 per cent of total farm holdings fall in the category of small and marginal with an average holding of less than 1 ha. Research findings have amply shown 3 to 4 times productivity potential of land even with the currently available technologies.

Soil salinity has emerged as the most significant problem of present agriculture of India. It is estimated that 175 M ha of land of India is suffering from various degradation process like wind & water erosion, water logging and salinity. Around 6.727 million ha area in India, which is around 2.1% of geographical area of the country, is salt-affected, of which 2.956 million ha is saline and the rest 3.771 million ha is sodic (Arora *et al.* 2016) [2]. Nearly 75% of salt-affected soils in the country exist in the states of Gujarat (2.23 million ha), Uttar Pradesh (1.37 million ha), Maharashtra (0.61 million ha), West Bengal (0.44 million ha), and Rajasthan (0.38 million ha) (Mandal *et al.* 2018) [3]. In Gujarat, Saurashtra region has total geographical area of 64.3 lakh ha (32.8% of the state total) half of which is cultivable waste land. Salt affected soils are unproductive unless excess salts are reduced or removed. These soils occur most extensively in arid and semi-arid climates, but these soils are also found in coastal sea areas where soils are inundated by ocean or sea water.

The state has a coast line of 1600 km which comprises the Agro Ecological Sub Regions (AESR) 2.2, AESR 2.4 and AESR 5.3. In the state, recently, the soil degradation through salinity has caught hold over 1.2 m ha of land. Of which, about 0.3 m ha occurs in the coastal area and rest 0.9 m ha comprises the inland saline area (Rao *et al.*, 2001) [4]. About 1125 km long coastal line is in Saurashtra and Kutch which comprises about 0.1079 m. ha of saline land.

The excessive withdrawal of groundwater disturbs hydrodynamic equilibrium that exists between the freshwater-seawater in the aquifer and causes upward movement of the seawater.

This causes depletion in the available fresh groundwater resources in coastal areas (Alfarrah and Walraevens, 2018) [5]. According to the studies conducted about the sea water intrusion, it has reached up to 1.3 to 4 km interior in coastal belt from Bhavnagar to Una, 2.4 to 3.2 km from Una to Madhavpur and 1 to 2.6 km from Madhavpur to Okha. The spread of sea water intrusion was 2.5 to 4.5 km in 1971 which increased to 5 to 7.5 km in 1977. The survey conducted by Kanzaria *et al.*, (1981) in coastal belt of Saurashtra-Kutch and North Gujarat disclosed that 35.5 per cent of the soil samples had moderate to very high salinity. The studies conducted long day about salinity of ground water revealed that there was 3500 ppm salinity in coastal belt of 2 km (from sea) and 860 ppm to 2600 ppm within the 5 km. In the state, the rate of salinity ingress is 1.5 km per decay.

Saline water intrusions and coastal salinity are also major problems of Saurashtra region due to about 700 km long sea coast, posing problem of coastal salinity as the result of over and endless pumping. Salt buildup in soils and water are major concerns for human habitat, sustainable development, soil health, and crop productivity (Mimura 2013) [7] due to severe problem of water and land salinity in the coastal regions (Rao *et al.*, 2019) [8].

Continuous saline water intrusion due to sea level rise and increased shrimp cultivation are resulting altered nutrient status in coastal area of Saurashtra region of Gujarat that is eventually impacting coastal agricultural production on a large scale. Soil provides a significant source of nutrients for crop production and the growth of plants (Ashman and Puri, 2013) [9]. Again soil nutrients provide a crucial role for the sustainability of soil quality, crop production and environmental quality (Andrews *et al.*, 2004) [10].

Soil properties such as soil pH, salinity, nutrient biogeochemical and physiochemical processes regulate the bioavailability of soil nutrients and soil salinity is recognized as a serious challenge in land cultivation (El-Ramady *et al.*, 2018) [11]. Hasanuzzaman *et al.*, (2013) [12] argued that salinity in soil act as important abiotic stress causing a remarkable decrease in the crop production. Moreover, soil salinization deteriorates one or more functions of soil that emerges as a major environmental constrain impeding soil productivity, agricultural sustainability and food security (Cuevas *et al.*, 2019) [13].

As a result, the varying degrees of soil salinity create the unfavorable condition for cultivation in coastal lands. Moreover, excess salinity deteriorates the hydrological situation and even restricts normal crop production throughout the year (Haque, 2006) [14].

## 2. Material and Method

This study has been performed in Southern Saurashtra coastal region of Gujarat. A total 240 surface soil samples were collected from four distance locations starting from 0 km of the sea coast (Bhavnagar, Amreli, Gir Somnath and Junagadh district) to 20 km towards inland. The distance between the sample locations was about 5 km. Twenty surface soils samples from each taluka at an interval of 0-5, 5-10, 10-15 and 15- 20 km from sea coast. The samples were collected from all the coastal area of Southern Saurashtra *viz.* Ghogha, Bhavnagar, Mahuva and Talaja talukas of Bhavnagar district, Rajula and Jafarabad talukas of Amreli district, Sutrapada, Kodinar, Una and Veraval talukas of Gir Somnath districts and Mangrol and Malia talukas of Junagadh district of coastal region of Southern Saurashtra of Gujarat during the Summer season of 2019.

The ECe was determined with Conductivity method as described by Richards (1954) [15] and pHs was determined with pH meter as per the methods described by Richards (1954) [15]. The SSP, SAR and ESP were calculated by the following formulas.

### 1) Soluble Sodium Percentage (SSP)

$$SSP = \frac{Na^+}{Ca^{++}+Mg^{++}+Na^{++}+K^+} \times 100$$

### 2) Sodium Adsorption Ratio (SAR)

$$SAR = \frac{Na^+}{\sqrt{(Ca^{++}+Mg^{++})/2}} \times 100$$

(Concentrations of all cations in me l<sup>-1</sup>)

### 3) Exchangeable Sodium Percentage (ESP)

$$ESP = \frac{Ex.Na}{CEC} \times 100$$

(Concentrations of all cations in me l<sup>-1</sup>)

## 3. Results and Discussion

### 3.1 EC<sub>e</sub>

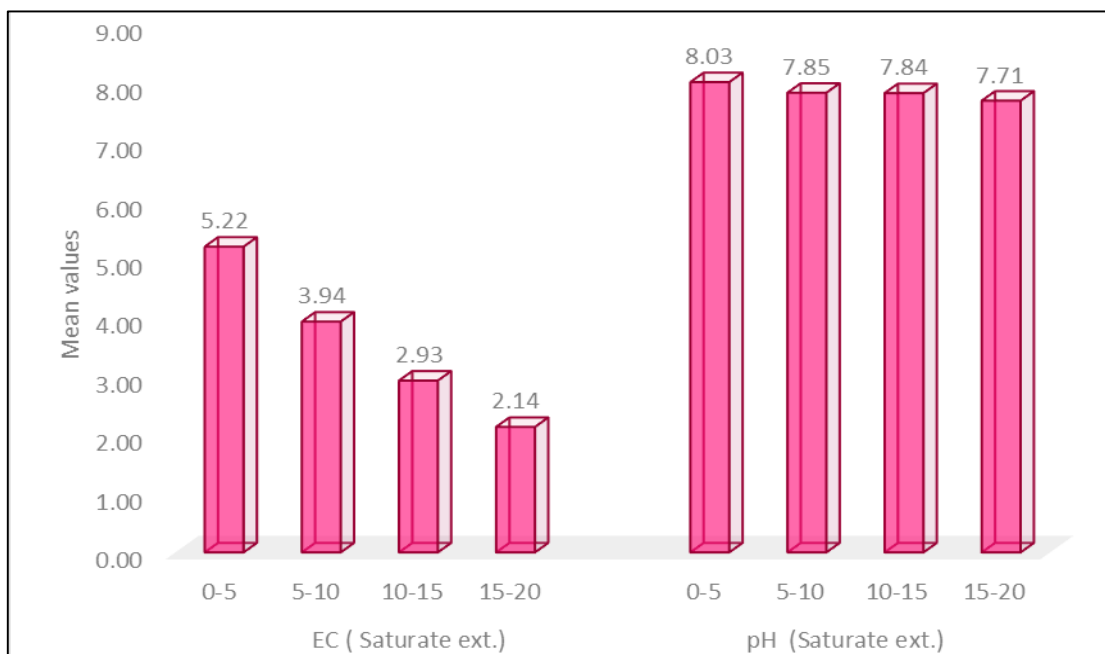
Electrical conductivity of saturation extract was determined from all 240 samples and taluka and district wise range and mean values of ECe are given in Table 3.1. The overall mean value of ECe in Bhavnagar district was 3.57 dS m<sup>-1</sup> with maximum 7.06 dS m<sup>-1</sup> at 0 to 5 km distance from sea coast and minimum value of 1.91 dS m<sup>-1</sup> at 15 to 20 km distance from sea coast. In Amreli district maximum ECe 6.66 dS m<sup>-1</sup> was found at 0 to 5 km distance from sea coast and minimum ECe 1.05 dS m<sup>-1</sup> at 15 to 20 km distance from sea coast with overall mean value of 3.45 dS m<sup>-1</sup>. In Gir Somnath district maximum and minimum values of ECe 7.33 dS m<sup>-1</sup> and 1.85 dS m<sup>-1</sup> were recorded at 0 to 5 km and 10 to 15 km distance from sea coast, respectively with overall mean value of 3.67 dS m<sup>-1</sup>. While, in Junagadh district the overall mean value of ECe was recorded 3.58 dS m<sup>-1</sup> with maximum 6.40 dS m<sup>-1</sup> at 0 to 5 km distance from sea coast and minimum 1.87 dS m<sup>-1</sup> at 15 to 20 km distance from sea coast. The lowest ECe value 1.05 dS m<sup>-1</sup> was recorded in the soil sample were collected from Rajula taluka in Amreli district; whereas highest values of ECe 7.33 dS m<sup>-1</sup> was recorded in Una taluka of Gir Somnath. The data further revealed that the lowest mean value of ECe 3.23 dS m<sup>-1</sup> was obtained in the soils of Rajula taluka of Amreli district and the highest mean value of ECe 3.85 dS m<sup>-1</sup> was registered in the soils of Mangrol taluka of Junagadh district. The data also revealed that the overall mean value of ECe decreased with increase in distance from sea coast. The maximum value of ECe was recorded 3.94 dS m<sup>-1</sup> at 0 to 5 km distance and minimum value 2.14 dS m<sup>-1</sup> was found at 15 to 20 km distance from sea coast. This finding is in conformity with the findings of earlier work done by Rajput and Polara (2012) [16] for North-West Agro Climatic zone of Gujarat and Timbalia and Maliwal (2000) [17] for soils of Amreli district.

### 3.2 pH<sub>s</sub>

The overall pH<sub>s</sub> status of the soils of South Saurashtra region are given in Table 3.2. The maximum pH<sub>s</sub> 8.27 was found at 0

to 5 km distance and minimum value of  $pH_s$  7.20 was found at 15 to 20 km distance from sea coast with overall mean of  $pH_s$  7.90 in Bhavnagar district. In Amreli district maximum value of  $pH_s$  8.22 was found at 0 to 5 km distance and minimum value 7.37 at 15 to 20 km distance from sea coast with overall mean 7.85. In Gir Somnath district maximum and minimum values of  $pH_s$  8.35 and 7.23 were found at 5 to 10 km distance and at 15 to 20 km distance from sea coast, respectively with overall mean value of 7.82. The overall mean for  $pH_s$  in Junagadh district was 7.87 with maximum value of 8.52 at 0 to 5 km distance and minimum value of 7.17 at 10 to 15 km distance from sea coast. The lowest  $pH_s$  value 7.17 was recorded in the soil of Malia taluka in Junagadh district; whereas highest value of  $pH_s$  8.52 was recorded in Mangrol taluka of Junagadh. The data further revealed that the lowest

mean value of  $pH_s$  7.66 was obtained in the soils of Una taluka of Gir Somnath district and the highest mean value of 8.09 was registered in the soils of Kodinar taluka of Gir Somnath district. In general, overall mean value of  $pH_s$  decreased with increase in the distance 0 to 20 km from the sea coast. The overall mean value of  $pH_s$  in all the district under study was 8.03 at 0 to 5 km distance and 7.71 at 15 to 20 km distance from sea coast. Although,  $pH_s$  values are slightly lower than the  $pH_{2.5}$  at all the times. In general, the soils of all district are alkaline in reaction. This finding is in conformity with the findings of earlier work done by Rajput and Polara (2013) for soils of Bhavnagar and Timbadia and Maliwal (2000) for the soils of Jafrabad and Rajula talukas of Amreli district.



**Fig 1:** Overall ECe and  $pH_s$  (saturate extract) status in soils of Southern coastal Saurashtra

**Table 1:** Taluka wise range and mean values of soil ECe ( $dS\ m^{-1}$ ) in different districts of Southern Saurashtra region

Taluka	Distance from sea coast (km)	0 to 5		5 to 10		10 to 15		15 to 20		Overall Mean
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	
<b>Bhavnagar district</b>										
	Ghogha	4.09-6.21	4.94	3.23-5.08	4.12	2.66-3.98	3.19	1.91-2.60	2.25	3.49
	Bhavnagar	4.64-5.52	5.09	3.18-5.18	4.11	2.82-3.50	3.18	2.18-2.91	2.44	3.75
	Mahuva	4.82-7.06	5.67	3.77-5.14	4.29	2.04-3.72	2.91	2.05-2.30	2.19	3.76
	Talaja	3.94-6.16	5.02	3.34-4.83	4.20	1.92-2.65	2.32	2.00-2.24	2.12	3.27
	Mean	3.94-7.06	3.18	3.18-5.18	4.18	1.92-3.98	2.90	1.91-2.91	2.25	3.57
<b>Amreli district</b>										
	Rajula	4.08-5.42	4.80	2.47-4.69	3.57	2.09-3.98	3.11	1.05-2.15	1.82	3.23
	Jafrabad	4.15-6.66	5.66	3.56-4.22	3.92	2.35-3.53	3.03	1.93-2.18	2.07	3.67
	Mean	4.08-6.66	5.23	2.47-4.69	3.74	2.09-3.98	3.07	1.05-2.18	1.94	3.45
<b>Gir Somnath district</b>										
	Sutrapada	3.23-6.98	5.00	3.76-5.36	4.37	2.47-3.99	3.16	1.96-2.16	2.06	3.68
	Kodinar	3.98-5.29	4.62	3.45-5.23	4.54	1.85-3.26	2.48	1.93-2.10	2.01	3.30
	Una	5.36-7.33	6.10	4.00-5.00	4.45	2.89-4.18	3.35	2.00-2.93	2.55	4.11
	Veraval	4.00-6.43	4.86	3.05-4.82	3.88	2.89-3.17	3.01	2.12-3.00	2.54	3.62
	Mean	3.23-7.33	5.14	3.05-5.36	4.31	1.85-4.18	3.00	1.93-2.93	2.29	3.67
<b>Junagadh district</b>										
	Mangrol	4.87-6.40	5.61	3.10-4.44	3.73	2.47-3.10	2.74	2.00-2.18	2.09	3.85
	Malia	4.27-6.20	5.05	2.93-3.60	3.33	2.20-3.20	2.79	1.87-2.28	2.08	3.31
	Mean	4.27-6.40	5.33	2.93-4.44	3.53	2.20-3.20	2.77	1.87-2.28	2.09	3.58
	Overall Mean	3.23-7.33	5.22	2.47-5.36	3.94	1.85-4.18	2.93	1.05-2.93	2.14	3.56

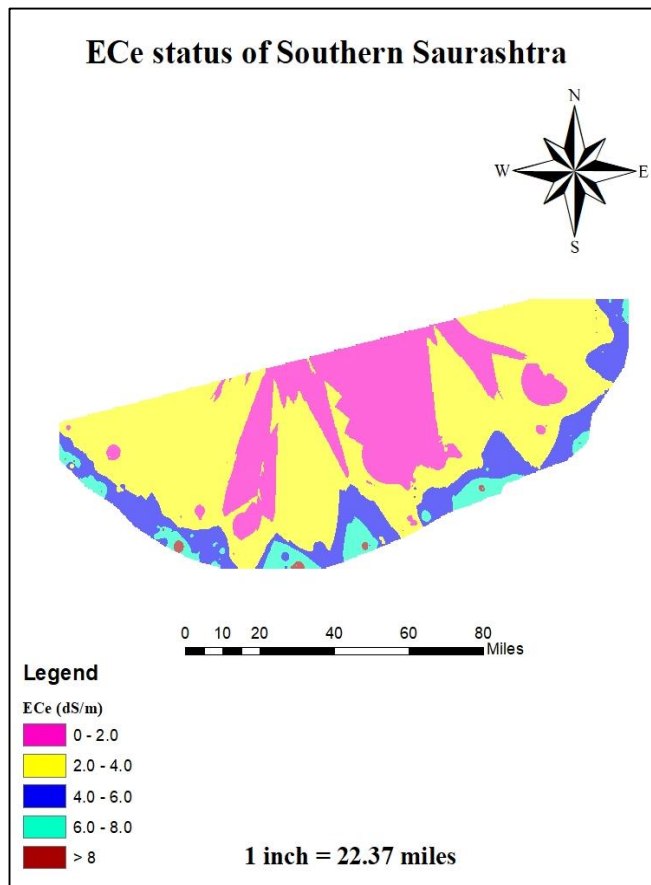


Fig 2: EC<sub>e</sub> (dS m<sup>-1</sup>) status in soils of Southern coastal Saurashtra

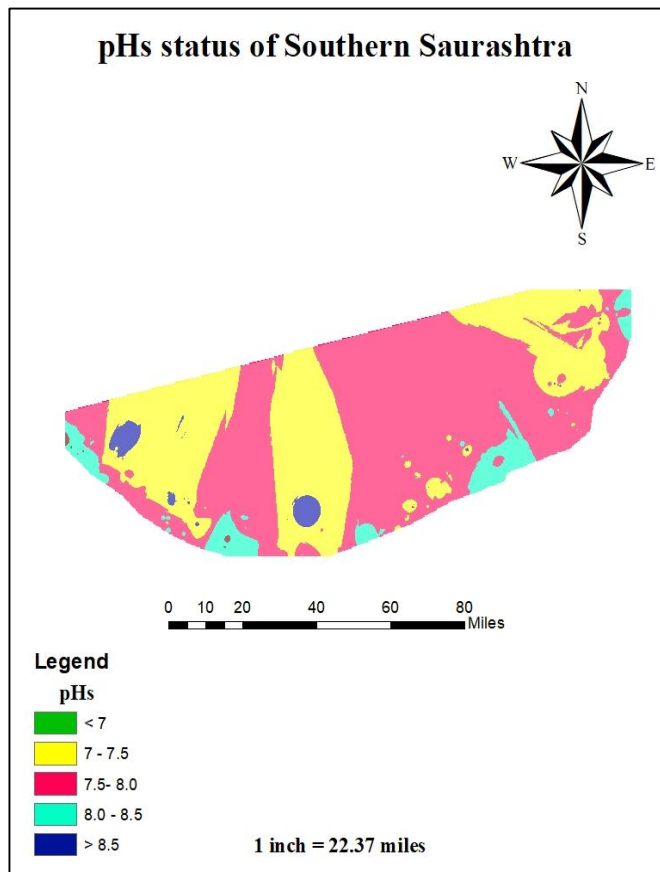


Fig 3: pH<sub>s</sub> status in soils of Southern coastal Saurashtra

Table 2: Taluka wise range and mean values of soil pH<sub>s</sub> in different districts of Southern Saurashtra region

Taluka	Distance from sea coast (km)	0 to 5		5 to 10		10 to 15		15 to 20		Overall Mean
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	
<b>Bhavnagar district</b>										
	Ghogha	8.10-8.27	8.15	7.83-8.14	8.05	7.42-8.12	7.80	7.20-8.02	7.71	7.91
	Bhavnagar	7.94-8.10	8.02	7.56-8.04	7.87	7.50-8.07	7.84	7.46-8.00	7.73	7.86
	Mahuva	8.00-8.12	8.06	7.85-8.19	8.03	7.82-8.12	7.98	7.42-8.12	7.82	7.97
	Talaja	7.94-8.04	7.99	7.70-8.04	7.85	7.74-8.12	7.98	7.34-8.00	7.69	7.86
	Mean	7.94-8.27	8.05	7.56-8.19	7.95	7.42-8.12	7.90	7.20-8.12	7.76	7.90
<b>Amreli district</b>										
	Rajula	7.52-7.90	7.77	7.47-7.99	7.76	7.58-8.19	7.91	7.58-8.07	7.82	7.82
	Jafrabad	7.84-8.22	8.06	7.56-8.10	7.94	7.67-8.01	7.77	7.37-8.02	7.79	7.89
	Mean	7.52-8.22	7.91	7.47-8.10	7.85	7.58-8.19	7.84	7.37-8.07	7.80	7.85
<b>Gir Somnath district</b>										
	Sutrapada	7.48-8.12	7.93	7.38-7.76	7.54	7.78-8.03	7.89	7.59-7.99	7.86	7.83
	Kodinar	8.00-8.33	8.21	8.09-8.35	8.22	7.87-8.20	8.04	7.78-8.21	7.94	8.09
	Una	7.56-8.06	7.81	7.51-7.99	7.71	7.47-8.00	7.73	7.23-7.60	7.39	7.66
	Veraval	7.98-8.20	8.07	7.34-8.09	7.62	7.26-7.82	7.49	7.44-7.81	7.58	7.69
	Mean	7.48-8.33	8.00	7.34-8.35	7.77	7.26-8.20	7.79	7.23-8.21	7.69	7.82
<b>Junagadh district</b>										
	Mangrol	8.10-8.52	8.29	7.37-8.19	7.98	7.95-8.10	8.04	7.56-7.99	7.80	8.06
	Malia	7.84-8.11	8.00	7.43-7.95	7.67	7.17-8.00	7.64	7.27-7.62	7.44	7.69
	Mean	7.84-8.52	8.15	7.37-8.19	7.83	7.17-8.10	7.84	7.27-7.99	7.62	7.87
	Overall Mean	7.48-8.52	8.03	7.34-8.35	7.85	7.17-8.20	7.84	7.20-8.21	7.71	7.86

**3.3 Exchangeable sodium percentage (ESP)**

The values of ESP estimated from the collected soil samples are given in Table 2. In Bhavnagar district overall mean value for ESP was 14.30 with maximum value of 22.89 at 15 to 20 km distance and minimum value of 5.34 at 10 to 15 km distance from sea coast. In Amreli district maximum ESP 31.53 was at 0 to 5 km distance and minimum ESP 15.38 was

found at 15 to 20 km distance from sea coast with overall mean 20.95. In Gir Somnath district maximum and minimum values of ESP were observed 19.73 and 10.37 at 10 to 15 km distance from sea coast, respectively with overall mean value of 14.29. The overall mean for ESP in Junagadh district was 14.21 with maximum and minimum values of 18.35 and 10.94 at 15 to 20 km distance from sea coast. The lowest ESP value



5.34 was recorded in the soil of Bhavnagar taluka of Bhavnagar district; whereas highest values of ESP 31.53 was recorded in Jafrabad taluka of Amreli district. The data further revealed that the lowest mean value of ESP 12.06 was obtained in the soils of Una taluka of Gir Somnath district and the highest mean value of ESP 21.13 was registered in the soils of Rajula taluka of Amreli district. Overall mean value of ESP content in soils of Southern Saurashtra coastal region was 17.44, 15.82, 15.53 and 14.91 at 0-5, 5-10, 10-15 and 15-20 km distance from seacoast. Similar results were also observed for soils of North-West Agro Climatic Zone of Gujarat by Rajput and Polara (2012) [16].

### 3.4 Soluble sodium percentage (SSP)

The values of SSP estimated from the collected soil samples are given in Table 3.4. In Bhavnagar district overall mean value for SSP was 35.96 with maximum value of 50.91 at 15 to 20 km distance and minimum value of 26.05 at 5 to 10 km distance from sea coast. In Amreli district maximum SSP 48.52 was at 15 to 20 km distance and minimum SSP 31.39 was found at 0 to 5 km distance from sea coast with overall mean 39.67. In Gir Somnath district maximum and minimum values of SSP were observed 45.94 and 25.66 at 10 to 15 km distance and at 0 to 5 km distance from sea coast, respectively with overall mean value of 36.44. The overall mean for SSP in Junagadh district was 33.41 with maximum value of 38.72 at 15 to 20 km distance and minimum value of 29.02 at 0 to 5 km distance from sea coast. The lowest SSP value 25.66 was recorded in the soils of Sutrapada taluka of Gir Somnath district; whereas highest values of SSP 50.91 was recorded in Bhavnagar taluka of Bhavnagar. The data further revealed that the lowest mean value of SSP 15.69 was obtained in the soils of Veraval taluka of Gir Somnath district and the highest mean value of SSP 40.19 was registered in the soils of Jafrabad taluka of Amreli district. The result also revealed

that the overall mean value of SSP was increased with increase in distance from sea coast. Overall mean value of SSP content in soils of Southern Saurashtra coastal region was 33.75, 35.20, 37.06 and 39.72 at 0-5, 5-10, 10-15 and 15-20 km distance from seacoast. Similar results were also observed for soils of North-West Agro Climatic Zone of Gujarat by Rajput and Polara (2012) [16].

### 3.5 Sodium absorption ratio (SAR)

The values of SAR estimated from the collected soil samples are given in Table 3.5. In Bhavnagar district overall mean value for SAR was 2.12 with maximum value of 3.38 at 10 to 15 km distance and minimum value of 1.27 at 15 to 20 km distance from sea coast. In Amreli district maximum SAR 2.73 was at 0 to 5 km distance and minimum SAR 1.62 was found at 15 to 20 km distance from sea coast with overall mean 2.26. In Gir Somnath district maximum and minimum values of SAR were observed 2.70 and 1.52 at 0 to 5 km distance and at 15 to 20 km distance from sea coast, respectively with overall mean value of 2.21. The overall mean for SAR in Junagadh district was 1.90 with maximum value of 2.44 at 0 to 5 km distance and minimum value of 1.50 at 10 to 15 km distance from sea coast. The lowest SAR value 1.27 was recorded in the soils of Ghogha taluka of Bhavnagar district; whereas highest values of SAR 3.38 was recorded in Bhavnagar taluka of Bhavnagar. The data further revealed that the lowest mean value of SAR 1.71 was obtained in the soils of Mangrol taluka of Junagadh district and the highest mean value of SAR 2.36 was registered in the soils of Jafrabad taluka of Amreli district. Overall mean value of SAR content in soils of Southern Saurashtra coastal region was 2.28, 2.15, 2.09 and 1.96 at 0-5, 5-10, 10-15 and 15-20 km distance from seacoast. Similar results were also observed for soils of North-West Agro Climatic Zone of Gujarat by Rajput and Polara (2012) [16].

**Table 3:** Taluka wise range and mean values of soil ESP in different districts of Southern Saurashtra region

Distance from sea coast (km)	0 to 5		5 to 10		10 to 15		15 to 20		Overall Mean
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
<b>Taluka</b>									
<b>Bhavnagar district</b>									
Ghogha	11.48-17.13	14.22	12.19-17.28	14.94	14.14-16.64	15.50	14.40-22.89	18.50	16.00
Bhavnagar	12.40-22.79	15.32	10.67-17.23	13.87	5.34-16.72	9.70	7.84-12.52	10.19	12.48
Mahuva	14.87-17.53	16.43	11.87-17.18	15.13	10.52-16.20	14.78	12.55-15.77	14.53	15.22
Talaja	16.57-17.64	17.08	9.47-17.05	13.31	8.30-13.99	11.98	8.74-15.43	12.53	13.50
Mean	11.48-22.79	15.76	9.47-17.28	14.31	5.34-16.72	12.99	7.84-22.89	13.94	14.30
<b>Amreli district</b>									
Rajula	23.92-24.99	24.68	19.63-22.24	21.37	18.50-20.83	19.91	16.95-21.45	19.01	21.13
Jafrabad	22.82-31.53	25.96	19.96-22.79	21.40	17.89-20.18	19.01	15.38-17.41	16.72	20.77
Mean	22.82-31.53	25.32	19.63-22.79	21.39	17.89-20.83	19.46	15.38-21.45	17.87	20.95
<b>Gir Somnath district</b>									
Sutrapada	13.81-16.92	15.36	12.10-14.81	14.02	13.52-17.54	14.98	13.75-16.65	15.17	14.95
Kodinar	13.76-14.09	13.93	13.33-14.63	14.14	13.52-19.73	15.23	10.47-15.68	12.86	14.11
Una	11.79-12.74	12.28	11.30-13.26	11.88	10.37-12.49	11.60	12.09-13.09	12.49	12.06
Veraval	15.90-17.49	16.78	13.62-16.73	14.94	15.72-17.08	16.42	12.42-17.72	16.10	12.69
Mean	11.79-17.49	14.59	11.30-16.73	13.75	10.37-19.73	14.56	10.47-17.72	14.16	14.29
<b>Junagadh district</b>									
Mangrol	13.08-15.84	14.53	14.82-15.83	15.54	15.59-17.51	16.78	10.94-18.35	13.90	15.24
Malia	12.37-15.55	13.64	11.59-13.15	12.16	12.71-13.94	13.46	11.92-15.52	13.47	13.18
Mean	12.37-15.84	14.09	11.59-15.83	13.85	12.71-17.51	15.12	10.94-18.35	13.69	14.21
Overall Mean	11.48-31.53	17.44	9.47-22.79	15.82	5.34-20.83	15.53	7.84-22.89	14.91	15.93

**Table 4:** Taluka wise range and mean values of soil SSP in different districts of Southern Saurashtra region

Distance from sea coast (km)	0 to 5		5 to 10		10 to 15		15 to 20		Overall Mean
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
<b>Taluka</b>									
<b>Bhavnagar district</b>									
Ghogha	30.29-32.88	31.79	28.90-33.95	32.01	29.64-39.79	34.05	26.99-43.40	35.32	33.47
Bhavnagar	30.61-35.82	33.44	30.47-37.41	33.02	33.29-49.77	40.83	37.35-50.91	44.63	37.59
Mahuva	31.36-38.27	35.81	36.37-39.66	38.33	34.32-42.71	38.20	33.61-43.24	40.19	38.13
Talaja	33.59-35.88	34.77	26.05-34.40	32.19	33.13-36.67	34.43	28.78-42.35	36.83	34.66
Mean	30.29-38.27	33.95	26.05-39.66	33.89	29.64-49.77	36.88	26.99-50.91	39.24	35.96
<b>Amreli district</b>									
Rajula	31.39-35.93	33.68	37.51-39.85	38.49	39.90-41.88	41.14	38.24-46.47	42.48	39.15
Jafrabad	36.29-37.39	37.02	37.15-38.34	37.82	37.69-43.17	40.75	42.65-48.52	45.16	40.19
Mean	31.39-37.39	35.35	37.15-39.85	38.15	37.69-43.17	40.94	38.24-48.52	43.82	39.67
<b>Gir Somnath district</b>									
Sutrapada	25.66-31.62	28.29	29.39-33.17	31.95	31.57-35.89	34.45	31.41-38.70	33.83	31.95
Kodinar	36.71-37.92	37.44	37.73-40.06	38.86	34.58-45.94	39.37	39.74-45.84	43.34	39.85
Una	32.47-33.89	33.25	33.12-38.22	35.97	37.73-40.76	39.37	38.73-40.95	40.21	37.20
Veraval	33.46-34.89	34.08	34.84-39.08	37.05	36.17-37.95	36.93	37.94-42.36	38.99	36.79
Mean	25.66-37.92	33.27	29.39-40.06	35.96	31.57-45.94	37.53	31.41-45.84	39.09	36.44
<b>Junagadh district</b>									
Mangrol	29.02-32.55	30.63	29.82-31.70	30.79	29.55-32.19	31.05	33.95-38.72	36.53	31.65
Malia	32.17-35.85	34.24	34.07-35.97	34.79	33.55-36.36	34.71	36.19-37.39	36.95	35.17
Mean	29.02-35.85	32.43	29.82-35.97	32.79	29.55-36.36	32.88	33.95-38.72	36.74	33.41
Overall Mean	25.66-38.27	33.75	26.05-40.06	35.20	29.55-49.77	37.06	38.24-50.91	39.72	36.37

**Table 5:** Taluka wise range and mean values of soil SAR in different districts of Southern Saurashtra region

Distance from sea coast (km)	0 to 5		5 to 10		10 to 15		15 to 20		Overall Mean
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
<b>Taluka</b>									
<b>Bhavnagar district</b>									
Ghogha	2.07-2.35	2.20	1.90-2.09	1.97	1.71-2.30	1.96	1.27-2.15	1.68	1.93
Bhavnagar	2.05-2.51	2.24	1.71-2.42	1.90	1.71-3.38	2.43	1.64-2.86	2.32	2.20
Mahuva	2.07-2.55	2.34	2.08-2.56	2.33	1.76-2.77	2.18	1.57-2.26	2.04	2.22
Talaja	2.34-2.69	2.56	1.54-2.35	2.10	2.04-2.20	2.09	1.57-2.31	1.92	2.14
Mean	2.05-2.69	2.33	1.54-2.56	2.08	1.71-3.38	2.17	1.27-2.86	1.99	2.12
<b>Amreli district</b>									
Rajula	2.08-2.31	2.25	2.26-2.35	2.29	2.10-2.31	2.20	1.62-2.23	1.97	2.17
Jafrabad	2.35-2.73	2.49	2.28-2.41	2.34	2.21-2.34	2.28	2.10-2.47	2.32	2.36
Mean	2.08-2.73	2.37	2.26-2.41	2.32	2.10-2.34	2.24	1.62-2.47	2.14	2.26
<b>Gir Somnath district</b>									
Sutrapada	1.69-2.20	1.90	1.82-2.13	1.98	1.67-2.25	1.99	1.52-1.84	1.63	1.87
Kodinar	2.54-2.70	2.59	2.34-2.55	2.47	1.71-2.57	2.19	1.89-2.05	1.97	2.28
Una	2.24-2.50	2.33	2.14-2.56	2.34	2.32-2.53	2.38	2.04-2.23	2.15	2.30
Veraval	2.25-2.36	2.32	2.20-2.54	2.36	2.09-2.25	2.16	1.87-2.09	2.00	2.21
Mean	1.69-2.70	2.29	1.82-2.56	2.29	1.67-2.57	2.18	1.52-2.23	1.94	2.16
<b>Junagadh district</b>									
Mangrol	1.77-1.97	1.88	1.63-1.79	1.69	1.50-1.64	1.56	1.58-1.69	1.63	1.71
Malia	2.30-2.44	2.37	2.06-2.31	2.16	1.91-2.05	1.95	1.72-1.98	1.88	2.09
Mean	1.77-2.44	2.12	1.63-2.31	1.92	1.50-2.05	1.76	1.58-1.98	1.75	1.90
Overall Mean	1.69-2.73	2.28	1.54-2.56	2.15	1.50-3.38	2.09	1.27-2.86	1.96	2.11

#### 4. Conclusion

The value of EC<sub>e</sub>, pH<sub>s</sub>, and SAR content in soil of Bhavnagar, Amreli, Gir Somanth and Junagadh district of coastal area of Southern Saurashtra region of Gujarat decreased with increases in distance and ESP slightly decreased with increases in distance from sea coast. The value of SSP content in soil of Bhavnagar, Amreli, Gir Somanth and Junagadh district of coastal area of South Saurashtra region of Gujarat increased with increase in distance from sea coast. On the basis of soil analysis data, it can be concluded that soil EC<sub>e</sub>, ESP and SAR were found beyond their critical or marginal limit up to the distance 0 to 10 km from sea coast.

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