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Nutrients pattern a long-distance gradient in coastal region soils of Southern Saurashtra of Gujarat

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Abstract

The present study was conducted to evaluate the fertility status of soils by collecting 240 surface soil samples in the year 2018-19. 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 from cultivated fields of different district of coastal region of South Saurashtra of Gujarat region. The results revealed that the available N, P₂O₅ and K₂O content in soil increased with increase in distance from sea coast. The overall mean values of available N in soil 253, 253, 283 and 301 kg ha⁻¹, available P₂O₅ in soil 15.78, 22.53, 24.21 and 19.44 kg ha⁻¹ and available K₂O in soil 313, 334, 334 and 288 kg ha⁻¹ were observed at 0 to 5 km distance from sea coast, while, the overall mean values of available N in soil 365, 322, 359 and 365 kg ha⁻¹, available P₂O₅ in soil 32.80, 34.94, 32.85 and 23.37 kg ha⁻¹ and available K₂O in soil 432, 501, 470 and 362 kg ha⁻¹ were observed at 15 to 20 km distance from sea coast in Bhavnagar, Amreli, Gir Somnath and Junagadh district, respectively. Whereas, overall mean values of soil available N, P₂O₅ and K₂O content in 0 to 20 km distance from sea coast were 308, 25.01 and 373 kg ha⁻¹, respectively.

Keywords: Sea coast, salinity, distance, available N, P₂O₅ and K₂O

1. Introduction

Soil salinity has emerged as the most significant problem of present agriculture of India. It is estimated that 175 mha 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) [3]. 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 mha), West Bengal (0.44 mha), and Rajasthan (0.38 mha) (Mandal *et al.* 2018) [10].

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; Werner *et al.*, 2013) [1, 19]. 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% 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) [11] due to severe problem of water and land salinity in the coastal regions (Rao *et al.*, 2019) [14]. Soil provides a significant source of nutrients for crop production and the growth of plants (Ashman and Puri, 2013) [4]. Again soil nutrients provide a crucial role for the sustainability of soil quality, crop production and environmental quality (Andrews *et al.*, 2004) [2].

The native coastal soils are highly argillaceous saline soils with poor porosity (Zhang *et al.*, 2015) [20], which could directly impact the soil microbial community and soil nutrient

availability (Cui *et al.*, 2016; Hu *et al.*, 2016) [5, 7]. Among the element properties, soil macro-nutrients such as N, P, K and S are the primary nutrients that dominate the properties of soil while, salinity intrusion may impact the status and distribution of these major nutrients thereby sustainability of coastal region. Nutrient deficiencies of N and P are quite common in saline soils. Micronutrients such as Cu and Zn are both widespread. As a result, the reduction of food crop production in the coastal region has significant impact on the national economy (Haque, 2006) [6]. While, salinity intrusion, contaminating soil and water, is causing significant economic and environmental loss in coastal zone of Saurashtra region of Gujarat, it is still unknown how distant this salinity has spread so far towards inland. It is critical to understand how soil salinity may affect other elemental soil nutrients that are mandatory for sustainable agricultural production in disaster prone-coastal area.

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 (21.5092° N, 71.8571° E), Amreli (21.4445° N, 71.2874° E), Gir Somnath (21.0119° N, 70.7168° E) and Junagadh district (21.3321° N, 70.3361° E) to 20 km towards inland. The distance between the sample locations was about 5 km. Twenty surface soils samples from each talukas 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 available N was determined by alkaline KMnO_4 method as described by Subbaih and Asija (1956) [17], available P_2O_5 was determined as per the methods described by Olsen *et al.* (1954) [12] and available K_2O was determined as per the methods described by Jackson (1973) [8].

3. Results and Discussion

3.1 Available N status

Taluka and district wise range and mean values of available N are given in Table 1. The overall mean for available nitrogen in Bhavnagar district was 308 kg ha^{-1} with maximum value of 509 kg ha^{-1} at 15 to 20 km distance and minimum value of N was 190 kg ha^{-1} at 5 to 10 km distance from sea coast. In Amreli district maximum N 423 kg ha^{-1} found at 15 to 20 km distance and minimum N 170 kg ha^{-1} at 5 to 10 km distance from sea coast with overall mean 273 kg ha^{-1} N. In Gir Somnath district maximum N 522 kg ha^{-1} was found at 10 to 15 km distance from sea coast and minimum N 180 kg ha^{-1} was found at 0 to 5 km distance from sea coast with overall mean was 317 kg ha^{-1} N. The overall mean for available nitrogen in Junagadh district was 335 kg ha^{-1} with maximum value of 455 kg ha^{-1} at 15 to 20 km distance and minimum 213 kg ha^{-1} at 5 to 10 km distance from sea coast. The lowest N value 170 kg ha^{-1} was recorded in the soil samples were collected from Rajula taluka in Amreli district; whereas highest values of N 522 kg ha^{-1} was recorded in Kodinar taluka of Gir Somanth. The data further revealed that the lowest mean value of N 270 kg ha^{-1} was obtained in the soils

of Rajula taluka of Amreli district and the highest mean value of N 348 kg ha^{-1} was registered in the soils of Malia taluka of Junagadh district. The data also revealed that the available N content in soil increased with increase in distance from sea coast. The overall mean values of available N in soil were 253, 253, 283 and 301 kg ha^{-1} at 0 to 5 km distance and 365, 322, 359 and 365 kg ha^{-1} at 15 to 20 km distance from sea coast in Bhavnagar, Amreli, Gir Somnath and Junagadh district, respectively. Overall mean value of available N content in soils of Southern Saurashtra coastal region was 272, 289, 319 and 353 kg ha^{-1} at 0-5, 5-10, 10-15 and 15-20 km distance from seacoast. Similar results were also reported by Rajput and Polara (2012) [13] for Bhavnagar district and for Rajkot district, for Rajasthan region Sharma *et al.* (2003) [15].

3.2 Available P_2O_5 status

The values of available P estimated from the collected soil samples are given in Table 2. In Bhavnagar district overall mean value for available P_2O_5 was observed 23.90 kg ha^{-1} with maximum and minimum values of P_2O_5 60.63 kg ha^{-1} at 10 to 15 km distance and 8.12 kg ha^{-1} at 5 to 10 km distance from sea coast. In Amreli district maximum P_2O_5 54.66 kg ha^{-1} was found at 15 to 20 km distance from sea coast and minimum P_2O_5 10.50 kg ha^{-1} was found at 10 to 15 km distance from sea coast with overall mean value of 27.05 kg ha^{-1} . In Gir Somnath district maximum P_2O_5 68.72 kg ha^{-1} was observed at 15 to 20 km distance and minimum value 14.85 kg ha^{-1} at 10 to 15 km distance from sea coast with overall mean value of 29.36 kg ha^{-1} . The overall mean for available P_2O_5 in Junagadh district was 19.74 kg ha^{-1} with maximum value of 39.50 kg ha^{-1} at 15 to 20 km distance and minimum value of 10.50 kg ha^{-1} at 10 to 15 km distance from sea coast. The lowest P_2O_5 value 8.12 kg ha^{-1} was recorded in the soil samples were collected from Bhavnagar taluka in Bhavnagar district; whereas highest values of P_2O_5 68.72 kg ha^{-1} was recorded in Veraval taluka of Gir Somanth. The data further revealed that the lowest mean value of P_2O_5 19.03 kg ha^{-1} was obtained in the soils of Malialaluka of Junagadh district and the highest mean value of P_2O_5 27.67 kg ha^{-1} was registered in the soils of Una taluka of Gir Somnath district. With increase in distance from sea coast, there was also increase in available P_2O_5 content in soil in all the district under study. The overall mean values of available P_2O_5 in soil were 15.78, 22.53, 24.21 and 19.44 kg ha^{-1} at 0 to 5 km distance and 32.80, 34.94, 32.85 and 23.37 kg ha^{-1} at 15 to 20 km distance from sea coast in Bhavnagar, Amreli, Gir Somnath and Junagadh district, respectively. Overall mean value of P_2O_5 content in soils of Southern Saurashtra coastal region was 20.49, 22.35, 25.95 and 30.99 kg ha^{-1} at 0-5, 5-10, 10-15 and 15-20 km distance from seacoast. Moreover, Haque (2006) [6] reported that nutrient deficiency of N and P are quite dominant in saline soil. Thus, it is evident that saline soils of coastal area deficient to the soil P, therefore the reports of the following researchers support the results of the present study. Similar results were also reported for soils of Bhavnagar by Rajput and Polara (2012) [13], for Latur district and Shirgire *et al.* (2018) [16] for Jamnagar district.

3.3 Available K_2O status

Taluka and district wise range and mean values of available K_2O are given in Table 3. The overall mean value for available K_2O in Bhavnagar district was 379 kg ha^{-1} with maximum 773 kg ha^{-1} at 15 to 20 km distance and minimum 178 kg ha^{-1} at 0 to 5 km distance from sea coast. In Amreli

district maximum value of available K_2O was observed 877 $kg\ ha^{-1}$ at 15 to 20 km distance with minimum value of 199 $kg\ ha^{-1}$ at 10 to 15 km distance from sea coast with overall mean value of 393 $kg\ ha^{-1}$. In Gir Somnath district maximum value of available K_2O 935 $kg\ ha^{-1}$ was recorded at 10 to 15km distance and minimum value 182 $kg\ ha^{-1}$ at 0 to 5 km distance from sea coast with overall mean 397 $kg\ ha^{-1}$. The overall mean for available potassium in Junagadh district was 322 $kg\ ha^{-1}$ with maximum value of available K_2O 505 $kg\ ha^{-1}$ was observed at 15 to 20 km distance and minimum value of 208 $kg\ ha^{-1}$ at 0 to 5 km distance from sea coast. The lowest value of available K_2O 178 $kg\ ha^{-1}$ was recorded in the soil samples were collected from Bhavnagar taluka of Bhavnagar district; whereas highest values of available K_2O 935 $kg\ ha^{-1}$ was recorded in Veraval taluka of Gir Somanth. The data further revealed that the lowest mean value of K_2O 277 $kg\ ha^{-1}$ was

obtained in the soils of Malia taluka of Junagadh district and the highest mean value of K_2O 465 $kg\ ha^{-1}$ was registered in the soils of Una taluka of Gir Somnath district. The result also indicated that the increase in distance from sea coast there was increased in availability of potassium content in soils of all the district. The overall mean values of available K_2O in soil were 313, 334, 334 and 318 $kg\ ha^{-1}$ at 0 to 5 km distance and 432, 501, 470 and 362 $kg\ ha^{-1}$ at 15 to 20 km distance from sea coast in Bhavnagar, Amreli, Gir Somnath and Junagadh district, respectively. Overall mean value of K_2O content in soils of Southern Saurashtra coastal region was 318, 340, 391 and 442 $kg\ ha^{-1}$ at 0-5, 5-10, 10-15 and 15-20 km distance from seacoast. Similar results were also reported by Timbadia and Maliwal (2000) ^[18] for Amreli District, Rajput and Polara (2012) ^[13] for Bhavnagar district.

Table 1: Taluka wise range and mean values of soil available nitrogen ($kg\ ha^{-1}$) of Southern Saurashtra region

Distance (km)	0 to 5		5 to 10		10 to 15		15 to 20		Overall Mean
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
Bhavnagar									
Ghogha	257-321	289	263-327	297	232-370	321	259-509	404	334
Bhavnagar	207-296	249	212-390	276	257-463	340	320-410	351	299
Mahuva	201-250	226	249-323	300	232-423	313	318-490	380	308
Tadaja	230-278	248	190-321	264	245-410	318	273-441	326	291
Bhavnagar Mean		253		284		323		365	308
Amreli									
Rajula	227-295	254	170-370	263	207-337	261	213-410	294	270
Jafrabad	198-314	252	202-289	241	190-315	260	276-423	350	277
Amreli Mean		253		252		261		322	273
Gir Somnath									
Sutrapada	183-314	259	243-421	314	259-451	336	290-458	388	319
Kodinar	263-332	298	223-315	263	232-522	371	325-439	368	326
Una	180-337	259	223-330	283	229-455	345	234-423	338	305
Veraval	254-361	315	195-345	267	216-431	326	241-383	340	311
Gir Somnath Mean		283		282		344		359	317
Junagadh									
Mangrol	245-392	299	213-439	315	262-447	352	274-448	361	324
Malia	232-376	304	298-439	367	267-398	345	282-455	370	348
Junagadh Mean		301		341		349		365	335
Overall Mean		272		289		319		353	308

Table 2: Talukawise range and mean values of soil available P_2O_5 ($kg\ ha^{-1}$) of Southern Saurashtra region

Distance (km)	0 to 5		5 to 10		10 to 15		15 to 20		Overall Mean
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
Bhavnagar									
Ghogha	10.85-18.10	14.95	20.22-35.42	28.52	19.42-60.63	32.64	18.25-47.31	30.55	27.44
Bhavnagar	8.52-20.12	15.57	8.12-20.90	14.75	12.60-33.20	20.60	22.90-40.21	30.42	19.64
Mahuva	8.68-20.11	14.67	8.71-27.85	16.87	20.78-38.33	27.07	30.10-51.32	40.80	25.30
Tadaja	11.52-22.21	17.94	11.12-23.99	19.48	19.24-30.00	23.92	17.06-47.55	29.44	22.90
Bhavnagar Mean		15.78		19.19		26.06		32.80	23.90
Amreli									
Rajula	18.18-37.82	28.86	23.76-30.10	26.54	22.97-42.18	31.49	31.88-54.66	39.24	32.20
Jafrabad	11.29-22.00	16.20	12.89-23.27	17.07	10.50-38.56	23.83	25.14-42.99	30.64	22.19
Amreli Mean		22.53		21.80		27.66		34.94	27.05
Gir Somnath									
Sutrapada	19.89-37.63	25.83	20.00-39.80	27.96	24.36-59.93	33.96	24.36-41.79	33.98	30.18
Kodinar	18.10-30.00	24.10	18.22-30.30	23.40	14.85-44.86	24.93	22.93-30.00	26.57	24.71
Una	16.65-27.92	22.77	19.43-31.69	24.97	22.18-52.08	32.32	24.95-38.42	31.19	27.67
Veraval	18.42-30.11	24.12	26.34-57.43	36.97	25.94-58.02	37.34	27.80-68.72	39.66	34.30
Gir Somnath Mean		24.21		28.32		32.14		32.85	29.36
Junagadh									
Mangrol	16.46-30.67	19.86	13.53-33.77	19.69	14.65-24.89	18.58	22.00-31.79	25.97	20.32
Malia	12.72-23.33	19.02	10.91-34.00	19.03	10.50-24.40	17.29	13.84-39.50	20.77	19.03

Junagadh Mean		19.44		19.36		17.93		23.37	19.74
Overall Mean		20.49		22.35		25.95		30.99	25.01

Table 3: Talukawise range and mean values of soil available K₂O (kg ha⁻¹) of Southern Saurashtra region

Distance (km) \ District	0 to 5		5 to 10		10 to 15		15 to 20		Overall Mean
	Range	Average	Range	Average	Range	Average	Range	Average	
Bhavnagar									
Ghogha	187-424	303	224-646	417	204-685	438	286-514	379	388
Bhavnagar	178-363	297	217-402	321	190-515	318	268-630	440	340
Mahuva	314-437	373	261-541	387	247-663	463	288-773	430	415
Tadaja	225-309	280	235-347	284	306-529	393	328-679	480	363
Bhavnagar Mean		313		352		403		432	379
Amreli									
Rajula	277-394	364	232-407	343	331-456	381	275-877	532	415
Jafrabad	256-351	305	255-433	332	199-685	383	346-646	470	375
Amreli Mean		334		337		382		501	393
Gir Somnath									
Sutrapada	290-443	346	231-489	368	265-467	367	253-519	370	361
Kodinar	248-426	336	255-400	329	202-644	362	324-730	469	371
Una	318-400	360	329-620	463	245-784	518	459-679	532	465
Veraval	182-371	295	190-351	281	275-935	450	221-787	510	379
Gir Somnath Mean		334		360		424		470	397
Junagadh									
Mangrol	208-486	301	269-452	360	347-478	426	323-505	437	366
Malia	241-291	275	213-300	263	260-319	281	278-301	288	277
Junagadh Mean		288		312		354		362	322
Overall Mean		318		340		391		442	373

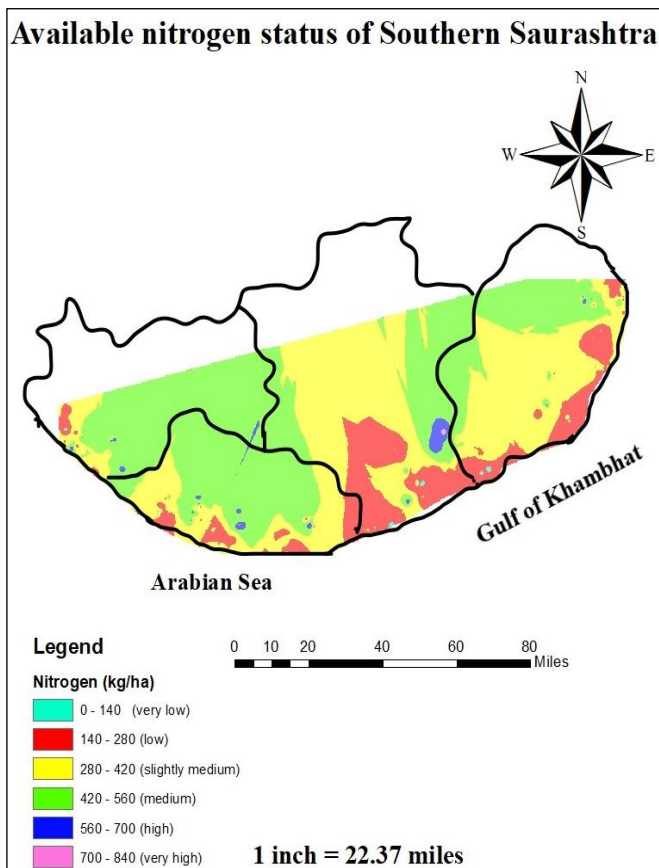


Fig 1: Available nitrogen (kg ha⁻¹) status of coastal region soils of Southern Saurashtra

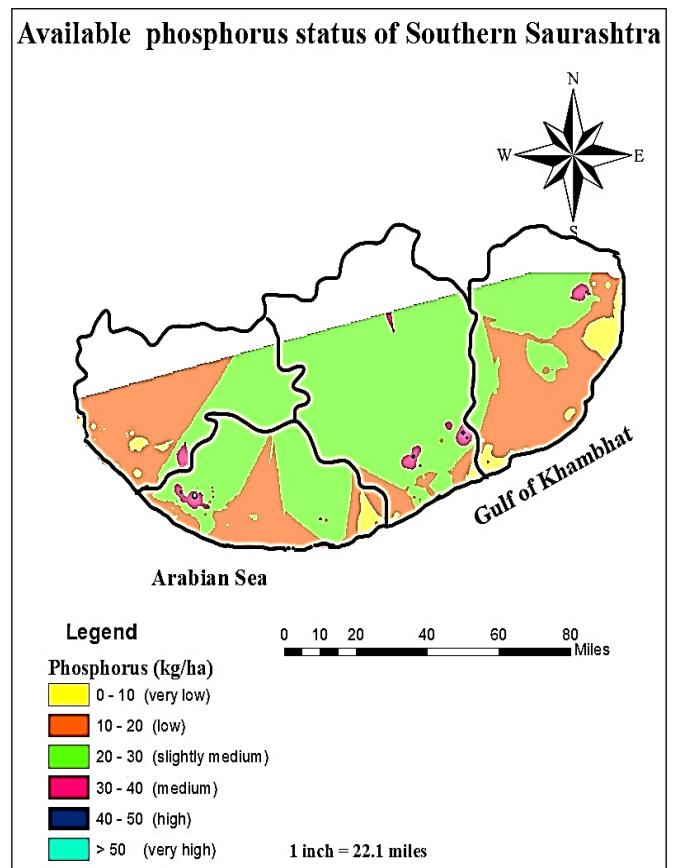


Fig 2: Available phosphorus (kg ha⁻¹) status of coastal region soils of Southern Saurashtra

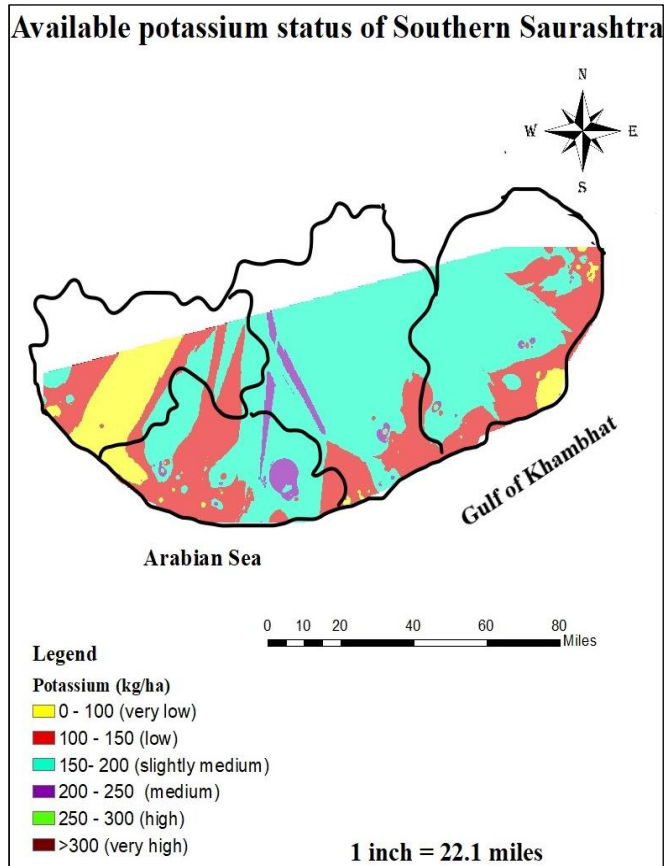


Fig 3: Available potassium (kg ha^{-1}) status of coastal region soils of Southern Saurashtra

4. Conclusion

The value of available N, P_2O_5 and K_2O content in soil of Bhavnagar, Amreli, Gir Somanth and Junagadh district of coastal area of Southern Saurashtra region of Gujarat increased with increase in distance from sea coast. Higher values of available N, P_2O_5 and K_2O were observed in 15 to 20 km distance and lower in 0 to 5 km distance from sea coast.

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