



ISSN (E): 2277- 7695  
ISSN (P): 2349-8242  
NAAS Rating: 5.23  
TPI 2021; SP-10(10): 1149-1162  
© 2021 TPI  
[www.thepharmajournal.com](http://www.thepharmajournal.com)  
Received: 22-08-2021  
Accepted: 28-09-2021

**Kiran Yadav**  
Ph. D Scholar, Department of  
Soil Science and Agricultural  
Chemistry, College of  
Agriculture, JAU, Junagadh,  
Gujarat, India

**KB Parmar**  
Associate Research Scientist,  
Directorate of research, JAU,  
Junagadh, Gujarat, India

## Assessment of available macro and micronutrients status in coastal soils along the distance gradient from coastal line of northern Saurashtra region of Gujarat

**Kiran Yadav and KB Parmar**

### Abstract

An attempt had been made in the present investigation to study the soil properties of Northern Saurashtra coastal region (Jamnagar, Devbhumi Dwarka and Porbandar district) of Gujarat by collecting 141 grid based surface (0-15 cm) soil samples from farmer's cultivated field, through the use of GPS at distance demarcation of 0-5, 5-10, 10-15 and 15-20 km from sea coast, during May, 2019 and were analyzed for different chemical properties.

The soils were low with respect to available N (204.70 kg ha<sup>-1</sup>), but medium in available P<sub>2</sub>O<sub>5</sub> (28.95 kg ha<sup>-1</sup>) and S (20.00 mg kg<sup>-1</sup>), whereas high in K<sub>2</sub>O (401.82 kg ha<sup>-1</sup>) status. The overall available (DTPA extractable) Fe, Mn, Cu and Zn varied between 2.92 to 8.92, 1.32 to 18.80, 0.13 to 7.31 and 0.06 to 3.58 with their corresponding mean values of 5.44, 7.45, 1.01 and 0.46 mg kg<sup>-1</sup>, respectively. The available B was found high and it was ranged from 0.78 to 6.61 with the mean value of 3.49 mg kg<sup>-1</sup>.

On the basis of analyzed data, it can be concluded that all the fertility parameters *viz.*, available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, S, Fe, Mn, Cu and Zn content were increased with increasing the sampling distance (0-5, 5-10, 10-15, 15-20 km) from coastal line except B.

**Keywords:** Nitrogen, phosphorus, potassium, saurashtra, coastal

### Introduction

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 for efficient irrigation water management. So, depending on the suitability of mapped agro-ecological units for asset of crops, optimum cropping patterns have to be suggested taking into consideration the present cropping system and the socio-economic condition of the farming community.

Soil fertility and plant nutrients are two closely related subjects that emphasize the forms and availability of nutrients in the soil, their movement and uptake by plant roots, and the utilization of nutrients within plants. Knowledge of soil fertility is important for the development of soil management systems that produce profitable crop yield while maintaining soil sustainability and environmental quality (Foth and Ellis, 1997) [2].

The application of high analysis NPK fertilizers in the soil having only major nutrients, the loss of micronutrients through plant uptake and leaching, the decreasing proportion of farm yard manure (FYM) and other organic manures in comparison to fertilizers and several other factors collectively contribute towards the deficiency of micronutrients in soil. In the current concept of sustainable agriculture, there is a need to understand the characteristics and inherent fertility of irrigated soils for enhancing its productivity (Singaravel *et al.*, 1996) [28].

Micronutrients are important for maintaining the soil health and also increasing the productivity of crops. The soil must supply micronutrients for desired growth of plants and synthesis of human food, increased the removal of micronutrients in consequence of adoption of high yielding varieties and intensive cropping together with shift towards high analysis NPK fertilizers has caused decline in the level of micronutrients in the soil to below normal at which productivity of crops cannot be sustained. The improper nutrient management has led to emergence of multinutrient deficiencies in the Indian soils (Sharma, 2008) [25].

The inadequate and imbalanced fertilizer use has caused widespread nutrient (N, P, K, S, Zn and B) deficiency and deterioration of soil health in many parts of India. It has been estimated that at India level 63, 42, 13 and 40% soils are deficient in N, P, K, and S respectively. Further, 49% of soils have been found to be deficient in Zn, 15 % in Fe, 3 % in Cu, 5 % in Mn, 33 % in B and 13 % Mo (Singh and Behera, 2011) [26].

**Corresponding Author**  
**Kiran Yadav**  
Ph. D Scholar, Department of  
Soil Science and Agricultural  
Chemistry, College of  
Agriculture, JAU, Junagadh,  
Gujarat, India

## Material and Methods

### Collection and preparation of soil samples

This study had been performed in Northern Saurashtra coastal region of Gujarat. Soil samples were collected 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 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).

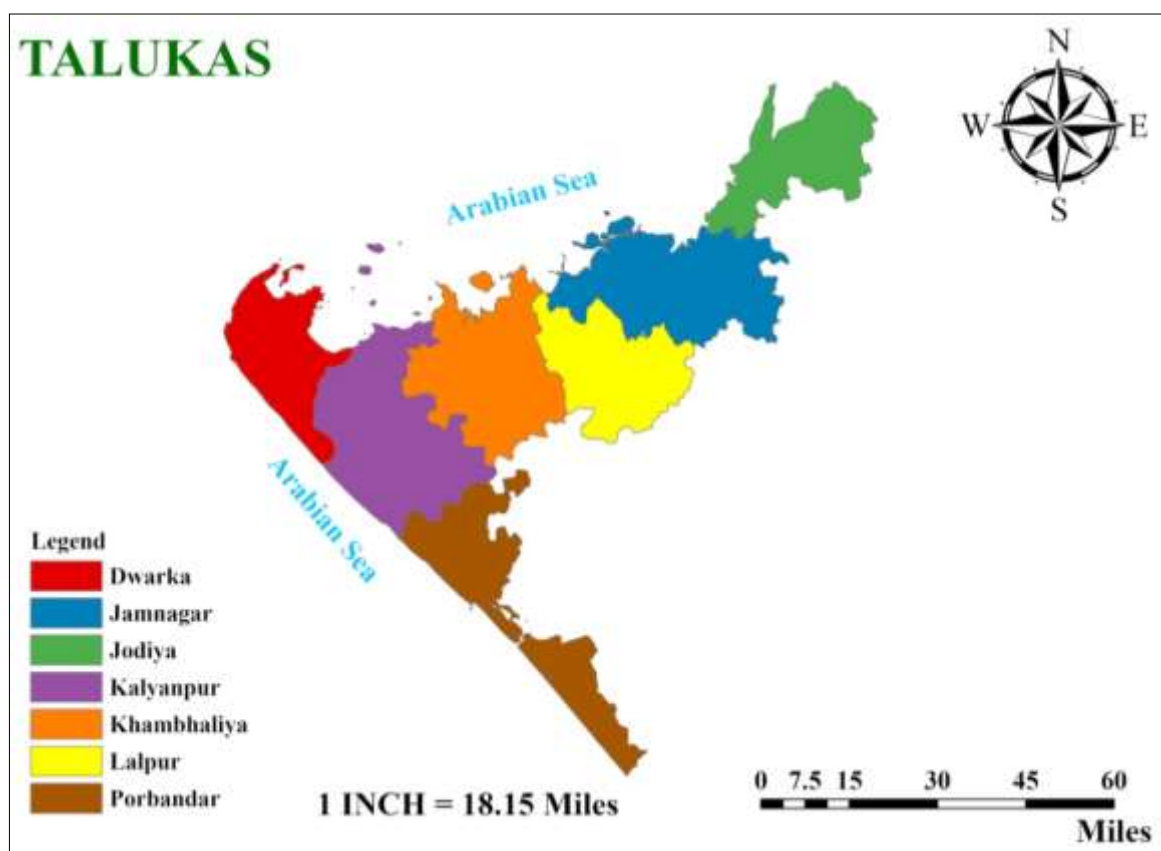


Fig 1: Map of survey talukas of Jamnagar, Devbhumi Dwarka and Porbandar district

Two kilograms of soil sample were collected in plastic bag and transfer to cotton bag from the surface soils of study area and it was label properly. The collected soil samples were air dried. Then, it was gently crushed (ground) with a wooden mortar with pestle and passed through the 2 mm sieve and chemical analysis.

Available nitrogen was determined by alkaline  $\text{KMnO}_4$  method as described by Subbiah and Asija (1956) [31], available P was estimated by Olsen reagent (Olsen *et al.* 1954) [12], available K by flame photometry as described by Jackson (1973) [4] and available S by Heat soluble as described by Williams and Stainbergs (1959) [36]. Available iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) in the soil were extracted with DTPA (Lindsay and Norvell 1978) [8], available B by Tan (1996) [33] and were determined with the help of atomic absorption spectrophotometer (AAS). The nutrient indices (NI) for available nutrients was calculated using the formula as suggested by Parker *et al.* (1951) [14]:  $\text{NI} = \frac{[(\text{Nl} \times 1) + (\text{Nm} \times 2) + (\text{Nh} \times 3)]}{\text{Nt}}$ , where NI, Nm and Nh are the number of soil samples falling in low, medium and high categories for nutrient status and are given weightage of 1, 2 and 3, respectively. The Nt is the total number of samples and classified this index as low (< 1.5), medium (1.5 to 2.5) and high (> 2.5). Simple correlation coefficients were computed between macronutrient, micronutrient content with physicochemical properties of the soils as suggested by Panse and Sukhatme (1961) [13].

## Results and discussion

### Available N status

The values of available N estimated from the collected soil samples are given in table-1. The overall range of available N in Northern Saurashtra coastal region was 80.41 to 431 kg ha<sup>-1</sup> with the mean value of 204.70 kg ha<sup>-1</sup>. The data revealed that the lowest mean value of available N (156.26 kg ha<sup>-1</sup>) was obtained from the samples of Lalpur taluka of Jamnagar district and the highest mean value of available N (250.45 kg ha<sup>-1</sup>) was found in the samples of Jamnagar taluka of Jamnagar district. In Jamnagar district, maximum available N (423.40 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available N (80.41 kg ha<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, whereas overall mean value of available N was 207.34 kg ha<sup>-1</sup> (Fig-2). In Devbhumi Dwarka district, maximum available N (431.59 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available N (122.30 kg ha<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, while overall mean value of available N was 194.22 kg ha<sup>-1</sup>. In Porbandar district, overall mean value of available N was 227.11 kg ha<sup>-1</sup>, maximum available N (428.61 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available N (126.80 kg ha<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast. The lowest value of available N (80.41 kg ha<sup>-1</sup>) was recorded in the samples collected from Lalpur taluka in Jamnagar district, whereas the highest value of available N (431.59 kg

ha<sup>-1</sup>) was found in Dwarka taluka of Devbhumi Dwarka district.

Overall 73.05 per cent samples were tested as low class (<250 kg N ha<sup>-1</sup>), 26.95 per cent samples were under medium class for available N. None of the sample was found under high class of available N (Table-4). Such lower values for available N might be because of poor addition of organic matter as well as less use of organic manures in the semi arid tract. About 70.00, 80.00 and 61.90 per cent soil samples of Jamnagar, Devbhumi Dwarka and Porbandar districts, respectively were found under low class of available N. The soils of Northern Saurashtra coastal region were deficient (<250 kg ha<sup>-1</sup>) in respect of available N upto 15 km from sea coast, while it was medium status i.e. 311.54 kg ha<sup>-1</sup> between 15 to 20 km away from sea coast. Similar results were reported for Tonk district of Rajasthan by Meena *et al.* (2006) [10], for Bhavnagar district by Rajput and Polara (2012) [23], for Janjgir district by Devdas and Srivastava (2013) [1], for Sivaganga district of Tamil Nadu by Malavath and Mani (2014) [9], by Nagaral *et al.* (2016) [11] for Northern Transitional Zone of Karnataka

and for Kapada district of Tamil Nadu by Reddy and Naidu (2016) [24].

#### Available P<sub>2</sub>O<sub>5</sub> status

Taluka wise range and mean values of available P<sub>2</sub>O<sub>5</sub> in soils of Northern Saurashtra coastal region are given in table-2 and fig.-3. In Jamnagar district, overall mean value of available P<sub>2</sub>O<sub>5</sub> was 28.58 kg ha<sup>-1</sup> whereas, maximum available P<sub>2</sub>O<sub>5</sub> (52.51 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available P<sub>2</sub>O<sub>5</sub> (15.53 kg ha<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast. In Devbhumi Dwarka district, maximum P<sub>2</sub>O<sub>5</sub> (109.60 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available P<sub>2</sub>O<sub>5</sub> (14.82 kg ha<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, while overall mean value of available P<sub>2</sub>O<sub>5</sub> was 30.97 kg ha<sup>-1</sup>. In Porbandar district, overall mean value of P<sub>2</sub>O<sub>5</sub> was 24.25 kg ha<sup>-1</sup>, maximum available P<sub>2</sub>O<sub>5</sub> (54.07 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available P<sub>2</sub>O<sub>5</sub> (12.34 kg ha<sup>-1</sup>) was found at 5 to 10 km distance from the sea coast.

**Table 1:** Talukawise range and mean values of available N (kg ha<sup>-1</sup>) 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	180.60-190.50	185.55	140.60-300.50	226.80	140.20-380.50	251.28	223.60-423.40	328.93	140.20-423.40	250.45
Jodiya	118.80-200.00	152.90	140.40-250.50	180.33	150.20-310.20	247.93	248.60-354.80	321.93	118.80-354.80	215.31
Lalpur	80.41-116.80	103.20	90.40-180.50	133.33	114.50-220.70	158.79	226.70-289.40	256.93	80.41-289.40	156.26
Jamnagar District	80.41-200.00	144.52	90.40-300.50	182.27	114.50-380.50	212.41	223.60-423.40	306.75	80.41-423.40	207.34
Kalyanpur	136.60-189.80	162.62	150.17-200.35	175.55	160.81-362.30	247.76	253.20-408.60	323.90	136.60-408.60	223.65
Khambhalia	124.60-147.09	134.39	130.63-180.50	146.79	168.99-240.76	215.25	153.16-251.62	210.56	124.60-251.62	173.94
Dwarka	122.30-162.72	139.61	134.20-184.10	158.28	158.20-252.40	204.65	403.10-431.59	417.35	122.30-431.59	185.06
Devbhumi Dwarka District	122.30-189.80	144.84	130.63-200.35	158.63	158.20-362.30	226.15	153.16-431.59	289.37	122.30-431.59	194.22
Porbandar	126.80-136.10	130.80	131.20-291.00	193.40	170.20-329.10	232.64	328.60-428.61	370.87	126.80-428.61	227.11
Overall	80.41-200.00	142.27	90.40-300.50	174.40	114.50-380.50	220.56	153.16-431.59	311.54	80.41-431.59	204.70

**Table 2:** Talukawise range and mean values of available P<sub>2</sub>O<sub>5</sub> (kg ha<sup>-1</sup>) 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	17.72-32.31	25.02	19.74-43.30	28.75	21.39-44.24	30.01	22.03-49.28	32.86	17.72-49.28	29.58
Jodiya	18.66-32.77	23.83	19.10-34.24	26.60	25.63-49.19	31.99	25.28-52.51	34.13	18.66-52.51	28.49
Lalpur	15.53-28.01	23.21	19.05-36.20	25.85	22.40-40.69	29.74	24.82-43.90	31.56	15.53-43.90	27.67
Jamnagar District	15.53-32.77	23.88	19.05-43.30	27.14	21.39-49.19	30.37	22.03-52.51	32.97	15.53-52.51	28.58
Kalyanpur	17.91-38.01	26.93	21.14-41.31	28.76	20.93-50.20	30.83	31.42-109.60	62.87	17.91-109.60	35.75
Khambhalia	21.69-27.80	24.32	22.56-34.03	27.59	22.12-41.54	28.50	23.43-44.59	31.90	21.69-44.59	28.20
Dwarka	14.82-35.98	23.97	25.72-41.82	31.60	25.97-45.34	32.97	27.87-45.66	36.77	14.82-45.66	28.96
Devbhumi Dwarka District	14.82-38.01	24.87	21.14-41.82	29.11	20.93-50.20	30.78	23.43-109.60	44.05	14.82-109.60	30.97
Porbandar	13.21-25.30	16.81	12.34-26.95	18.43	17.22-32.91	24.23	30.32-54.07	39.03	12.34-54.07	24.25
Overall	13.21-38.01	23.16	12.34-43.30	26.91	17.22-50.20	29.67	22.03-109.60	38.60	12.34-109.60	28.95

The lowest value of available P<sub>2</sub>O<sub>5</sub> (12.34 kg ha<sup>-1</sup>) was recorded in the samples collected from Porbandar taluka in Porbandar district, whereas the highest value of available P<sub>2</sub>O<sub>5</sub> (109.60 kg ha<sup>-1</sup>) was found in Kalyanpur taluka of Devbhumi Dwarka district. The data further revealed that the lowest mean value of available P<sub>2</sub>O<sub>5</sub> (24.25 kg ha<sup>-1</sup>) was obtained from the samples of Porbandar taluka of Porbandar district and the highest mean value of available P<sub>2</sub>O<sub>5</sub> (35.75 kg ha<sup>-1</sup>) was registered in the samples of Kalyanpur taluka of Devbhumi Dwarka district.

About 58.16, 40.43 and 1.42 per cent soil samples were observed as low, medium and high in available P<sub>2</sub>O<sub>5</sub>, respectively (Table-4). About 61.67, 51.67 and 66.67 per cent soil samples of Jamnagar, Devbhumi Dwarka and Porbandar

districts, respectively were found under low class of available P<sub>2</sub>O<sub>5</sub>. The status of available P<sub>2</sub>O<sub>5</sub> was increased from 23.16 to 38.00 kg ha<sup>-1</sup> in Northern Saurashtra coastal region with increased the distance from sea coast. It was deficient to marginal level. However, overall value of available P<sub>2</sub>O<sub>5</sub> in the region was found medium status i.e. 28.95 kg ha<sup>-1</sup>. Similar results were also reported by Punithraj *et al.* (2012) [20] for Hassan district of Karnataka, Srinivasan and Poongothai (2013) [30] for Tittakudi taluka of Tamil Nadu, Sudharani *et al.* (2013) [32] for Visakhapatnam district of Andhra Pradesh, Nagaral *et al.* (2016) [11] for Northern Transitional Zone of Karnataka, for Kapada district of Tamil Nadu by Reddy and Naidu (2016) [24].

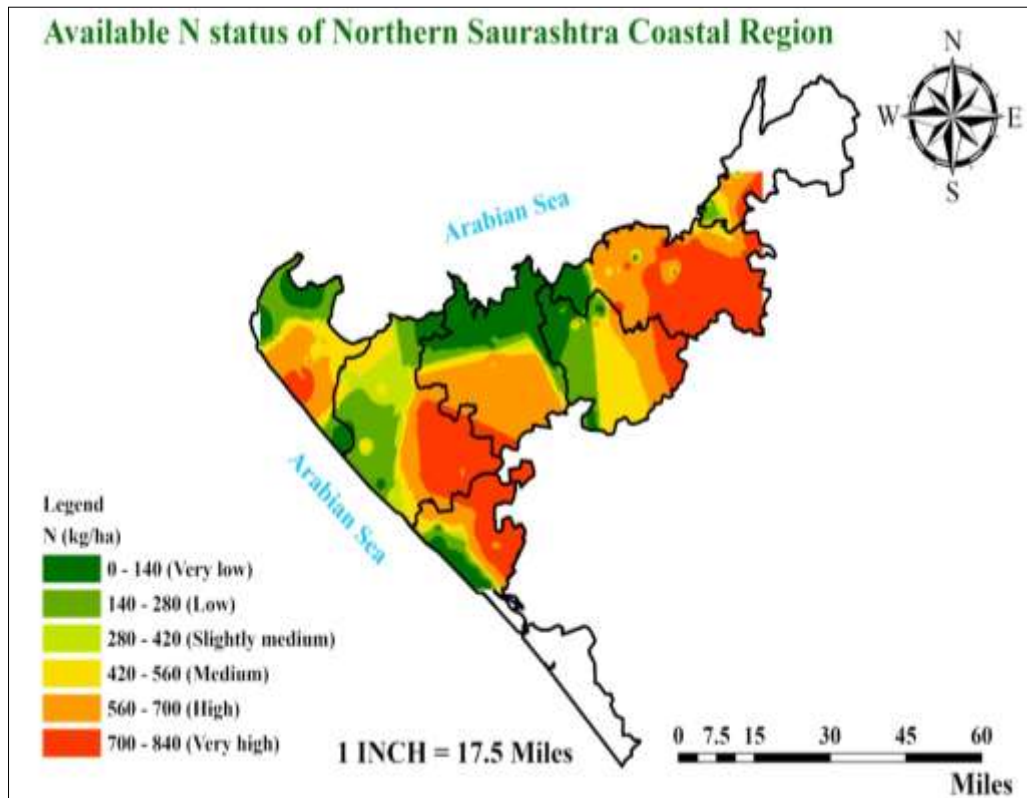


Fig 2: Map of overall available N status in coastal soils of Northern Saurashtra region

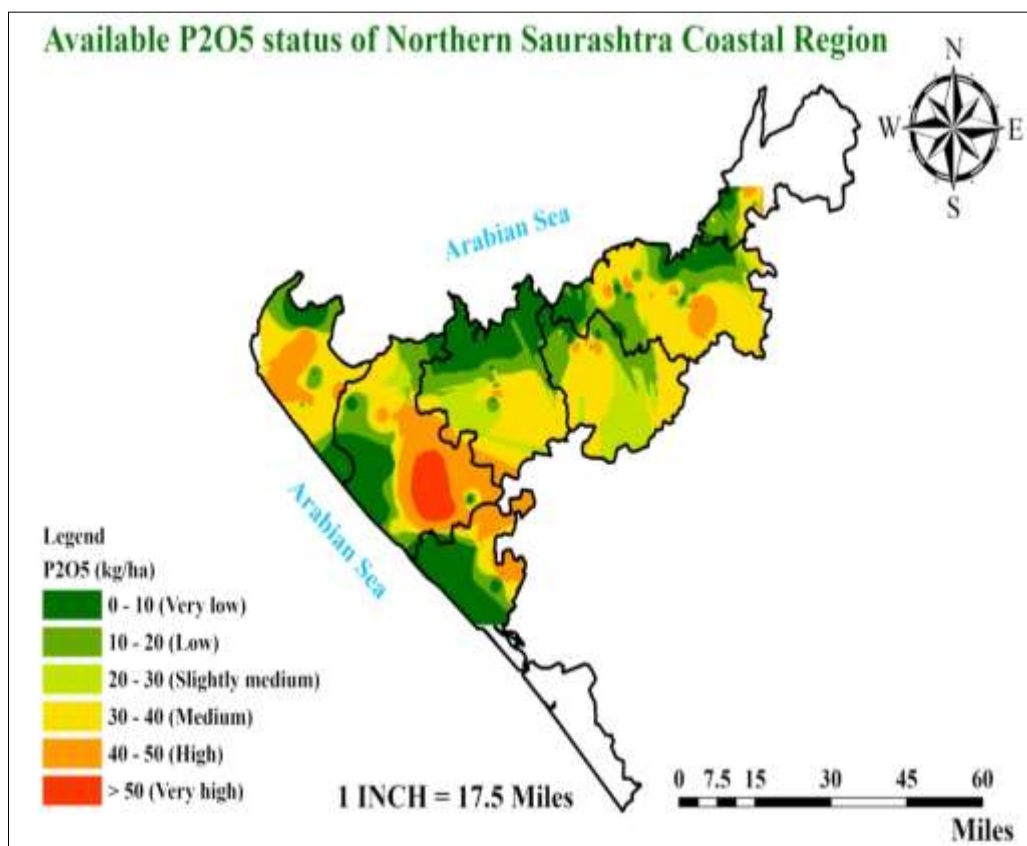


Fig 3: Map of overall available P<sub>2</sub>O<sub>5</sub> status in coastal soils of Northern Saurashtra region

**Available K<sub>2</sub>O status**

The values of available K<sub>2</sub>O estimated from the collected soil samples are given in table-3. The overall range of available K<sub>2</sub>O in Northern Saurashtra coastal region was 126.60 to 1014.20 kg ha<sup>-1</sup> with the mean value of 401.82 kg ha<sup>-1</sup>. The

data revealed that the lowest mean value of available K<sub>2</sub>O (243.94 kg ha<sup>-1</sup>) was obtained from the samples of Lalpur taluka of Jamnagar district and the highest mean value of available K<sub>2</sub>O (527.25 kg ha<sup>-1</sup>) was found in the samples of Dwarka taluka of Devbhumi Dwarka district. In Jamnagar

district, maximum available K<sub>2</sub>O (572.60 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available K<sub>2</sub>O (126.60 kg ha<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, whereas overall mean value of available K<sub>2</sub>O was 308.45 kg ha<sup>-1</sup> (Fig-4). In Devbhumi Dwarka district, maximum available K<sub>2</sub>O (935.60 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available K<sub>2</sub>O (135.00 kg ha<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, while overall mean value of available K<sub>2</sub>O was 467.21 kg ha<sup>-1</sup>. In Porbandar district,

overall mean value of available K<sub>2</sub>O was 481.80 kg ha<sup>-1</sup>, maximum available K<sub>2</sub>O (1014.20 kg ha<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available K<sub>2</sub>O (260.80 kg ha<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast. The lowest value of available K<sub>2</sub>O (126.60 kg ha<sup>-1</sup>) was recorded in the samples collected from Lalpur taluka in Jamnagar district, whereas the highest value of available K<sub>2</sub>O (1014.20 kg ha<sup>-1</sup>) was found in Porbandar taluka of Porbandar district.

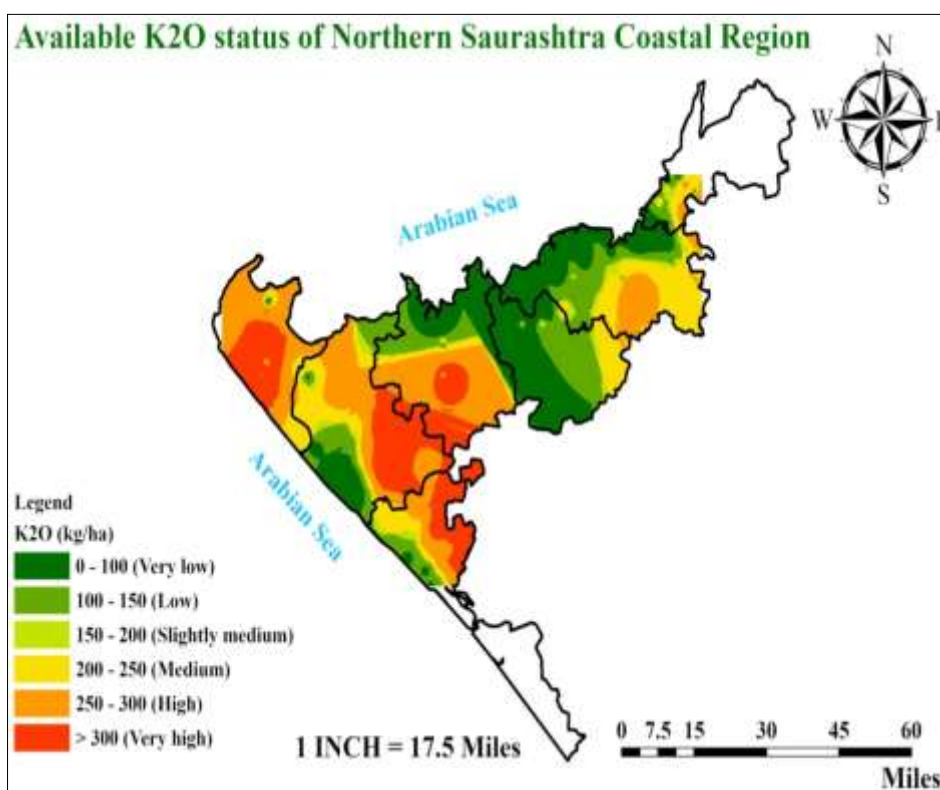
**Table 3:** Talukawise range and mean values of available K<sub>2</sub>O (kg ha<sup>-1</sup>) in different districts of Northern Saurashtra coastal region

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	170.60-220.30	195.45	187.20-321.20	257.65	287.40-415.20	352.53	472.40-524.20	496.88	170.60-524.20	327.74
Jodiya	164.50-340.90	233.12	207.80-423.30	319.87	274.40-492.90	397.45	478.10-572.60	519.65	164.50-572.60	353.66
Lalpur	126.60-190.10	167.03	145.30-246.40	194.61	201.90-370.60	263.04	372.40-405.60	391.37	126.60-405.60	243.94
Jamnagar District	126.60-340.90	205.76	145.30-423.30	257.39	201.90-492.90	326.25	372.40-572.60	476.38	126.60-572.60	308.45
Kalyanpur	135.00-294.10	203.28	264.70-439.80	338.96	423.90-541.20	494.52	578.60-935.60	817.43	135.00-935.60	447.40
Khambhalia	171.60-264.20	207.65	280.60-436.70	341.43	459.80-527.70	501.63	467.80-807.60	660.56	171.60-807.60	426.50
Dwarka	216.90-490.00	388.06	427.80-596.20	531.74	598.20-781.50	702.65	780.80-812.30	796.55	216.90-812.30	527.25
Devbhumi Dwarka District	135.00-490.00	296.64	264.70-596.20	396.68	423.90-781.50	556.01	467.80-935.60	742.33	135.00-935.60	467.21
Porbandar	260.80-321.90	285.00	345.20-409.10	377.80	405.90-677.80	517.98	614.60-1014.20	785.76	260.80-1014.20	481.80
Overall	126.60-490.00	267.86	145.30-596.20	324.89	201.90-781.50	442.23	372.40-1014.20	642.02	126.60-1014.20	401.82

Likewise to available N and P<sub>2</sub>O<sub>5</sub>, the status of available K<sub>2</sub>O was increased with increased the distance from sea coast of Northern Saurashtra coastal region. However, it was found sufficient in terms of 401.82 kg ha<sup>-1</sup> in all sampling distance of the study on the basis of overall mean value.

About 1.42, 31.21 and 67.38 per cent samples were found in low, medium and high categories of available K<sub>2</sub>O, respectively (Table-4). Such high values of available K<sub>2</sub>O might be due to the higher content of potash bearing minerals (feldspar, biotite and muscovite) which upon weathering slowly release potash. About 48.33, 80.00 and 85.71 per cent

soil samples of Jamnagar, Devbhumi Dwarka and Porbandar districts, respectively were found under high class of available K<sub>2</sub>O. Almost similar results were reported for Porbandar district by Hadiyal (2005) [3], for Amreli district by Kabaria and Polara (2006) [19], for Tonk district of Rajasthan by Meena *et al.* (2006) [10], for Junagadh district by Sojitra (2010) [29], for Bhavnagar district by Rajput and Polara (2012) [23], for Janjgir district by Devdas and Srivastava (2013) [1], for Sivaganga district of Tamil Nadu by Malavath and Mani (2014) [9] and for Gir Somnath district of Gujarat by Polara and Chauhan (2015a) [18].



**Fig 4:** Map of overall available K<sub>2</sub>O status in coastal soils of Northern Saurashtra region

**Table 4:** Talukawise percentage and number of soil samples falling in low, medium and high fertility classes for macronutrients

Name of taluka	Available N			Available P <sub>2</sub> O <sub>5</sub>			Available K <sub>2</sub> O			Available S		
	L	M	H	L	M	H	L	M	H	L	M	H
Jamnagar	50.00 (10)*	50.00 (10)	0.00 (0)	55.00 (11)	45.00 (9)	0.00 (0)	0.00 (0)	40.00 (8)	60.00 (12)	35.00 (7)	15.00 (3)	50.00 (10)
Jodiya	70.00 (14)	30.00 (6)	0.00 (0)	65.00 (13)	35.00 (7)	0.00 (0)	0.00 (0)	40.00 (8)	60.00 (12)	30.00 (6)	35.00 (7)	35.00 (7)
Lalpur	90.00 (18)	10.00 (2)	0.00 (0)	65.00 (13)	35.00 (7)	0.00 (0)	5.00 (1)	70.00 (14)	25.00 (5)	40.00 (8)	35.00 (7)	25.00 (5)
Jamnagar district	70.0 (42)	30.00 (18)	0.00 (0)	61.67 (37)	38.33 (23)	0.00 (0)	1.67 (1)	50.00 (30)	48.33 (29)	35.00 (21)	28.33 (17)	36.67 (22)
Kalyanpur	60.00 (12)	40.00 (8)	0.00 (0)	40.00 (8)	50.00 (10)	10.00 (2)	5.00 (1)	25.00 (5)	70.00 (14)	50.00 (10)	15.00 (3)	35.00 (7)
Khambhalia	95.00 (19)	5.00 (1)	0.00 (0)	65.00 (13)	35.00 (7)	0.00 (0)	0.00 (0)	20.00 (4)	80.00 (16)	25.00 (5)	20.00 (4)	55.00 (11)
Dwarka	85.00 (17)	15.00 (3)	0.00 (0)	50.00 (10)	50.00 (10)	0.00 (0)	0.00 (0)	10.00 (2)	90.00 (18)	40.00 (8)	15.00 (3)	45.00 (9)
Devbhumi Dwarka district	80.00 (48)	20.00 (12)	0.00 (0)	51.67 (31)	45.00 (27)	3.33 (2)	1.67 (1)	18.33 (11)	80.00 (48)	38.33 (23)	16.67 (10)	45.00 (27)
Porbandar	61.90 (13)	38.10 (8)	0.00 (0)	66.67 (14)	33.33 (7)	0.00 (0)	0.00 (0)	14.29 (3)	85.71 (18)	28.57 (6)	14.29 (3)	57.14 (12)
Overall	73.05 (103)	26.95 (38)	0.00 (0)	58.16 (82)	40.43 (57)	1.42 (2)	1.42 (2)	31.21 (44)	67.38 (95)	35.46 (50)	21.28 (30)	43.26 (61)

(\*)- Values in parenthesis are number of samples

#### Available S status

The values of available S estimated from collected soil samples are given in table-5 and fig.-5. The overall range of available S in Northern Saurashtra coastal region was 1.06 to 58.24 mg kg<sup>-1</sup> with mean value of 20.00 mg kg<sup>-1</sup>. The data revealed that lowest mean value of available S (13.72 mg kg<sup>-1</sup>) was obtained from the samples of Lalpur taluka and highest mean value of available S (26.28 mg kg<sup>-1</sup>) was found in samples of Khambhalia taluka. In Jamnagar district, maximum available S (48.69 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available S (1.37 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, whereas overall mean value of available S was 17.61 mg kg<sup>-1</sup>. In Devbhumi Dwarka district, maximum available S (58.24 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available S (1.07 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, while overall mean value of available S was 21.27 mg kg<sup>-1</sup>. In Porbandar district, overall mean value of available S was 23.23 mg kg<sup>-1</sup>, maximum available S (52.90 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum available S (1.06 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea

coast. The lowest value of available S (1.06 mg kg<sup>-1</sup>) was recorded in the samples collected from Porbandar taluka in Porbandar district, whereas highest value of available S (58.24 mg kg<sup>-1</sup>) was found in Khambhalia taluka of Devbhumi Dwarka district. Overall, value of available S (20.00 mg kg<sup>-1</sup>) was noted which was higher than its critical limit (10-20 mg kg<sup>-1</sup>) in soils of Northern Saurashtra coastal region but it was deficient (3.58 mg kg<sup>-1</sup>) in soils belong under 5 km distance from sea coast.

About 35.46 per cent samples were tested as low class (< 10 mg kg<sup>-1</sup>), 21.28 per cent samples were under medium class for available S and 43.26 per cent sample falls in high available S class (Table-4). Such lower status of sulphur in soils of Northern Saurashtra coastal region might be due to use of fertilizers such as urea and DAP by farmers and cultivation of S loving legume crops, resulting its deficiency. About 35.00, 38.33 and 28.57 per cent soil samples of Jamnagar, Devbhumi Dwarka and Porbandar districts, respectively were found under low class of available S. Such lower status of available sulphur was also recorded by Patel *et al.* (2016) [16] for Patan district and Reddy and Naidu (2016) [24] for Kapada district of Tamil Nadu.

**Table 5:** Talukawise range and mean values of available S (mg kg<sup>-1</sup>) 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	2.77-4.20	3.49	5.77-18.02	9.88	22.03-40.51	30.59	40.03-48.69	45.12	2.77-48.69	22.50
Jodiya	1.44-4.54	2.71	8.06-16.07	11.68	18.06-27.24	23.27	31.26-40.45	35.89	1.44-40.45	16.60
Lalpur	1.37-2.04	1.72	4.54-10.51	7.78	13.73-25.56	18.34	21.56-36.24	28.77	1.37-36.24	13.72
Jamnagar District	1.37-4.54	2.57	4.54-18.02	9.79	13.73-40.51	23.83	21.56-48.69	37.30	1.37-48.69	17.61
Kalyanpur	1.87-5.10	3.47	5.41-9.54	8.27	10.47-31.70	21.09	38.90-56.80	46.25	1.87-56.80	18.51
Khambhalia	1.92-8.47	4.46	9.12-26.74	16.20	31.75-46.53	38.33	42.07-58.24	48.22	1.92-58.24	26.28
Dwarka	1.07-10.02	4.31	18.15-26.34	22.14	28.36-36.47	31.88	46.72-56.67	51.70	1.07-56.67	19.02
Devbhumi Dwarka District	1.07-10.02	4.11	5.41-26.74	15.61	10.47-46.53	29.10	38.90-58.24	48.14	1.07-58.24	21.27
Porbandar	1.06-7.34	3.67	13.41-24.15	18.96	22.14-31.36	26.77	43.50-52.90	47.44	1.06-52.90	23.23
Overall	1.06-10.02	3.58	4.54-26.74	13.08	10.47-46.53	26.29	21.56-58.24	43.59	1.06-58.24	20.00

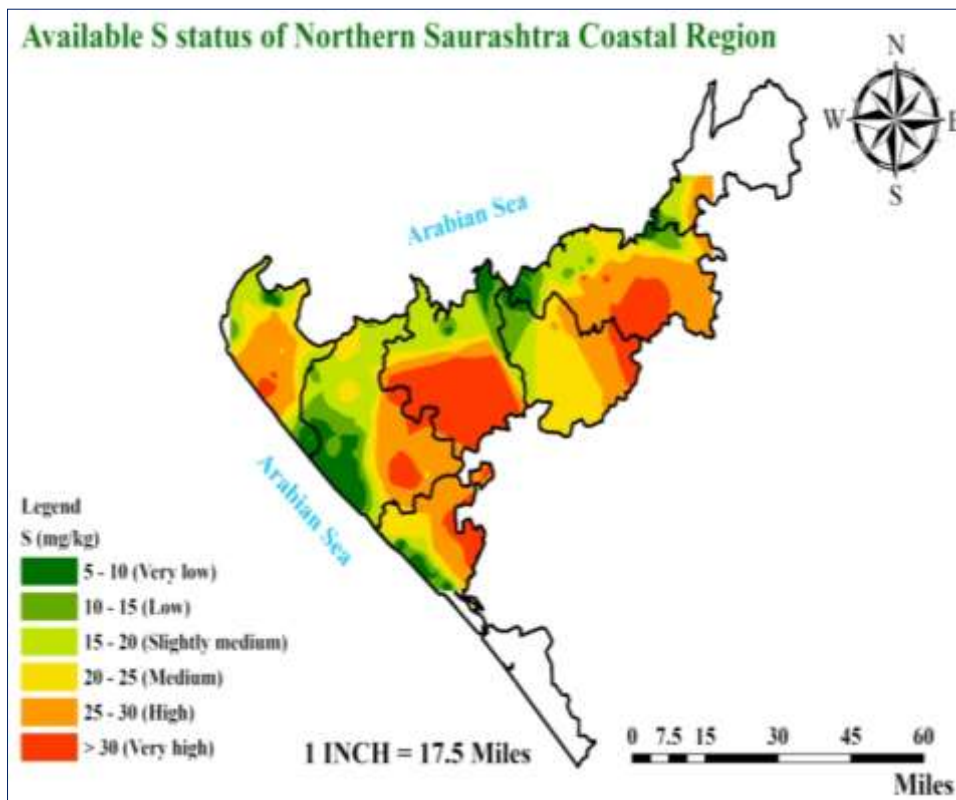


Fig 5: Map of overall available S status in coastal soils of Northern Saurashtra region

**Available micronutrients status**

Taluka wise range and mean values for available micronutrients are given in tables-6 to 10.

**DTPA Extractable Fe**

The overall Fe status of the soils of Northern Saurashtra coastal region was medium (Table-6 and Fig-6). However, it was deficient (4.69 mg kg<sup>-1</sup>) in soils of 0-5 km distance from sea coast. It was ranged from 2.92 to 8.92 mg kg<sup>-1</sup> with mean value of 5.44 mg kg<sup>-1</sup>. The data revealed that the lowest mean value of Fe (4.38 mg kg<sup>-1</sup>) was obtained from the samples of Lalpur taluka of Jamnagar district and the highest mean value of Fe (6.01 mg kg<sup>-1</sup>) was found in the samples of Khambhalia taluka of Devbhumi Dwarka district. In Jamnagar district, maximum Fe (8.43 mg kg<sup>-1</sup>) was found at 15 to 20 km

distance from the sea coast and minimum Fe (3.12 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, whereas overall mean value of Fe was 5.20 mg kg<sup>-1</sup>. In Devbhumi Dwarka district, maximum Fe (8.92 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum Fe (3.30 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, while overall mean value of Fe was 5.59 mg kg<sup>-1</sup>. In Porbandar district, overall mean value of Fe was 5.72 mg kg<sup>-1</sup>, maximum Fe (8.76 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum Fe (2.92 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast. The lowest value of Fe (2.92 mg kg<sup>-1</sup>) was recorded in the samples collected from Porbandar taluka in Porbandar district, whereas the highest value of Fe (8.92 mg kg<sup>-1</sup>) was found in Khambhalia taluka of Devbhumi Dwarka district.

Table 6: Talukawise range and mean values of available Fe (mg kg<sup>-1</sup>) 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	4.44-5.28	4.86	4.30-6.10	5.04	4.37-7.54	5.81	5.19-7.97	6.35	4.30-7.97	5.51
Jodiya	4.21-5.46	4.71	4.29-7.73	5.37	5.13-8.06	6.39	5.51-8.43	6.82	4.21-8.43	5.70
Lalpur	3.12-4.20	3.51	3.24-5.09	3.93	4.06-5.68	4.71	4.81-6.09	5.54	3.12-6.09	4.38
Jamnagar District	3.12-5.46	4.38	3.24-7.73	4.79	4.06-8.06	5.49	4.81-8.43	6.30	3.12-8.43	5.20
Kalyanpur	4.03-6.14	4.72	4.11-6.65	5.28	4.87-7.03	5.81	5.16-7.71	6.17	4.03-7.71	5.48
Khambhalia	4.37-6.57	5.38	4.61-7.14	5.84	5.12-7.74	6.15	5.53-8.92	6.65	4.37-8.92	6.01
Dwarka	3.30-6.43	4.78	4.23-6.74	5.16	4.52-7.54	5.95	5.56-7.57	6.57	3.30-7.57	5.29
Devbhumi Dwarka District	3.30-6.57	4.90	4.11-7.14	5.48	4.52-7.74	5.94	5.16-8.92	6.46	3.30-8.92	5.59
Porbandar	2.92-5.36	4.60	4.18-7.64	5.29	4.74-8.09	6.38	5.18-8.76	6.82	2.92-8.76	5.72
Overall	2.92-6.57	4.69	3.24-7.73	5.11	4.06-8.09	5.79	4.81-8.92	6.46	2.92-8.92	5.44

Overall 38.30, 61.70 and 0.00 per cent samples rated as low, medium and high in DTPA-Fe status, respectively (Table-11). About 55.00, 68.33 and 61.90 per cent soil samples of Jamnagar, Devbhumi Dwarka and Porbandar districts, respectively were found under medium class of DTPA-Fe.

Similar results were also reported for villages of northern Madhya Pradesh by Rajput *et al.* (2015) [22], Karajanagi *et al.* (2016) [6] for Malaprabha command area of Karnataka, for Patan district by Patel *et al.* (2016) [16], Wagh *et al.* (2016) [35] for Nagpur district of Maharashtra.

### DTPA Extractable Mn

The soils of Northern Saurashtra coastal region were ranged from 1.32 to 18.80 mg kg<sup>-1</sup> with the mean value of 7.45 mg kg<sup>-1</sup> in case of DTPA-Mn (Table-7 and Fig-7). In Jamnagar district, overall mean value of Mn was 7.31 mg kg<sup>-1</sup>, maximum Mn (15.48 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum Mn (1.32 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast. In Devbhumi Dwarka district, maximum Mn (18.80 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum Mn (1.88 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, while overall mean value of Mn was 7.04 mg kg<sup>-1</sup>. In Porbandar district, overall mean value of Mn was 9.04 mg kg<sup>-1</sup>, maximum Mn (15.27 mg kg<sup>-1</sup>) was found at 15

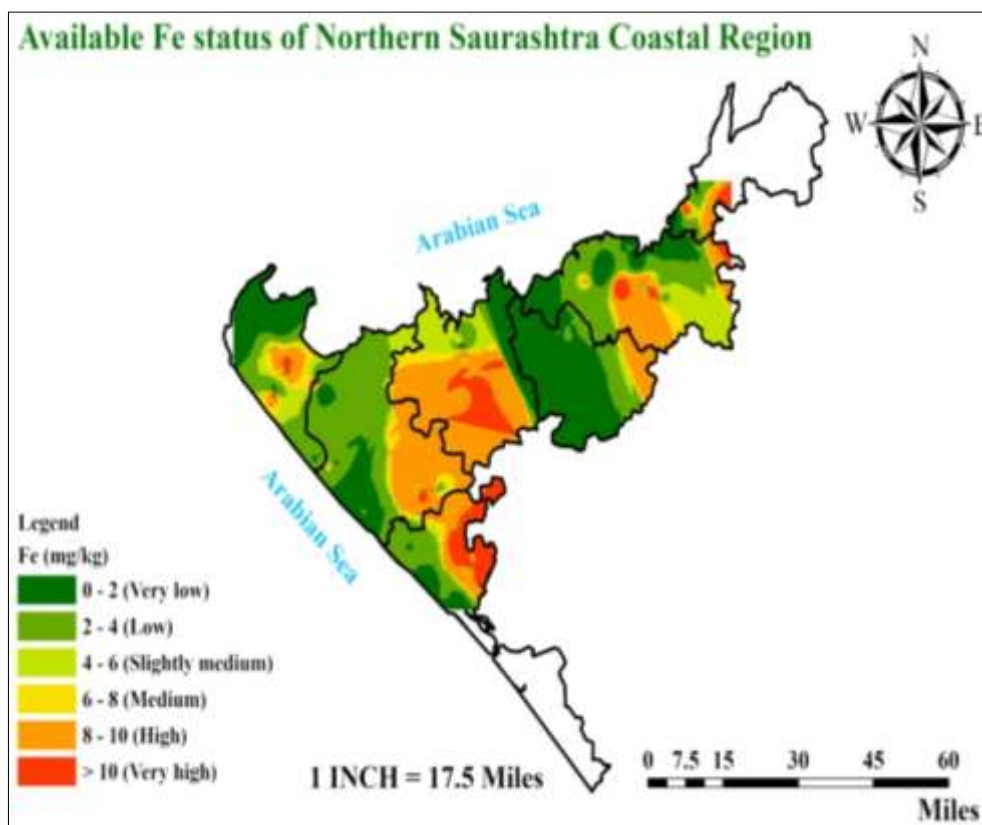
to 20 km distance from the sea coast and minimum Mn (5.02 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast. The lowest value of Mn (1.32 mg kg<sup>-1</sup>) was recorded in the samples collected from Jodiya taluka in Jamnagar district, whereas the highest value of Mn (18.80 mg kg<sup>-1</sup>) was found in Dwarka taluka of Devbhumi Dwarka district. The data further revealed that the lowest mean value of Mn (6.01 mg kg<sup>-1</sup>) was obtained from the samples of Khambhalia taluka of Devbhumi Dwarka district and the highest mean value of Mn (9.04 mg kg<sup>-1</sup>) was registered in the samples of Porbandar taluka of Porbandar district. Likewise to Fe, Mn content was also deficient (4.30 mg kg<sup>-1</sup>) in soils nearest to sea coast (upto 5 km distance) of Northern Saurashtra coastal region.

**Table 7:** Talukawise range and mean values of available Mn (mg kg<sup>-1</sup>) 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	2.92-3.90	3.41	4.15-8.18	5.60	5.59-11.80	8.96	9.43-15.48	12.17	2.92-15.48	7.70
Jodiya	1.32-4.87	3.03	4.82-6.68	5.98	8.31-10.24	9.25	9.42-11.23	10.43	1.32-11.23	6.79
Lalpur	3.25-4.44	3.96	4.15-7.61	6.06	6.28-10.73	8.22	11.37-13.40	12.26	3.25-13.40	7.43
Jamnagar District	1.32-4.87	3.38	4.15-8.18	5.87	5.59-11.80	8.73	9.42-15.48	11.56	1.32-15.48	7.31
Kalyanpur	1.88-4.68	2.87	4.93-6.89	5.74	8.02-10.93	9.36	11.32-12.95	12.36	1.88-12.95	7.43
Khambhalia	3.68-4.37	4.05	4.30-5.58	4.91	5.30-7.92	6.43	7.25-10.91	8.77	3.68-10.91	6.01
Dwarka	2.62-6.94	5.40	6.27-8.32	7.44	8.38-9.06	8.69	14.11-18.80	16.46	2.62-18.80	7.67
Devbhumi Dwarka District	1.88-6.94	4.40	4.30-8.32	5.90	5.30-10.93	8.33	7.25-18.80	11.47	1.88-18.80	7.04
Porbandar	5.02-6.59	5.54	7.28-9.50	8.38	9.05-10.60	9.55	11.67-15.27	13.40	5.02-15.27	9.04
Overall	1.32-6.94	4.30	4.15-9.50	6.16	5.30-11.80	8.69	7.25-18.80	11.87	1.32-18.80	7.45

Overall 22.70, 57.45 and 19.86 per cent samples rated as low, medium and high in DTPA-Mn status, respectively (Table-11). Similar results were also reported for for villages of northern Madhya Pradesh by Rajput *et al.* (2015) [22],

Karajanagi *et al.* (2016) [6] for Malaprabha command area of Karnataka, for Patan district by Patel *et al.* (2016) [16], Wagh *et al.* (2016) [35] for Nagpur district of Maharashtra.



**Fig 6:** Map of overall available Fe status in coastal soils of Northern Saurashtra region



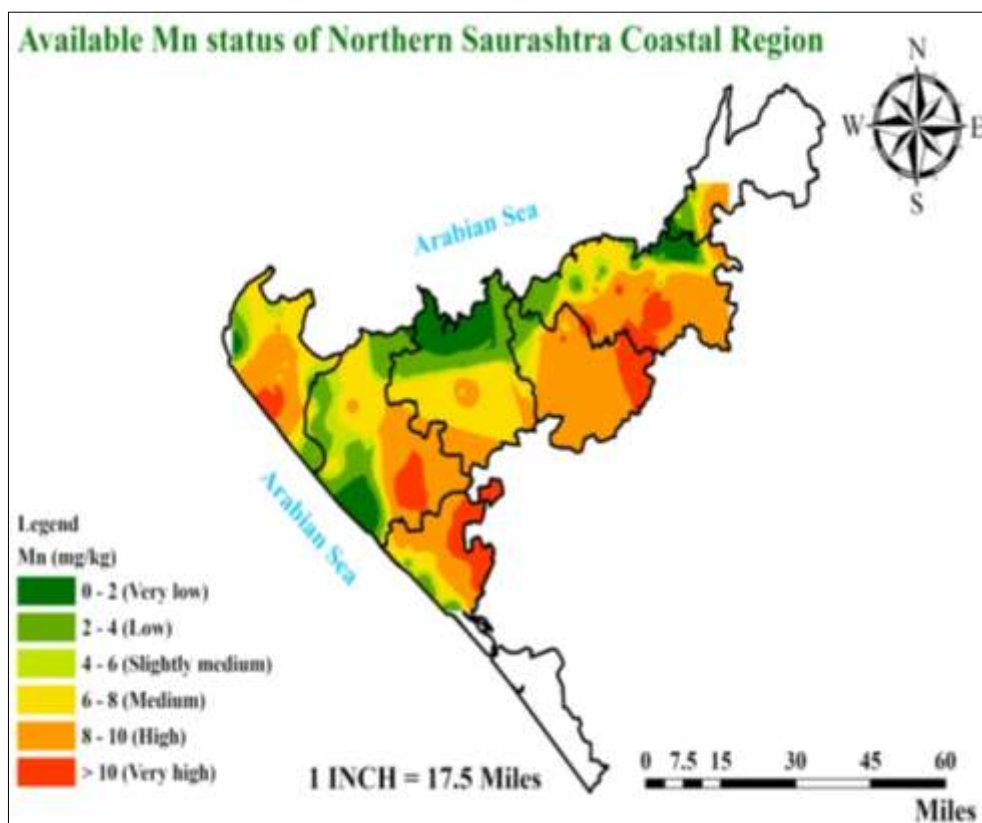


Fig 7: Map of overall available Mn status in coastal soils of Northern Saurashtra region

#### DTPA Extractable Cu

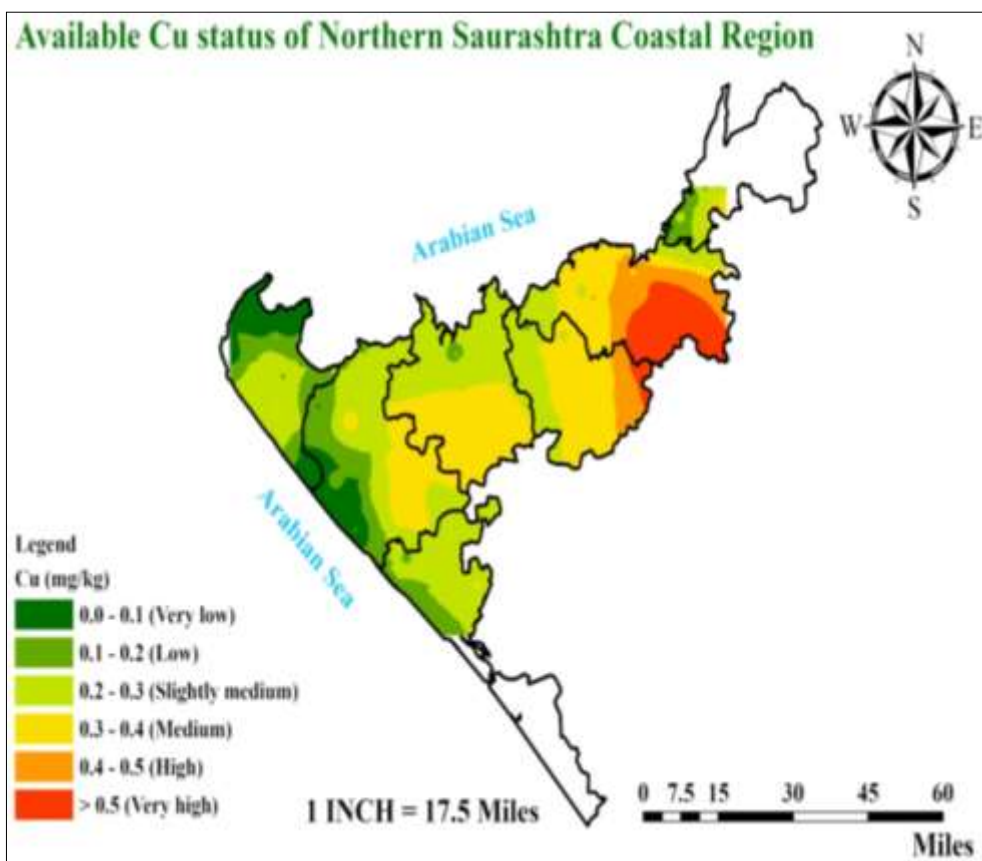
In general, the DTPA-Cu status of soils of Northern Saurashtra coastal region was high (Table-8). The DTPA-Cu ranged from 0.13 to 7.31 mg kg<sup>-1</sup> with the mean value of 1.01 mg kg<sup>-1</sup>. In Jamnagar district, the lowest (0.23 mg kg<sup>-1</sup>) Cu value was recorded in the soil samples collected from Jodiya taluka at the distance of 0 to 5 km from the sea coast and the highest (7.31 mg kg<sup>-1</sup>) Cu value was recorded in soil samples collected from the Jamnagar taluka at the distance of 15 to 20 km from the sea coast, while the overall mean value of Cu was 1.38 mg kg<sup>-1</sup> (Fig-8). In Devbhumi Dwarka district, maximum Cu (1.83 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum Cu (0.13 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, while overall mean value of Cu was 0.74 mg kg<sup>-1</sup>. In Porbandar district, overall mean value of Cu was 0.74 mg kg<sup>-1</sup>, maximum Cu (1.30 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum Cu (0.49 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast. Data further revealed that the highest (2.47 mg kg<sup>-1</sup>) and the lowest (0.57 mg kg<sup>-1</sup>) mean Cu values were registered in Jamnagar and Dwarka talukas, respectively.

Overall 1.42, 3.55 and 95.04 per cent samples were found in low, medium and high categories of DTPA-Cu, respectively (Table-11). About 96.67, 91.67 and 100.00 per cent soil samples of Jamnagar, Devbhumi Dwarka and Porbandar districts, respectively were found under high class of DTPA-Cu. Results reported in present investigation find supports from the work reported elsewhere for villages of northern Madhya Pradesh by Rajput *et al.* (2015) [22], Karajanagi *et al.* (2016) [6] for Malaprabha command area of Karnataka, for Patan district by Patel *et al.* (2016) [16] and Wagh *et al.* (2016) [35] for Nagpur district of Maharashtra.

#### DTPA Extractable Zn

The DTPA-Zn status of the soils of Northern Saurashtra coastal region was low (0.46 mg kg<sup>-1</sup>). However, it was vary with distance away from soil sampling. The soil is deficient in Zn content upto 10 km distance and marginal in soils of 10 to 20 km distance. It was ranged from 0.06 to 3.58 mg kg<sup>-1</sup> with the mean value of 0.46 mg kg<sup>-1</sup>. The data (Table-9 and Fig-9) revealed that the lowest mean value of Zn (0.21 mg kg<sup>-1</sup>) was obtained from the samples of Kalyanpur taluka of Devbhumi Dwarka district and the highest mean value of Zn (1.10 mg kg<sup>-1</sup>) was found in the samples of Jamnagar taluka of Jamnagar district. In Jamnagar district, the maximum Zn (3.58 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and the minimum Zn (0.13 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, whereas the overall mean value of Zn was 0.64 mg kg<sup>-1</sup>. In Devbhumi Dwarka district, maximum Zn (2.41 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum Zn (0.06 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast, while overall mean value of Zn was 0.33 mg kg<sup>-1</sup>. In Porbandar district, overall mean value of Zn was 0.32 mg kg<sup>-1</sup>, maximum Zn (1.02 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast and minimum Zn (0.14 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast. The lowest value of Zn (0.06 mg kg<sup>-1</sup>) was recorded in the samples collected from Dwarka taluka in Devbhumi Dwarka district.

About 78.01, 12.06 and 9.93 per cent soil samples were categorized as low, medium and high in DTPA-Zn status, respectively (Table-11). Similar results were also reported for Coastal Region of Kutch district by Patel *et al.* (2012) [15], by Srinivasan and Poongothai (2013) [30] for villages of Tittakudi taluka of Tamil Nadu, by Verma *et al.* (2013) [34] for Malkharauda block of Janjgir Champa district, Singh *et al.* (2014) [27] for Chambal region of Madhya Pradesh, by Kumar (2015) [7] for Saharsa district of Bihar.



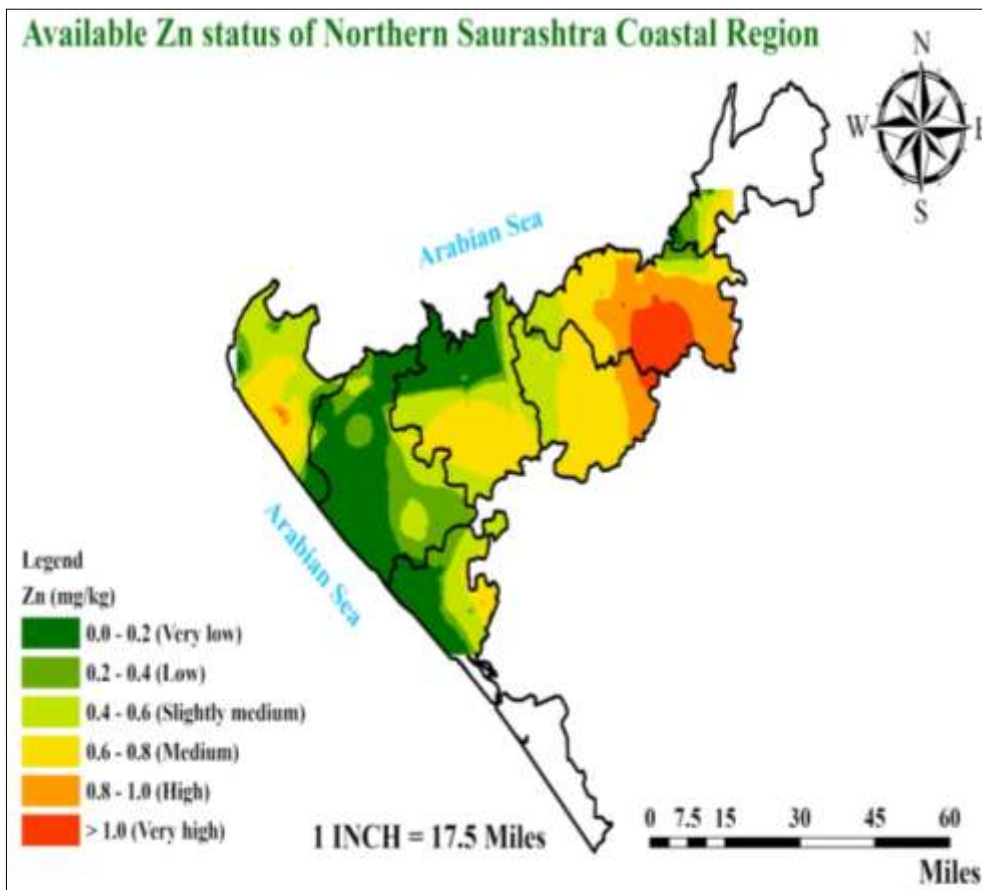
**Fig 8:** Map of overall available Cu status in coastal soils of Northern Saurashtra region

**Table 8:** Talukawise range and mean values of available Cu (mg kg<sup>-1</sup>) 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	0.62-0.83	0.73	0.71-1.66	1.21	1.96-4.29	2.72	4.27-7.31	5.49	0.62-7.31	2.47
Jodiya	0.23-0.57	0.45	0.48-0.72	0.60	0.75-0.85	0.81	0.86-2.35	1.29	0.23-2.35	0.74
Lalpur	0.39-0.75	0.59	0.76-0.87	0.81	0.91-1.22	1.03	1.24-1.46	1.34	0.39-1.46	0.93
Jamnagar District	0.23-0.83	0.55	0.48-1.66	0.89	0.75-4.29	1.57	0.86-7.31	2.83	0.23-7.31	1.38
Kalyanpur	0.25-0.55	0.45	0.46-0.62	0.55	0.79-1.13	0.90	1.20-1.39	1.30	0.25-1.39	0.78
Khambhalia	0.47-0.70	0.59	0.65-0.78	0.72	0.77-0.89	0.85	1.03-1.83	1.33	0.47-1.83	0.87
Dwarka	0.13-0.52	0.35	0.59-0.70	0.65	0.71-0.77	0.73	0.84-1.29	1.07	0.13-1.29	0.57
Devbhumi Dwarka District	0.13-0.70	0.43	0.46-0.78	0.65	0.71-1.13	0.84	0.84-1.83	1.27	0.13-1.83	0.74
Porbandar	0.49-0.64	0.56	0.60-0.76	0.65	0.72-0.87	0.80	0.81-1.30	0.97	0.49-1.30	0.74
Overall	0.13-0.83	0.49	0.46-1.66	0.77	0.71-4.29	1.18	0.81-7.31	1.85	0.13-7.31	1.01

**Table 9:** Talukawise range and mean values of available Zn (mg kg<sup>-1</sup>) 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	0.23-0.30	0.27	0.25-0.69	0.49	1.17-1.64	1.41	1.64-3.58	2.29	0.23-3.58	1.10
Jodiya	0.13-0.21	0.18	0.17-0.32	0.26	0.41-0.58	0.48	0.63-1.12	0.82	0.13-1.12	0.39
Lalpur	0.18-0.31	0.24	0.28-0.41	0.36	0.38-0.63	0.48	0.53-0.66	0.60	0.18-0.66	0.42
Jamnagar District	0.13-0.30	0.21	0.17-0.69	0.37	0.38-1.64	0.81	0.53-3.58	1.29	0.13-3.58	0.64
Kalyanpur	0.08-0.19	0.12	0.12-0.21	0.16	0.20-0.30	0.25	0.26-0.45	0.33	0.08-0.45	0.21
Khambhalia	0.13-0.19	0.16	0.15-0.29	0.22	0.27-0.34	0.30	0.35-1.11	0.67	0.13-1.11	0.33
Dwarka	0.06-0.36	0.20	0.29-0.40	0.35	0.41-0.66	0.49	0.79-2.41	1.60	0.06-2.41	0.43
Devbhumi Dwarka District	0.06-0.36	0.17	0.12-0.40	0.24	0.20-0.66	0.33	0.26-2.41	0.71	0.06-2.41	0.33
Porbandar	0.14-0.23	0.18	0.16-0.25	0.20	0.22-0.46	0.30	0.48-1.02	0.63	0.14-1.02	0.32
Overall	0.06-0.36	0.18	0.12-0.69	0.30	0.20-1.64	0.55	0.26-3.58	0.93	0.06-3.58	0.46



**Fig 9:** Map of overall available Zn status in coastal soils of Northern Saurashtra region

**Available B status**

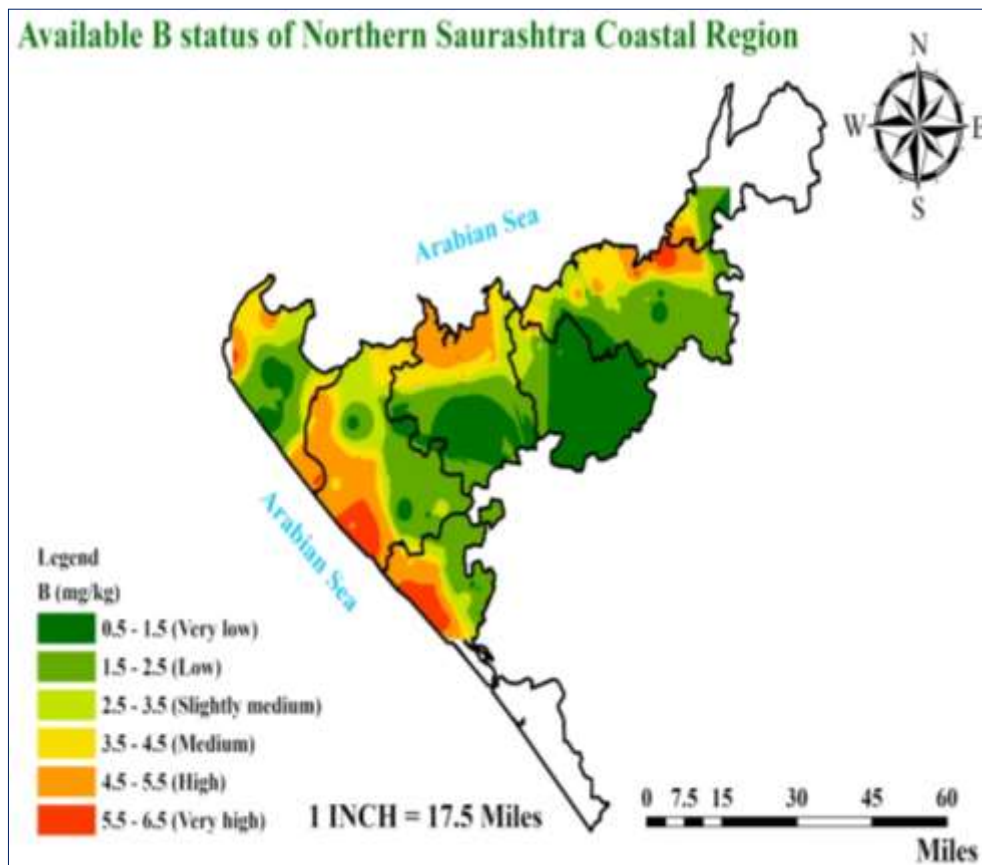
The values of available B estimated from the collected soil samples are given in the table-10 and fig.-10. The overall range of available B in Northern Saurashtra coastal region was 0.78 to 6.61 mg kg<sup>-1</sup> with the mean value of 3.49 mg kg<sup>-1</sup>. In Jamnagar district, maximum available B (5.95 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast and minimum available B (0.78 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast, whereas overall mean value of available B was 3.26 mg kg<sup>-1</sup>. In Devbhumi Dwarka district, maximum available B (6.27 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast and minimum available B (0.78 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast, while

overall mean value of available B was (3.56 mg kg<sup>-1</sup>). In Porbandar district, overall mean value of available B was (3.95 mg kg<sup>-1</sup>), maximum available B (6.61 mg kg<sup>-1</sup>) was found at 0 to 5 km distance from the sea coast and minimum available B (1.99 mg kg<sup>-1</sup>) was found at 15 to 20 km distance from the sea coast. Similar results were also reported by Rajput and Polara (2012) [23] for soils of Bhavnagar district and Rajendra *et al.* (2011) [21] for Mokala soil series of Rajasthan.

In general, all the soil fertility parameters *viz.*, available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, Fe, Mn, Cu and Zn content were increased with increasing the sampling distance (0-5, 5-10, 10-15, 15-20 km) from coastal line except B.

**Table 10:** Talukawise range and mean values of available B (mg kg<sup>-1</sup>) 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	5.17-5.34	5.26	2.09-5.26	4.36	2.36-3.80	2.94	1.77-2.64	2.31	1.77-5.34	3.61
Jodiya	3.80-5.95	4.96	2.77-4.41	3.49	2.38-3.21	2.82	1.02-2.73	1.92	1.02-5.95	3.41
Lalpur	3.87-4.77	4.44	2.62-4.08	3.28	1.08-3.18	2.14	0.78-1.97	1.24	0.78-4.77	2.75
Jamnagar District	3.80-5.95	4.86	2.09-5.26	3.74	1.08-3.80	2.58	0.78-2.73	1.88	0.78-5.95	3.26
Kalyanpur	4.69-6.27	5.41	3.71-4.81	4.22	2.22-3.86	3.26	1.43-2.87	2.24	1.43-6.27	3.83
Khambhalia	4.07-5.14	4.65	3.19-4.62	3.93	2.24-3.81	3.07	0.78-2.55	1.69	0.78-5.14	3.34
Dwarka	3.39-6.07	4.71	2.17-3.87	3.17	1.74-2.75	2.25	0.93-1.89	1.41	0.93-6.07	3.50
Devbhumi Dwarka District	3.39-6.27	4.89	2.17-4.81	3.79	1.74-3.86	2.92	0.78-2.87	1.84	0.78-6.27	3.56
Porbandar	4.08-6.61	5.33	3.77-4.85	4.23	2.36-3.88	3.49	1.99-2.77	2.46	1.99-6.61	3.95
Overall	3.39-6.61	4.96	2.09-5.26	3.82	1.08-3.88	2.84	0.78-2.87	1.97	0.78-6.61	3.49



**Fig 10:** Map of overall available B status in coastal soils of Northern Saurashtra region

**Nutrient index values of available macronutrients**

The nutrient index values for available macronutrient are presented in table-12. Overall, the soils of Northern Saurashtra coastal region had nutrient index values of 1.27, 1.43, 2.66 and 2.08 for available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and S, respectively. The highest nutrient index values of 1.50, 1.70, 2.90 and 2.86 for available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and S were reported in soils of the Jamnagar, Kalyanpur, Dwarka and Porbandar talukas, respectively. The lowest nutrient index values of 1.05 was recorded for available N in the soils of Khambhalia taluka, while it was for P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and S as 1.33, 2.20 and

1.85 for soils of Porbandar, Lalpur and Lalpur-Kalyanpur talukas, respectively. In districts, highest nutrient index values of 1.38, 2.86 and 2.86 for available N, K<sub>2</sub>O and S, respectively were found in Porbandar district while 1.52 for P<sub>2</sub>O<sub>5</sub> was reported in Devbhumi Dwarka district. Based on nutrient index values of soils and the criteria suggested by Parker *et al.* (1951) [14] the soils of Northern Saurashtra coastal region were found deficient with respect to available N and P<sub>2</sub>O<sub>5</sub>, medium fertility class for available S, while high fertility class for available K<sub>2</sub>O status.

**Table 11:** Talukawise percentage and number of soil samples falling in low, medium and high fertility classes for DTPA extractable micronutrients

Name of taluka	Fe <sup>++</sup>			Mn <sup>++</sup>				Cu <sup>++</sup>			Zn <sup>++</sup>		
	L	M	H	L	L	M	H	L	L	M	H	L	
Jamnagar	35.00 (7)*	65.00 (13)	0.00 (0)	30.00 (6)	45.00 (9)	25.00 (5)	0.00 (0)	0.00 (0)	10.00 (20)	35.00 (7)	15.00 (3)	50.00 (10)	
Jodiya	30.00 (6)	70.00 (14)	0.00 (0)	30.00 (6)	50.00 (10)	20.00 (4)	0.00 (0)	5.00 (1)	95.00 (19)	75.00 (15)	20.00 (4)	5.00 (1)	
Lalpur	70.00 (14)	30.00 (6)	0.00 (0)	20.00 (4)	60.00 (12)	20.00 (4)	0.00 (0)	5.00 (1)	95.00 (19)	80.00 (16)	20.00 (4)	0.00 (0)	
Jamnagar district	45.00 (27)	55.00 (33)	0.00 (0)	26.67 (16)	51.67 (31)	21.67 (13)	0.00 (0)	3.33 (2)	96.67 (58)	63.33 (38)	18.33 (11)	18.33 (11)	
Kalyanpur	30.00 (6)	70.00 (14)	0.00 (0)	30.00 (6)	40.00 (8)	30.00 (6)	0.00 (0)	5.00 (1)	95.00 (19)	100.00 (20)	0.00 (0)	0.00 (0)	
Khambhalia	15.00 (3)	85.00 (17)	0.00 (0)	35.00 (7)	65.00 (12)	5.00 (1)	0.00 (0)	0.00 (0)	100.00 (20)	85.00 (17)	10.00 (2)	5.00 (1)	
Dwarka	50.00 (10)	50.00 (10)	0.00 (0)	15.00 (3)	75.00 (15)	10.00 (2)	10.00 (2)	10.00 (2)	80.00 (16)	85.00 (17)	10.00 (2)	5.00 (1)	
Devbhumi Dwarka district	31.67 (19)	68.33 (41)	0.00 (0)	26.67 (16)	58.33 (35)	15.00 (9)	3.33 (2)	5.00 (3)	91.67 (55)	90.00 (54)	6.67 (4)	3.33 (2)	
Porbandar	38.10 (8)	61.90 (13)	0.00 (0)	0.00 (0)	71.43 (15)	28.57 (6)	0.00 (0)	0.00 (0)	100.00 (21)	85.71 (18)	9.52 (2)	4.76 (1)	
Overall	38.30 (54)	61.70 (87)	0.00 (0)	22.70 (32)	57.45 (81)	19.86 (28)	1.42 (2)	3.55 (5)	95.04 (134)	78.01 (110)	12.06 (17)	9.93 (14)	

**Table 12:** Taluka wise nutrient index values of macro and micronutrients in soils of different districts of Northern Saurashtra coastal region

Name of Taluka	Macronutrients				Micronutrients			
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	S	Fe <sup>++</sup>	Mn <sup>++</sup>	Cu <sup>++</sup>	Zn <sup>++</sup>
Jamnagar	1.50	1.45	2.60	2.15	1.65	1.95	3.00	2.15
Jodiya	1.30	1.35	2.60	2.05	1.70	1.90	2.95	1.30
Lalpur	1.10	1.35	2.20	1.85	1.30	2.00	2.95	1.20
Jamnagar District	1.30	1.38	2.47	2.02	1.55	1.95	2.97	1.55
Kalyanpur	1.40	1.70	2.65	1.85	1.70	2.00	2.95	1.00
Khambhalia	1.05	1.35	2.80	2.30	1.85	1.70	3.00	1.20
Dwarka	1.15	1.50	2.90	2.05	1.50	1.95	2.70	1.20
Devbhumi Dwarka District	1.20	1.52	2.78	2.07	1.68	1.88	2.88	1.13
Porbandar	1.38	1.33	2.86	2.86	1.62	2.29	3.00	1.19
Overall	1.27	1.43	2.66	2.08	1.62	1.97	2.94	1.32

### Nutrient index values of available micronutrients

Overall, the soils of Northern Saurashtra coastal region had nutrient index values of 1.62, 1.97, 2.94 and 1.32 for DTPA extractable Fe, Mn, Cu and Zn, respectively. The highest nutrient index values of 1.85, 2.29, 3.00 and 2.15 for DTPA extractable Fe, Mn, Cu and Zn were reported in the soils of Khambhalia, Porbandar, Jamnagar-Khambhalia-Porbandar and Jamnagar talukas, respectively (Table-12). The lowest nutrient index value of 1.30, 1.70, 2.70 and 1.19 for Fe, Mn, Cu and Zn were found in Lalpur, Khambhalia, Dwarka and Porbandar talukas, respectively. Based on nutrient index values of soils and the criteria suggested by Parker *et al.* (1951) <sup>[14]</sup>, the soils of Northern Saurashtra coastal region were found in high category for DTPA extractable Cu, medium category for Fe and Mn and low category for Zn. Similar results were also reported by Polara and Kabaria (2006) <sup>[5]</sup> for soils of Amreli district, by Polara *et al.* (2006a) <sup>[17]</sup> for soils of north west agro climatic zone of Gujarat, by Sojitra (2010) <sup>[29]</sup> for Junagadh district and by Rajput and Polara (2012) <sup>[23]</sup> for Bhavnagar district, by Malavath and Mani (2014) <sup>[9]</sup> for Sivaganga district of Tamil Nadu and by Polara and Chauhan (2015a) <sup>[18]</sup> for Gir Somnath district of Gujarat.

### 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 all the soil fertility parameters viz., SOC, available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, Fe, Mn, Cu and Zn content were increased with increasing the sampling distance (0-5, 5-10, 10-15, 15-20 km) from coastal line except B.

The soils were low with respect to available N (204.70 kg ha<sup>-1</sup>), but medium in P<sub>2</sub>O<sub>5</sub> (28.95 kg ha<sup>-1</sup>) and available S (20.00 mg kg<sup>-1</sup>), whereas it was high in available K<sub>2</sub>O (401.82 kg ha<sup>-1</sup>) status. Among the DTPA extractable micronutrients, available Mn (7.45 mg kg<sup>-1</sup>) and Fe (5.44 mg kg<sup>-1</sup>) were found medium, whereas the soils were low in Zn (0.46 mg kg<sup>-1</sup>) and high in Cu (1.01 mg kg<sup>-1</sup>) and available B (3.49 mg kg<sup>-1</sup>).

### References

- Devdas D, Srivastava LK. To analyse the major nutrients in black soil of Navagarh block under Janjgir district in Chhattisgarh. *An Asian Journal of Soil Science* 2013;8(2):348-350.
- Foth HD, Ellis BG. *Soil fertility* (2nd edition). Lewis publishers, Washington, D.C 1997.
- Hadiyal ST. Evaluation of soil fertility and quality of underground water of Porbandar district of Gujarat. M. Sc. (Agri.) Thesis (Unpublished), Junagadh Agricultural University, Junagadh 2005.
- Jackson ML. *Soil Chemical Analysis*, Prentice-Hall of India, Private, Inc. New Delhi 1973.
- Kabaria BD, Polara JV. Characterization and classification of cultivated soils of Amreli district of Gujarat. *Journal of the Indian Society of Coastal Agricultural Research* 2006;24(1):61-63.
- Karajanagi MS, Patil PL, Gundlur SS. GIS Mapping of available nutrients status of Dundur village under Malaprabha command area in Karnataka. *Journal of Farm Sciences* 2016;29(1):37-40.
- Kumar A. Spatial distribution of macro- and micro-nutrients in soils of Saharsa district of Bihar. *An Asian Journal of Soil Science* 2015;10(2):276-282.
- Lindsay WL, Norvell WA. Development of a DTPA Soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal* 1978;42:421-428.
- Malavath R, Mani S. Nutrients status in the surface and subsurface soils of dryland Agricultural Research Station at Chettinad in Sivaganga district of Tamil Nadu. *An Asian Journal of Soil Science* 2014;9(2):169-175.
- Meena HB, Sharma RP, Rawat US. Status of Macro and Micronutrients in some soils of Tonk District of Rajasthan. *Journal of the Indian Society of Soil Science* 2006;54:508-512.
- Nagaral IN, Kuligod VB, Singh VP. Soil nutrient status of chilli growing area of Northern Transitional Zone of Karnataka. *An Asian Journal of Soil Science* 2016;11(1):140-145.
- Olsen SR, Cole CV, Watanable JS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *USDA circular No. 939* 1954.
- Panse VG, Sukhatme PV. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi 1985,97-123p.
- Parker FW, Nelson WL, Miller IE. The broad interpretation of soil test informations. *Agronomy Journal* 1951;43:105-112.
- Patel JM, Patel MV, Patel BT. Delineation of sulphur deficient soil in Banaskantha district (Gujarat). *Gujarat Agricultural University Research Journal* 2012;37(1):23-25.
- Patel JM, Patel BT, Patel IM. Fertility status of cultivated soils in Patan district of North Gujarat. *Gujarat Agricultural Universities Research Journal*. 2016;41(1):23-27.
- Polara KB, Polara JV, Patel MS. Fertility status of status of salt affected soil of north-west agroclimatic zone of Gujarat. *Journal of the Indian Society of Coastal Agricultural Research* 2006a;24(1):48-49.
- Polara JV, Chauhan RB. Fertility Status of irrigated soils

- of coastal Gir Somnath district of Saurashtra region in Gujarat. *An Asian Journal of Soil Science* 2015a;10(2):263-265.
19. Polara JV, Kabaria BD. Fertility status of irrigation soils of coastal Amreli District of Gujarat. *Journal of the Indian Society of Coastal Agricultural Research* 2006;24(1):50-51.
  20. Punithraj TS, Nagaraja MS, Dhumgond P, Bhoopal S, Shivakumar KM. Soil fertility status of tomato (*Lycopersicon esculentum*, Mill) grown in areas of Hassan district, Karnataka. *An Asian Journal of Soil Science* 2012;7(2):288-291.
  21. Rajendra PR., Kameariya SR, Yadav BL. Available micronutrient status and their relationship with soil properties of mokala soil series of Rajasthan. *Journal of Indian Society of Soil Science* 2011;59(4):392-396.
  22. Rajput B, Trivedi SK, Gupta N, Toma AS. Status of Available Sulphur and Micronutrients in Mustard Growing Areas of Northern Madhya Pradesh. *Journal of the Indian Society of Soil Science* 2015;63(3):358-361.
  23. Rajput SG, Polara KB. Fertility status of cultivated soils in coastal Bhavnagar district of Saurashtra region of Gujarat. *Journal of the Indian Society of Soil Science* 2012;60(4):317-320.
  24. Reddy KS, Naidu MVS. Characterization and Classification of Soils in Semi-arid Region of Chennur Mandal in Kadapa District, Andhra Pradesh. *Journal of the Indian Society of Soil Science* 2016;64(3):207-217.
  25. Sharma PD. Nutrient management challenges and options. *Journal of the Indian Society of Soil Science* 2008;33:672-675.
  26. Singh MV, Behera SK. All India Coordinated Research project of micro and secondary nutrients and pollutant elements in soils and plants. A Profile Research Bulletin No. 10. Indian Institute of Soil Science, Bhopal 2011,1-57p.
  27. Singh YP, Raghubansi BPS, Tomar RS, Verma SK, Dubey SK. Soil fertility status and correlation of available macro and micronutrients in chambale region of Madhya Pradesh. *Journal of the Indian Society of Soil Science* 2014;62:369-375.
  28. Singaravel R, Balasundaram GS, Johnson K. Physico-chemical characteristics and nutrient status of coastal saline soils of Tamil Nadu. *Journal of the Indian Society of Coastal Agricultural Research* 1996;14(1- 2):59-61.
  29. Sojitra KP. Evaluation of soil fertility and underground water quality of Junagadh district of Gujarat. M. Sc. (Agri.) Thesis (Unpublished). Junagadh Agricultural University, Junagadh 2010.
  30. Srinivasan K, Poongothai S. Macronutrients and Micronutrients Relation to Soil Characteristics of Wellington Reservoir, Tamil Nadu, India. *Journal of Chemistry and Chemical Sciences* 2013;3(3):107-116.
  31. Subbaih BV, Asija GL. Available rapid procedure for the estimation of available nitrogen in soils. *Current Science* 1956;25:259-260.
  32. Sudharani Y, Jayasree G, Sai MVR, Sessa. Mapping of nutrient status of rice soils in Visakhapatnam district using GIS techniques. *An Asian Journal of Soil Science* 2013;8(2):325-329.
  33. Tan KH. Soil sampling, preparation and analysis. Mrcel Dekker, Inc. New York. U.S.A 1996.
  34. Verma US, Jatav GK, Bhagat RK. Evaluation of soil fertility status in Inceptisol of Malkharuda block in Janjgir district of Chhattisgarh. *An Asian Journal of Soil Science* 2013;8(1):103-109.
  35. Wagh NS, Mandaland DK, Sadanshiv NS. Available micronutrient status of sunflower growing soils of Nagpur district (Maharashtra). *An Asian Journal of Soil Science* 2016;11(1):225-229.
  36. Williams CH, Steinberg A. Soil sulphur fraction as chemical indices of available sulphur in some Australian soils. *Australian Journal of Agricultural Research* 1959;10:340-352.