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Soil salinity/sodicity pattern along the distance gradient from sea coast in soils of Northern Saurashtra coastal region of Gujarat

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Abstract
Grid based 141 surface (0-15 cm) soil samples were collected from farmer's cultivated field by systematic survey, through the use of GPS at distance demarcation of 0-5, 5-10, 10-15 and 15-20 km from sea coast in Northern Saurashtra coastal region of Gujarat (Jamnagar, Devbhumi Dwarka and Porbandar district), during May, 2019. These soil samples were analyzed for determination of ECe, pHs, exchangeable cations (cmol (p+) kg^{-1}), ESP, SAR and SSP to study the salinity status of soil. The soils of Northern Saurashtra coastal region were low saline in nature and EC_e values ranged from 0.49 to 18.22 dS m^{-1} with mean value of 3.21 dS m^{-1}. The overall mean value of pH_s was 7.58 and it was ranged from 6.82 to 8.36. The average value of exchangeable sodium percentage was 12.56, suggesting relatively lower hazard of alkalinity in soils of Northern Saurashtra coastal region. The overall values of soluble sodium percentage were ranged from 33.67 to 88.38 and mean value of sodium adsorption ratio was 6.04, it was ranged from 1.15 to 21.57. About 12.06, 14.89, 9.93 and 63.12 per cent soil samples were found saline, saline-sodic, sodic and normal, respectively.
On the basis of analyzed data, it can be concluded that ECe, exchangeable cations (cmol (p+) kg^{-1}) except K^+, ESP, SSP and SAR were decreased, while pHs was slightly increased with increasing the distance from sea coast. ECe was found beyond to its critical or marginal limit up to 0 to 5 km distance from sea coast, while SSP was found beyond to its critical limit up to 20 km distance from sea coast. The highest number of samples were found under normal class followed by saline-sodic, saline and sodic.

Keywords: Saline, ECe, ESP, Saurashtra, alkalinity, sea coast

Introduction
Soil is medium for plant growth, which supplies moisture, air, nutrient and supports plant life. The life supporting system of a country and the socio-economic development of people depends upon the proper use of soil. Success in agriculture depends on the quality of soil characteristics. To meet the requirements of food, fiber, fuel, fruits for the increasing population, farm land development is often extended even to the areas unsuitable for agriculture with the shrinking of land for agriculture (Minami, 1990) [1]. Salinity in coastal groundwater is a widespread problem in many parts of India and Gujarat. Around 6.7 million ha area in India, which is around 2.1% of geographical area of the country, is salt-affected, of which 2.9 million ha is saline and the rest 3.7 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. The coastal tract of Saurashtra is about 850 km in Gujarat. Soil salinity issue through secondary salinization and saline water due to ingress of sea water in aquifer are major constraints for cultivation of crops.
In present time, salinity and alkalinity of the soils are serious problems in India as well as in Gujarat. These soils are usually supposed to be originated as a result of high water table, arid and semi-arid weather, ingress the sea, water, saline nature of barren materials, poor drainage and salt deposition through windblown particles. Better crop production in salt affected soils can be attained by if the nature and extent of salinity problems are correctly diagnosed and appropriate reclamation and management practices are adopted. Soil survey provides useful information for planning proper soil management practices, with play an important part in augmenting crop production. Information about the soil and related properties obtained from the soil survey and soil classification can help in better delineation of soil and land suitability (Sehgal, 1991) [4].

Poor performance of crops in salts affected soil may be due to excessive quantities of soluble salts and higher exchangeable sodium percentage, which consequently resulted in nutritional disorders in plants.

Material and Methods

Study had been performed in Northern Saurashtra coastal region of Gujarat by collecting soil samples from distance demarcation of 0-5, 5-10, 10-15 and 15-20 km from sea coast through use of GPS. The twenty surface soil samples were collected from each taluka *viz.* Jodiya, Jamnagar and Lalpur talukas of Jamnagar district, Khambhalia, Dwarka and Kalyanpur talukas of Devbhumi Dwarka district and Porbandar taluka of Porbandar district of Northern Saurashtra Coastal region of Gujarat during the summer season of year 2019 (Fig. 1).

Saturation paste of soil was prepared as described by Richards (1954) [5]. The extract was obtained after transferring the paste on the Buchner funnel under vacuum. These extract were utilized for determination of ECe and pHs. The exchangeable cations (Na^+, K^+, Ca^{++} and Mg^{++}) were determined by neutral normal ammonium acetate method as described by Richards (1954) [5].

The following other indices were calculated by standard formulas for categorization purpose-

1) Soluble Sodium Percentage (SSP)

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

2) Sodium Adsorption Ratio (SAR)

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

3) Exchangeable Sodium Percentage (ESP)

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

(Concentration of all cations are in me L^{-1})

Results and Discussion

ECe

The ECe of soil samples were determined by saturation extract of soil. The overall mean value of ECe of soil samples was 3.21 dS m^{-1}, which was varied widely from 0.49 to 18.22 dS m^{-1}. So, as per the classification given by Richards (1954) [5], the soils of Northen Saurashtra coastal region were lied in low saline soil. In Jamnagar district, the overall mean value of ECe was 2.20 dS m^{-1}, maximum ECe (12.04 dS m^{-1}) was found at 0 to 5 km distance from the sea coast and the minimum ECe (0.49 dS m^{-1}) was found at 15 to 20 km distance from the sea coast. In Devbhumi Dwarka district, the maximum ECe (18.22 dS m^{-1}) was found at 0 to 5 km distance from the sea coast and minimum ECe (0.54 dS m^{-1}) was found at 15 to 20 km distance from the sea coast, while overall mean value of ECe was 3.98 dS m^{-1}. In Porbandar district, overall mean value of ECe was 3.90 dS m^{-1}, maximum ECe (12.20 dS m^{-1}) was found at 0 to 5 km distance from the sea coast and minimum ECe (0.66 dS m^{-1}) was found at 15 to 20 km distance from the sea coast (Table 1 and Fig. 2). The lowest value of ECe (0.49 dS m^{-1}) was recorded in the soil samples collected from Jodiya taluka in Jamnagar district, whereas the highest value of ECe (18.22 dS m^{-1}) was found in Dwarka taluka of Devbhumi Dwarka district. The data further revealed that the lowest mean value of ECe (2.03 dS m^{-1}) was obtained from the samples of Jamnagar taluka of Jamnagar district and the highest mean value of ECe (5.56 dS m^{-1}) was registered in the samples of Dwarka taluka of Devbhumi Dwarka district. From this information we can say that the soils of Northen Saurashtra coastal region were normal to highly saline. This might be due to arid and semi-arid climate and less annual rainfall prevailed in the area. So, it is necessary to monitored soil frequently in respect to ECe.

This finding is in conformity with the findings of earlier work done for Bhavnagar district by Rajput and Polara (2012) [6] and by Wagh *et al*. (2016) [7] for Nagpur district of Maharashtra.

pH_s

The pH_s values of the soils for entire Northen Saurashtra region were ranging from 6.82 to 8.36 with mean values of 7.58 (Table 2 and Fig. 3). The values of pH_s do not differ much from the values of $pH_{2.5}$. Although, pH_s values are slightly lower than the $pH_{2.5}$ at all the times. In general, soils of Northen Saurashtra coastal region are slightly alkaline in reaction. The data revealed that the lowest mean value of pH_s (7.53) was obtained from the samples of Jodiya taluka of Jamnagar district and the highest mean value of pH_s (7.65) was found in the samples of Porbandar taluka of Porbandar district. In Jamnagar district, maximum pH_s (8.19) was found at 5 to 10 km distance from the sea coast and minimum pH_s (6.91) was found at 0 to 5 km distance from the sea coast, whereas overall mean value of pH_s was 7.57. In Devbhumi Dwarka district, maximum pH_s (8.36) was found at 15 to 20 km distance from the sea coast and minimum pH_s (6.82) was found at 0 to 5 km distance from the sea coast, while overall mean value of pH_s was 7.57. In Porbandar district, overall mean value of pH_s was 7.65, maximum pH_s (8.08) was found at 15 to 20 km distance from the sea coast and minimum pH_s (7.14) was found at 0 to 5 km distance from the sea coast.

The lowest value of pH_s (6.82) was recorded in the samples collected from Khambhalia taluka in Devbhumi Dwarka district, whereas the highest value of pHs (8.36) was found in Dwarka taluka of Devbhumi Dwarka district.

This finding is in conformity with the findings of earlier work done for Latur district of Maharashtra by Patil *et al*. (2014) [8] and for Gir Somnath district of Gujarat by Polara and Chauhan (2015) [9].

Exchangeable Cations

The mean values for exchangeable cations (ammonium acetate extractable – water soluble) were estimated from the soils of Northern Saurashtra coastal region and are presented in table 3. The Ca^{++} was the dominant exchangeable cation followed by Mg^{++}, Na^+ and K^+. The corresponding mean values of exchangeable Ca^{++}, Mg^{++}, Na^+ and K^+ were 16.96, 11.94, 4.68 and 0.46 cmol (p+) kg^{-1}, respectively.

Similar findings were also recorded by Kabaria and Polara (2006) [10] for Amreli district, by Marsonia *et al.* (2008) [11] for Porbandar district, by Rajput and Polara (2012) [6] for Bhavnagar district and by Chauhan and Polara (2015a) [12] for Gir Somnath district of Gujarat

Exchangeable Sodium Percentage (ESP)

The overall range of ESP in Nothern Saurashtra region was 4.74 to 32.14 with the mean value of 12.56. The data (Table 4) revealed that the lowest mean value of ESP (9.88) was obtained from the samples of Khambhalia taluka of Devbhumi Dwarka district and the highest mean value of ESP (14.61) was found in the samples of Porbandar taluka of Porbandar district. In Jamnagar district, maximum ESP (21.20) was found at 10 to 15 km distance from the sea coast and minimum ESP (5.41) was found at 0 to 5 km distance from the sea coast, whereas overall mean value of ESP was 12.89. In Devbhumi Dwarka district, maximum ESP (32.14) was found at 0 to 5 km distance from the sea coast and minimum ESP (4.74) was found at 15 to 20 km distance from the sea coast, while overall mean value of ESP was 12.03. In Porbandar district, overall mean value of ESP was 13.15, maximum ESP (18.81) was found at 0 to 5 km distance from the sea coast and minimum ESP (5.54) was found at 15 to 20 km distance from the sea coast. The highest value of ESP (32.14) and lowest value of ESP (4.74) were recorded in the samples collected from Dwarka taluka in Devbhumi Dwarka district. The values of ESP were beyond to its critical limit (>15) in all talukas of Northern Saurashtra coastal region except Jodiya Lalpur and taluka up to 5 km distance from sea coast.

Similar findings were also recorded by Singh and Sharma (2013) [13] for Bhatinda district of Punjab by Malavath and Mani (2014) [14] for Sivaganga district of Tamil Nadu, by Chauhan and Polara (2015a) [12] for Gir Somnath district.

Soluble Sodium Percentage (SSP)

The SSP values of the soils for entire Northen Saurashtra coastal region were ranging from 33.67 to 88.38 with mean value of 66.09 (Table 5). The data revealed that the lowest mean value of SSP (62.44) was obtained from the samples of Khambhalia taluka of Devbhumi Dwarka district and the highest mean value of SSP (68.59) was found in the samples of Jamnagar taluka of Jamnagar district. In Jamnagar district, maximum SSP (86.92) was found at 5 to 10 km distance from the sea coast and minimum SSP (54.64) was found at 15 to 20 km distance from the sea coast, whereas overall mean value of SSP was 66.60. In Devbhumi Dwarka district, maximum SSP (88.38) was found at 0 to 5 km distance from the sea coast and minimum SSP (33.67) was found at 15 to 20 km distance from the sea coast, while overall mean value of SSP was 65.18. In Porbandar district, overall mean value of SSP was 67.25, maximum SSP (82.17) was found at 10 to 15 km distance from the sea coast and minimum SSP (45.95) was found at 15 to 20 km distance from the sea coast. The lowest value of SSP (33.67) was recorded in the samples collected from Kalyanpur taluka in Devbhumi Dwarka district, whereas the highest value of SSP (88.38) was found in Dwarka taluka of Devbhumi Dwarka district. Overall the value of SSP (66.09) in coastal soils of North Saurashtra region recorded slightly higher than its safe limit (60.00).

This finding is in conformity with the findings of earlier work done for Bhavnagar district by Rajput and Polara (2012) [6], for Latur district of Maharashtra by Patil *et al*. (2014) [8] and for Gir Somnath district of Gujarat by Polara and Chauhan (2015) [12].

Sodium Adsoption Ratio (SAR)

The overall range of SAR in Nothern Saurashtra coastal region was 1.15 to 21.57 with the mean value of 6.04. The data (Table 6) revealed that the lowest mean value of SAR (4.90) was obtained from the samples of Lalpur taluka of Jamnagar district and the highest mean value of SAR (7.66) was found in the samples of Dwarka taluka of Devbhumi Dwarka district. In Jamnagar district, maximum SAR (15.04) was found at 0 to 5 km distance from the sea coast and minimum SAR (1.53) was found at 15 to 20 km distance from the sea coast, whereas overall mean value of SAR was 5.76. In Devbhumi Dwarka district, maximum SAR (21.57) was found at 0 to 5 km distance from the sea coast and minimum SAR (1.15) was found at 15 to 20 km distance from the sea coast, while overall mean value of SAR was 6.02. In Porbandar district, overall mean value of SAR was 6.89, maximum SAR (16.35) was found at 0 to 5 km distance from the sea coast and minimum SAR (2.14) was found at 15 to 20 km distance from the sea coast. The lowest value of SAR (1.15) was recorded in the samples collected from Kalyanpur taluka in Devbhumi Dwarka district, whereas the highest value of SAR (21.57) was found in Dwarka taluka of Devbhumi Dwarka district.

Similar findings were also recorded by Singh and Sharma (2013) [13] for Bhatinda district of Punjab by Malavath and Mani (2014) [14] for Sivaganga district of Tamil Nadu and by Chauhan and Polara (2015a) [12] for Gir Somnath district.

Soil Characterization

By making use of ECe and ESP criteria as initially suggested by Richards (1954) [5], the 141 soil samples collected from the Northern Saurashtra coastal region were categorized into three classes, *viz*., saline, saline-sodic and sodic soils. The soils having ECe value > 4.0 dS m^{-1} and ESP value < 15 were classified as saline, those having ECe value > 4.0 dS m^{-1} and ESP value > 15 as saline-sodic and those having ECe value < 4 dS m-1 and ESP value > 15 as sodic soils. As the samples were collected from the cultivated fields, some of the samples did not fall into the said criteria, hence samples were placed in the non-saline and non-sodic group which we called as normal soils.

Out of 141 samples, 17, 21, 14 and 89 samples were dropped as saline, saline-sodic, sodic and normal soils, respectively. About 12.06, 14.89, 9.93 and 63.12 percent soil samples were found in saline, saline-sodic, sodic and normal soil, respectively. Among the salt affected soil samples, higher number of sample falls under normal class followed by saline-sodic, saline and sodic (Table 7). After the exclusion of non-saline and non-sodic samples, the remaining 52 samples were then grouped into three different salt affected soil classes by adopting USDA norms. The distribution indicates that 32.69 per cent soil samples were falling in the saline group, 40.38 per cent into saline-sodic group and 26.92 per cent sample falls into sodic group. This amply suggests that soil salinity-sodicity is more dominant process, while soil salinity more or less equally distributed in the soils of Northern Saurashtra coastal region. The highest percentage of saline soils (35.00%) was recorded in Dwarka taluka followed by Porbandar (19.05%). Soils of Jamnagar taluka had the highest proportion of sodic soils (25.00%). The highest percentage of saline-sodic soils (30.00%) was reported in Dwarka taluka followed by Kalyanpur taluka (25.00%) and Porbandar taluka (23.81 %). These findings are supported by Kabaria and Polara (2006) [10], Marsonia *et al*. (2008) [11], Rajput and Polara (2012) [6] and Chauhan and Polara (2015a) [12].

Table 1: Talukawise range and mean values of ECe (dS m^{-1}) in different districts of Northern Saurashtra coastal region

Distance (km) / Talukas	0 to 5		5 to 10		10 to 15		15 to 20		Overall	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Jamnagar	6.12-10.40	8.26	1.09-2.31	1.80	0.74-1.66	1.11	0.52-1.03	0.76	0.52-10.40	2.03
Jodiya	3.14-12.04	6.07	1.28-3.64	2.36	0.67-1.78	1.20	0.49-1.17	0.78	0.49-12.04	2.74
Lalpur	3.02-10.27	5.86	0.90-2.72	1.47	0.57-1.46	0.95	0.56-0.81	0.68	0.56-10.27	1.83
Jamnagar District	3.02-12.04	6.44	0.90-3.64	1.88	0.57-1.78	1.07	0.49-1.17	0.74	0.49-12.04	2.20
Kalyanpur	4.03-17.03	7.80	2.17-3.98	2.96	1.12-2.40	1.55	0.54-0.97	0.74	0.54-17.03	3.30
Khambhalia	2.84-15.17	8.46	1.65-4.12	2.45	1.25-1.58	1.37	0.67-1.30	1.05	0.67-15.17	3.09
Dwarka	4.06-18.22	8.26	3.12-6.87	5.20	0.93-3.83	2.26	0.78-0.96	0.87	0.78-18.22	5.56
Devbhumi Dwarka District	2.84-18.22	8.18	1.65-6.87	3.41	0.93-3.83	1.70	0.54-1.30	0.90	0.54-18.22	3.98
Porbandar	4.10-12.20	7.49	3.05-6.27	4.02	0.91-4.09	2.47	0.66-1.28	0.92	0.66-12.20	3.90
Overall	2.84-18.22	7.55	0.90-6.87	2.71	0.57-4.09	1.51	0.49-1.30	0.84	0.49-18.22	3.21

Table 2: Talukawise range and mean values of pHs in different districts of Northern Saurashtra coastal region

Distance (km) / Talukas	0 to 5		5 to 10		10 to 15		15 to 20		Overall	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Jamnagar	6.91-7.32	7.12	7.15-8.19	7.58	7.24-8.12	7.64	7.38-8.15	7.63	6.91-8.19	7.56
Jodiya	7.01-7.31	7.20	7.04-7.84	7.45	7.46-8.05	7.74	7.53-8.11	7.86	7.01-8.11	7.53
Lalpur	7.14-7.42	7.31	7.20-7.90	7.63	7.32-7.97	7.66	7.80-7.94	7.87	7.14-7.94	7.63
Jamnagar District	6.91-7.42	7.21	7.04-8.19	7.56	7.24-8.12	7.67	7.38-8.15	7.78	6.91-8.19	7.57
Kalyanpur	6.97-7.51	7.22	7.46-7.80	7.61	7.33-7.72	7.61	7.47-7.88	7.74	6.97-7.88	7.54
Khambhalia	6.82-8.05	7.46	7.11-8.14	7.51	7.35-8.03	7.80	7.53-7.85	7.66	6.82-8.14	7.60
Dwarka	7.13-7.54	7.38	7.27-8.00	7.51	7.33-8.12	7.79	8.04-8.36	8.20	7.13-8.36	7.58
Devbhumi Dwarka District	6.82-8.05	7.35	7.11-8.14	7.54	7.33-8.12	7.72	7.47-8.36	7.79	6.82-8.36	7.57
Porbandar	7.14-7.91	7.55	7.26-7.92	7.58	7.48-8.00	7.70	7.55-8.08	7.80	7.14-8.08	7.65
Overall	6.82-8.05	7.35	7.04-8.19	7.55	7.24-8.12	7.69	7.38-8.36	7.78	6.82-8.36	7.58

Table 3: Mean values of exchangeable cations (cmol (p+) kg^{-1}) in soils of Northern Saurashtra coastal region

Distance (km)	Exchangeable Cations (cmol (p+) kg^{-1})			
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
0 to 5	18.08	12.02	6.20	0.31
5 to 10	17.95	12.75	4.83	0.37
10 to 15	16.44	12.05	4.04	0.51
15 to 20	14.60	10.39	3.39	0.73
Overall	16.96	11.94	4.68	0.46

Table 4: Talukawise range and mean values of ESP (Exchangeable Sodium Percentage) in different districts of Northern Saurashtra coastal region

Distance (km) / Talukas	0 to 5		5 to 10		10 to 15		15 to 20		Overall	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Jamnagar	15.39-18.58	16.98	6.61-14.67	10.55	9.50-21.20	13.67	15.35-18.91	17.52	6.61-21.20	13.52
Jodiya	5.41-18.53	10.41	12.30-17.94	14.08	8.95-16.98	13.34	8.92-13.73	10.88	5.41-18.53	12.38
Lalpur	8.34-14.80	11.24	12.21-18.80	13.80	9.84-15.98	12.70	9.72-13.97	12.05	8.34-18.80	12.77
Jamnagar District	5.41-18.58	11.98	6.61-18.80	12.71	8.95-21.20	13.19	8.92-18.91	13.62	5.41-21.20	12.89
Kalyanpur	15.51-30.24	20.09	6.01-15.31	11.40	6.32-8.22	7.29	7.30-8.58	7.69	6.01-30.24	11.60
Khambhalia	6.93-20.28	14.87	5.03-15.17	9.38	5.76-10.08	7.63	5.54-11.22	8.38	5.03-20.28	9.88
Dwarka	9.73-32.14	19.56	10.04-24.38	15.11	4.81-15.36	7.75	4.74-4.91	4.83	4.74-32.14	14.61
Devbhumi Dwarka District	6.93-32.14	18.67	5.03-24.38	11.66	4.81-15.36	7.51	4.74-11.22	7.48	4.74-32.14	12.03
Porbandar	12.88-18.81	15.25	13.04-15.88	14.43	11.96-16.09	13.57	5.54-11.49	8.91	5.54-18.81	13.15
Overall	5.41-32.14	16.10	5.03-24.38	12.50	4.81-21.20	11.04	4.74-18.91	10.25	4.74-32.14	12.56

Table 5: Talukawise range and mean values of SSP (Soluble Sodium Percentage) in different districts of Northern Saurashtra coastal region

Distance (km) / Talukas	0 to 5		5 to 10		10 to 15		15 to 20		Overall	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Jamnagar	64.94-74.07	69.50	63.30-86.92	72.67	60.93-74.83	67.17	58.90-68.40	62.11	58.90-86.92	68.59
Jodiya	64.29-76.31	70.81	60.15-77.12	68.87	61.52-73.86	66.35	54.64-70.34	62.74	54.64-77.12	67.62
Lalpur	58.73-82.71	73.73	53.86-74.27	66.32	53.10-71.14	60.96	44.06-59.50	53.16	44.06-82.71	63.58
Jamnagar District	58.73-82.71	71.42	53.86-86.92	69.44	53.10-74.83	64.42	44.06-70.34	59.90	54.64-86.92	66.60
Kalyanpur	68.26-72.02	70.17	57.47-77.05	65.85	63.67-78.54	71.17	33.67-65.91	48.07	33.67-78.54	64.97
Khambhalia	59.89-73.32	64.92	60.09-74.31	68.11	53.65-68.24	63.48	40.32-66.45	51.71	40.32-74.31	62.44
Dwarka	55.56-88.38	69.03	60.00-73.36	68.07	51.87-74.12	66.61	65.45-68.93	67.19	51.87-88.38	68.12
Devbhumi Dwarka District	55.56-88.38	68.43	57.47-77.05	67.43	51.87-78.54	67.67	33.67-68.93	53.20	33.67-88.38	65.18
Porbandar	65.45-80.28	75.93	55.43-71.48	62.34	60.56-82.17	72.64	45.95-65.00	56.37	45.95-82.17	67.25
Overall	55.56-88.38	70.63	53.86-86.92	67.86	51.87-82.17	66.83	33.67-70.34	56.52	33.67-88.38	66.09

Table 6: Talukawise range and mean values of SAR (Sodium Adsorption Ratio) in different districts of Northern Saurashtra coastal region

Distance (km) / Talukas	0 to 5		5 to 10		10 to 15		15 to 20		Overall	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Jamnagar	6.75-13.78	10.26	4.46-11.44	6.98	4.06-5.37	4.77	3.21-5.01	3.84	3.21-13.78	6.02
Jodiya	5.28-15.04	9.42	4.15-8.53	6.35	4.12-5.47	4.77	3.06-5.89	4.19	3.06-15.04	6.37
Lalpur	4.51-14.01	10.77	3.35-6.23	4.80	2.60-5.22	3.54	1.53-2.98	2.47	1.53-14.01	4.90
Jamnagar District	4.51-15.04	10.00	3.35-11.44	6.08	2.60-5.47	4.26	1.53-5.89	3.59	1.53-15.04	5.76
Kalyanpur	7.26-14.01	8.97	3.50-6.55	4.75	3.54-6.79	5.14	1.15-4.21	2.30	1.15-14.01	5.43
Khambhalia	5.27-10.85	7.97	4.06-7.11	5.32	2.92-5.41	4.15	1.86-4.24	2.67	1.86-10.85	4.96
Dwarka	4.66-21.57	10.04	4.30-8.33	6.65	3.10-6.53	5.14	4.26-4.86	4.56	3.10-21.57	7.66
Devbhumi Dwarka District	4.66-21.57	9.28	3.50-8.33	5.55	2.92-6.79	4.86	1.15-4.86	2.88	1.15-21.57	6.02
Porbandar	5.87-16.35	11.71	3.93-7.45	5.15	3.95-9.10	6.47	2.14-3.99	3.28	2.14-16.35	6.89
Overall	4.51-21.57	9.92	3.35-11.44	5.77	2.60-9.10	4.80	1.15-5.89	3.24	1.15-21.57	6.04

Table 7: Talukawise percentage distribution of soil samples into different categories of salt affected soils of different district of Northern Saurastra coastal region

Name of taluka	Percent distribution			
	Saline	Saline-Sodic	Sodic	Normal
Jamnagar	0.00(0)*	10.00(2)	25.00(5)	65.00(13)
Jodiya	10.00 (2)	5.00(1)	10.00(2)	75.00(15)
Lalpur	10.00(2)	0.00(0)	10.00(2)	80.00(16)
Jamnagar District	6.67(4)	5.00(3)	15.00(9)	73.33(44)
Kalyanpur	0.00(0)	25.00(5)	5.00(1)	70.00(14)
Khambhalia	10.00(2)	10.00(2)	5.00(1)	75.00 (15)
Dwarka	35.00(7)	30.00(6)	10.00(2)	25.00(5)
Devbhumi Dwarka District	15.00(9)	21.67(13)	6.67(4)	56.67(34)
Porbandar	19.05(4)	23.81(5)	4.76(1)	52.38(11)
Overall	12.06(17)	14.89(21)	9.93(14)	63.12(89)
Classification of salt affected soils (52)	32.69(17)	40.38(21)	26.92(14)	-

(*) - Values in parenthesis are number of samples

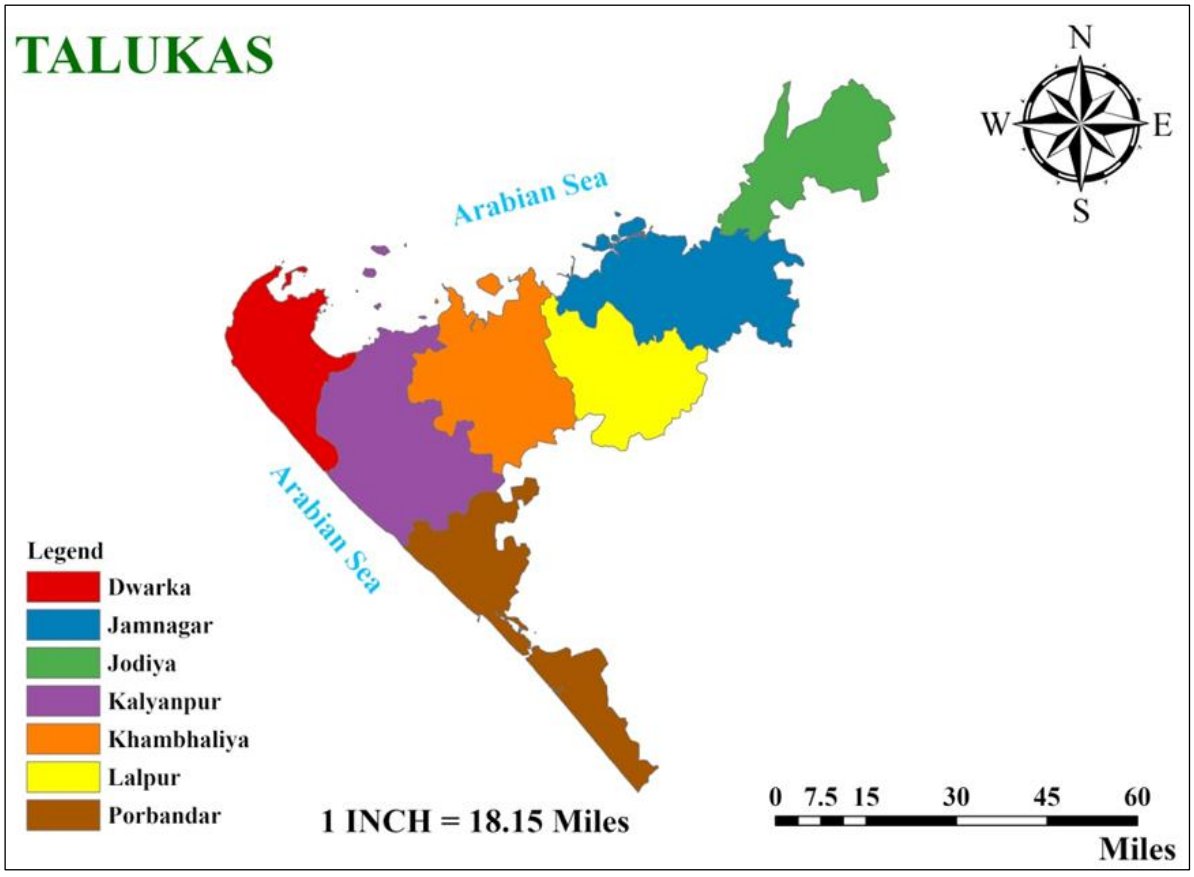

Fig 1: Map of survey talukas of Jamnagar, Devbhumi Dwarka and Porbandar district

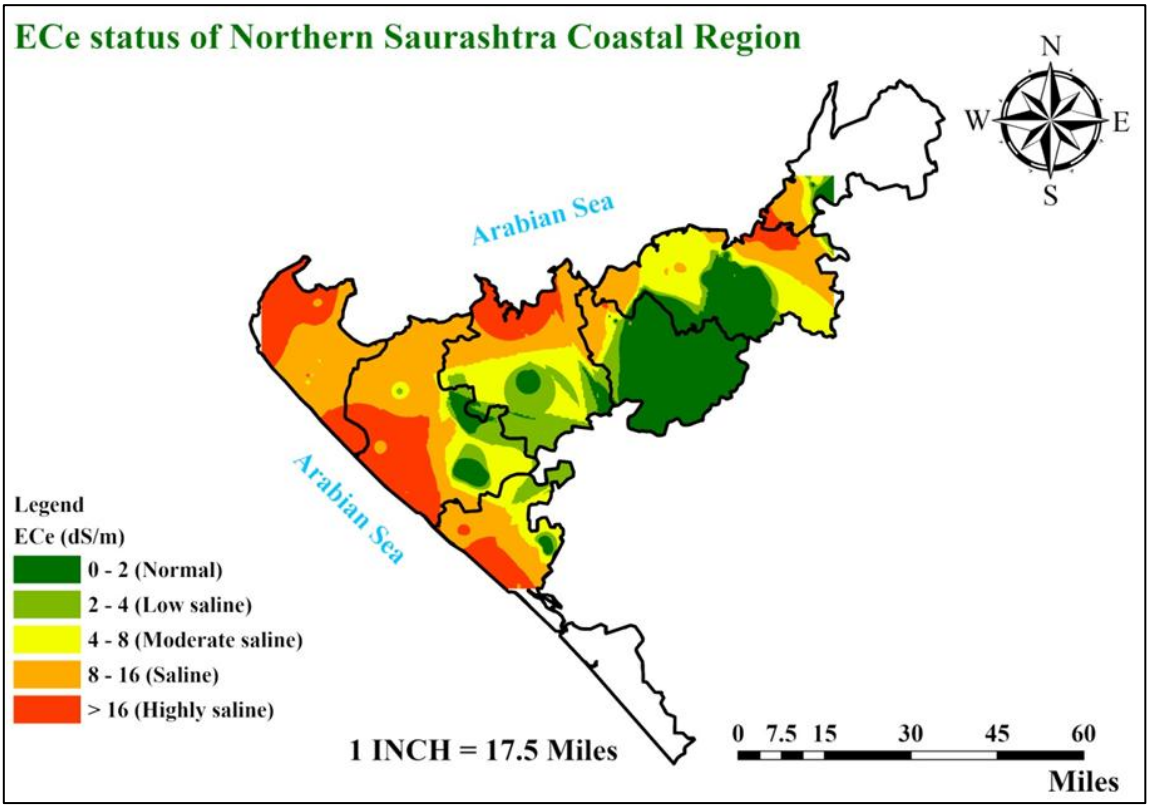

Fig 2: Map of overall ECe status in coastal soils of Northern Saurashtra region

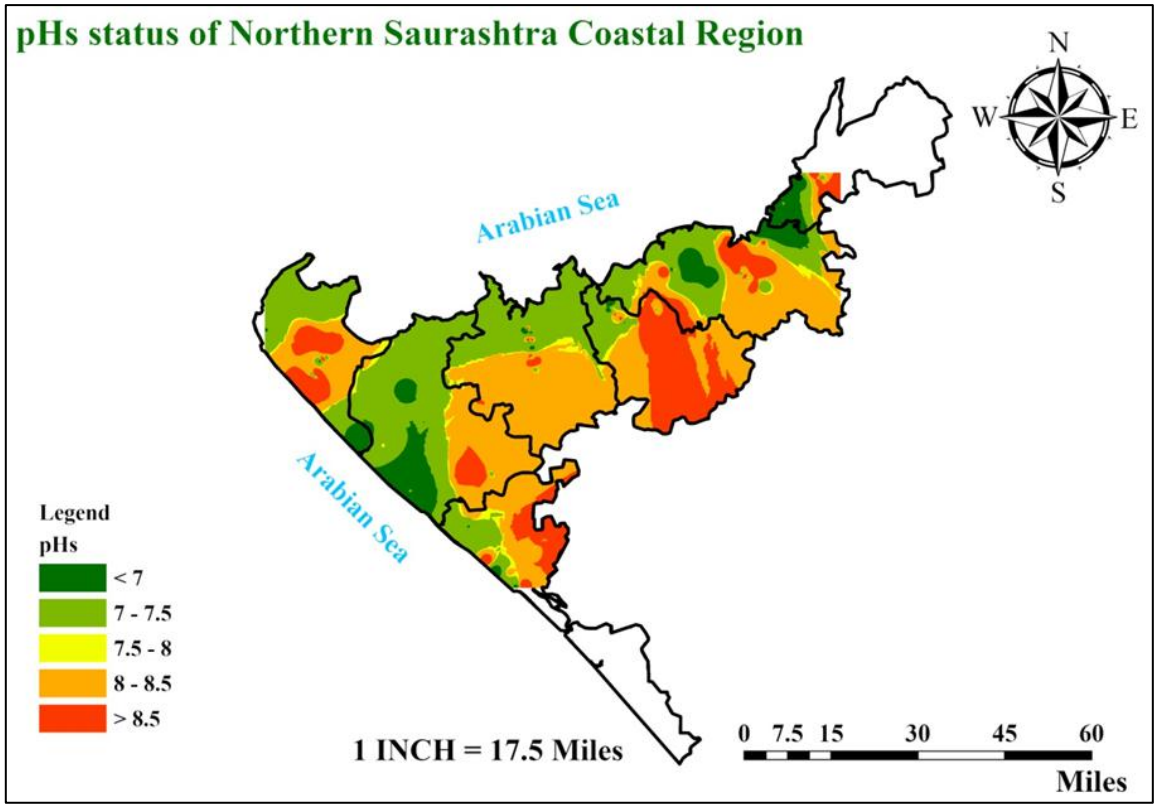

Fig 3: Map of overall pHs status in coastal soils of Northern Saurashtra region

Conclusion

On the basis of analyzed data of soil samples, collected from different districts (Jamnagar, Devbhumi Dwarka and Porbandar) of Northern Saurashtra coastal region of Gujarat, it can be concluded that salinity parameters ECe, exchangeable cations (cmol (p+) kg^{-1}) except K^{+}, ESP, SSP and SAR were decreased, while pHs was slightly increased with increasing the distance from sea coast. Soil ECe was found beyond to its critical or marginal limit up to 0 to 5 km distance from sea coast, while SSP was found beyond to its critical limit up to 20 km distance from sea coast.

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