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ASSESSMENT OF SPATIAL VARIABILITY IN AVAILABILITY OF BORON IN DIFFERENT DISTRICTS OF SAURASHTRA REGION OF INDIA USING ARC GIS

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ABSTRACT

Knowledge of spatial variability in nutrient assessment and mapping is important for site specific nutrient management. In this study, spatial variability in soil physio-chemical properties and their influence in soil available boron (B) in surface soils (0-20 cm) of different ten districts of Saurashtra region by using GPS based free survey sampling method. Total 750 soil samples collected from 75 Tehsils among 10 districts of Saurashtra region of Gujarat state. Samples were analysed by standard scientific methods. Based on data generate, quantified and respective thematic maps were prepared on the basis of nutrient rating using Arc Map 10.0 by employing interpolation method. A greater extent the lowest mean value of available boron (0.26 mg kg^{-1}) was obtained from Bhavnagar district. However, the highest value of 0.83 mg kg^{-1} was observed in Porbandar district. Data of available boron were categorizes into low, medium and high classes, about 2.13, 72.25 and 25.62 per cent samples as per these three tier categorization. In general overall concluded data shown soil chemical properties *viz.*, $EC_{2.5}$ (dS m^{-1}) were distributed normal to become tending to saline in range, $pH_{2.5}$ were alkaline in reaction and available boron (mg kg^{-1}) was in medium range. The observed spatial variability in soil properties that influence soil available boron status was used for deciding particular spots of deficient as well as sufficient zones. It was helpful for making particular site specific nutrient management decisions.

Key words : Spatial variability, Boron, Arc, GIS.

Introduction

Indian agriculture has achieved a fourfold growth in food production by adopting modern agricultural practices during the past 50 years. However, intensive cultivation of higher yield responsive varieties, decreased use of organic manures and lack of crop residue recycling have led to depletion of native nutrient status and resulted in wide spread deficiencies. Boron is nutrient element that plants require in tracer amounts (Marschner, 1995) and it plays wider roles in plants like cell wall formation and stabilization, xylem differentiation, imparting draught tolerance, pollen germination and pollen tube growth, lignification and facilitating potassium (K) transport in guard cells as well as in stomatal opening. Boron deficiency has been recorded as the second most important micronutrient constraint in crops after the zinc (Zn) on global scale (Sillanpaa, 1990; Alloway, 2008).

Boron is immobile in plants and release of boron in mineral soils, is usually quite slow. Soil organic matter holds much of the available boron rather tightly. Boron deficiencies are generally related to high rainfall areas with acid soil environment. Under acid soil conditions, boron is more water soluble and can therefore be leached below the root-zone of plants by rainfall or irrigation water particularly accentuated by light texture soils. It has also been shown that symptoms of boron deficiency are associated with high soil pH values (alkaline conditions). Reduced boron solubility under alkaline soil conditions can result in less plant uptake and increased the potential for boron deficiencies.

Understanding distribution of soil B fractions and their relative contribution to B availability for plants and B adsorption-desorption mechanisms in the soil, therefore, assume great significance, especially in the light of recent reports indicating the widespread incidence of B deficiencies in soils of even arid and semi-arid regions (Sahrawat *et al.*, 2007) that were earlier considered adequate in B supply.

Saurashtra is one of the major region of Gujarat, situated in western part of the state, including major 10 districts consisting of 75 tehsils. With total area of 6.43 mha (32.74% area of Gujarat state). From total area received up to 3.70 mha (61% of state total area) included under groundnut-wheat cropping sequence. Majority of oilseed and pulses grown area of state are included in Saurashtra region that are facing varied micro-nutrient deficiencies and also from that nutrients, Boron is most common because of soils are majorly in calcareous nature leads to create deficiency of this nutrient so need to evaluate these kind of spots from the region by random sampling. Hence this research work is designed with an objective to develop the thematic maps on spatial variability soil available boron (B) by using geo-statistics and GIS techniques.

Materials and Methods

Study area

The study area comprising of Saurashtra, a peninsular region of Gujarat state located on the Arabian Sea coast. With a total area of 66,000 sq. km. It is located on the West Coast of India in Gujarat and lies between 20° 30' to 23° N latitude and 69° to 72° E longitude.

Collection of soil samples

Soil samples were collected with use of free survey method through use of GPS technique, from surface soil level 0-20 cm. Ten soil samples were collected from each tehsils/talukas of 10 district of Saurashtra region during the summer season of year 2021. Soil sample was collected in plastic bag and transfer to cotton bag from the surface soils of study area and it was label properly.

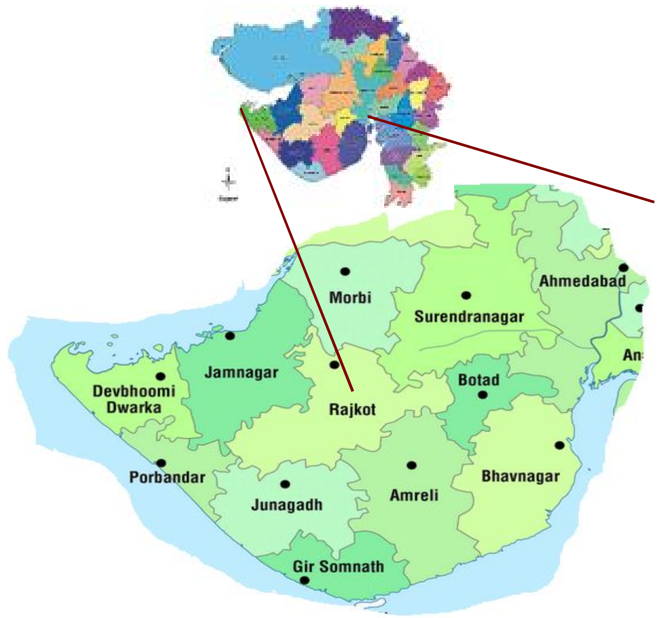

Fig. 1 : Sampling area (Saurashtra region).

Soil sample analysis

The standard analytical methods as followed for estimation of the following parameters are given in Table 1.

Rating used for categorizing the soil

Soil $EC_{2.5}$ and $pH_{2.5}$: The soil salinity was classified with use of $EC_{2.5}$ values of surveyed soil samples into different classes *i.e.*, for salinity, normal (0-0.25 dS m^{-1}), tending to become saline (0.25-0.75 dS m^{-1}), saline (0.75-2.25 dSm^{-1}) and highly saline (2.25-5.00 dS m^{-1}). For alkalinity classes with use of $pH_{2.5}$ values of surveyed soil samples likewise, normal (<8.0), alkaline (8.0-8.5), alkali (8.5-9.0), highly alkali (>9.0) as per proposed by Seth (1967) and Hirpara *et al.* (2021).

Available boron

The soil available boron (mg kg^{-1}) of 750 soil samples was classified in three different categories *i.e.*, low (<0.1 mg kg^{-1}), medium (0.1 to 0.5 mg kg^{-1}) and high (>0.5 mg kg^{-1}) as given by Thakor *et al.* (2014).

Geo-statistics and interpolation delineating maps

Soil samples points marked using GPS were fed into the GIS environment. Values of available boron was

Table 1 : The standard analytical methods.

S. no.	Characteristics	Method	Reference
1.	Available boron (B) (ppm)	Hot water extractable- Boron (HWS-B) by MP-AES	Tan (1996)
2.	$EC_{2.5}$ (1:2.5 Soil:Water ratio) (dS/m)	EC meter	Jackson (1979)
3.	$pH_{2.5}$ (1:2.5 Soil:Water ratio)	pH meter	Richards (1954)

tagged with corresponding points and interpolation of maps for each individual parameter was done using IDW technique in Arc GIS 10.0 software. Further, the maps of this buffered zone were generated for available boron (Trehan *et al*., 2008). GIS software was also used to estimate the area falling under different classes of respective chemical parameters.

Results and Discussion

Soil physio-chemical properties

Soil $EC_{2.5}$: The $EC_{2.5}$ of soil samples collected from entire Saurashtra region were determined by using 1:2.5 soil-water ratio. Overall, it was varied from 0.01 to 5.14 dS m^{-1} with a mean value of 0.49 dS m-1 (Table 2). The lowest $EC_{2.5}$ value (0.01 dS m^{-1}) was recorded in collected soil samples from Morbi district and the highest (5.14 dS m^{-1}) was recorded in soils of Porbandar district. Further revealing of data shown that lowest mean value of 0.24 dS m^{-1} was registered in the soils of Morbi district and highest mean value of 1.15 dS m^{-1} was obtained in samples collected from Porbandar district.

Based on the salinity classes proposed by Seth (1967) for $EC_{2.5}$ the soil samples were divided into following four groups as per Fig. 2. Majority of soils samples (58.93 per cent) found into tending to become saline range, followed by 26 per cent samples found in normal, whereas 14.13 and 0.93 per cent samples were classified into saline and highly saline class. Samples of Porbandar, Devbhumi Dwarka, Jamnagar and Junagadh contained soils with >2.25 $EC_{2.5}$ (dS m^{-1}) highly saline in range. The wider range of $EC_{2.5}$ in that districts could be due to the accumulation of salts in underground water that use as irrigation purpose and also ingression and inundation phenomena of sea water. Similar results were also obtained for Girnartopo sequence by Gandhi (2013), for North Saurashtra coastal region by Yadav (2022) and South Saurashtra coastal region by Bhorania (2021).

Soil $pH_{2.5}$: Typically, the soils in the Saurashtra area leaned towards being alkaline. The $pH_{2.5}$ values for the entire region varied between 6.74 to 9.18 with mean value of 8.03. The data (Table 2) revealed that the lowest value of $pH_{2.5}$ was 6.74 obtained from the samples of Junagadh district; whereas the highest value 9.18 was found in the samples of Amreli district. The data further revealed that lowest mean value of 7.87 was obtained from Porbandar district. However, the highest mean value of 8.16 was obtained from Amreli district.

Soils of the Saurashtra region were classified into alkalinity classes proposed by Seth (1967) as per given in Fig. 3. Overall the soils were distributed alkaline in nature

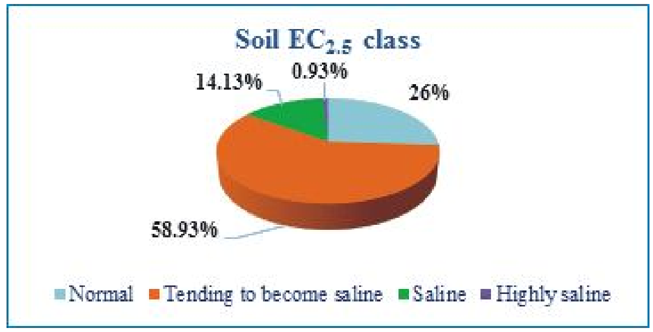

Fig. 2 : Percent distribution of soil $EC_{2.5}$ (dS m^{-1}).

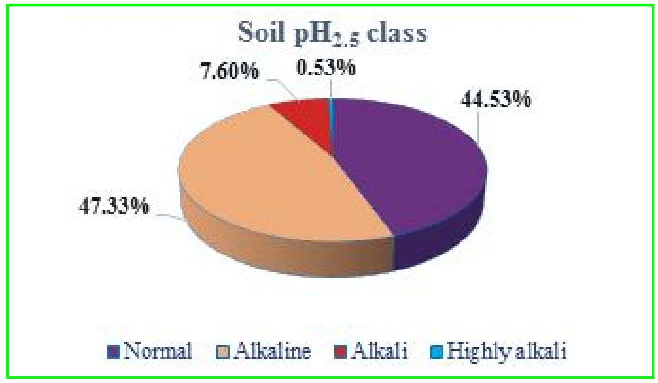

Fig. 3 : Percent distribution of soil $pH_{2.5}$.

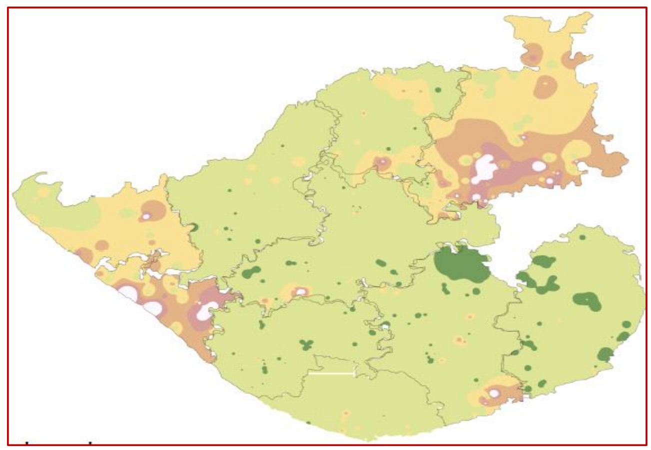

Fig. 4 : Map of available boron (mg kg^{-1}) status in soils of entire Saurashtra region.

about 47.33 per cent samples, followed by normal class 44.53 per cent. In every districts some patched area contained soil $pH_{2.5}$ in alkali range with 7.60 per cent. Only the district of Amreli and Bhavnagar had about 2.73, 1.00 percent samples in highly alkali class, respectively. Soils of the region were calcareous in nature might be the reason behind majority of samples under alkaline in nature. Similar results were also obtained for North Saurashtra coastal region by Yadav (2022) and South Saurashtra coastal region by Bhorania (2021).

Available boron (mg kg^{-1}) : Most general used form of boron among the boron fractions in the soil was hot water soluble boron (available boron) that was

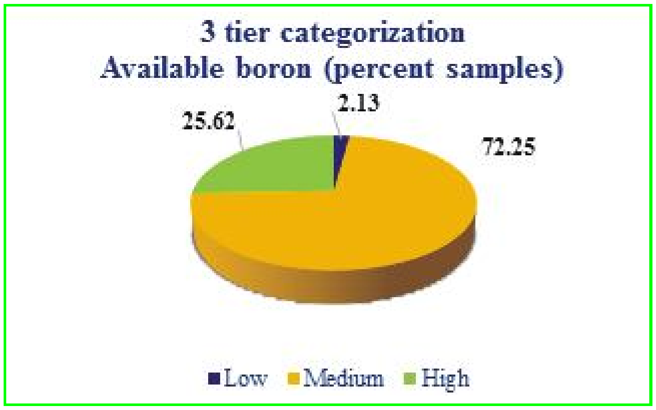

Fig. 5 : Three tier percent distribution of soil available boron (mg kg^{-1}).

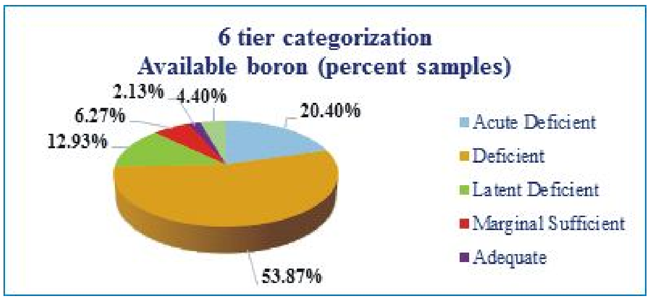

Fig. 6 : Six tier percent distribution of soil available boron (mg kg^{-1}).

samples of Bhavnagar district. However, the highest mean value (0.83 mg kg^{-1}) was registered in soil samples collected from Porbandar district.

The graphically presented data (Fig. 4) indicated that the mean value of available boron was noted marginal sufficient only in Surendranagar (0.71 mg kg^{-1}) and Porbandar (0.83 mg kg^{-1}) districts while, it was found deficient range (>0.2 to ≤0.5 mg kg^{-1}). In coastal belts range was quite high as normal due to salt concentration leads to increase the availability of boron in particular area. Similar study was done by Yadav (2022) for North Saurashtra coastal region, and for medium black calcareous soils of Saurashtra status was obtained by Hadwani (1989). For Gujarat state by Gandhi and Maheta (1960). For Indian soil by Shukla and Behera (2012).

As per the three tier classification, the samples were distributed into low, medium and high category (Fig. 5). It was resulted that majority of soils samples were categorized into medium range (72.25 per cent), next to high (25.65 per cent) and low (2.13 per cent) classes. The majorly cultivated area of Saurashtra region falls under low to medium status of boron which may alarming

Table 2 : District wise range and mean values of chemical properties and available boron in soils of Saurashtra region.

Name of district	$EC_{2.5}$		$pH_{2.5}$		Available boron	
	Range	Mean	Range	Mean	Range	Mean
Rajkot	0.10-1.79	(0.40)	7.26-8.43	(7.89)	0.07-2.71	(0.34)
Devbhumi Dwarka	0.13-3.04	(0.61)	7.50-8.90	(8.11)	0.11-1.44	(0.43)
Morbi	0.01-0.99	(0.24)	7.50-8.70	(8.11)	0.12-1.17	(0.44)
Surendranagar	0.11-2.20	(0.55)	7.20-8.90	(8.10)	0.07-3.09	(0.71)
Junagadh	0.23-3.09	(0.65)	6.74-8.70	(7.88)	0.07-0.82	(0.27)
Girsomnath	0.15-2.85	(0.45)	7.50-8.72	(8.04)	0.14-0.81	(0.37)
Amreli	0.12-1.85	(0.43)	7.35-9.18	(8.16)	0.06-2.02	(0.36)
Bhavnagar	0.08-1.34	(0.27)	7.30-9.00	(8.01)	0.03-0.93	(0.26)
Porbandar	0.21-5.14	(1.15)	7.10-8.80	(7.87)	0.20-1.71	(0.83)
Jamnagar	0.12-2.95	(0.57)	7.50-8.70	(8.08)	0.12-0.71	(0.31)
Overall	0.01-5.14	(0.49)	6.74-9.18	(8.03)	0.03-3.09	(0.41)

commonly denoted that the index of boron availability in soils. Here, for the Saurashtra region soils were analyzed with standard procedure of available boron estimation with using 0.01 M $CaCl_2$ in MP-AES instrument. Overall, it was varying ranged from 0.03 to 3.09 mg kg^{-1} with a mean value of 0.41 mg kg-1 (Table 2). The lower value of 0.03 mg kg^{-1} was registered in soil samples collected from Bhavnagar district and the highest value of 3.09 mg kg^{-1} was obtained from Surendranagar district. Further revealing of data showed that the lowest mean value of available boron (0.26 mg kg^{-1}) was obtained from soil boron sensitive crop like, groundnut and majority oilseeds and pulse crops.

For one advanced precise study soil samples of Saurashtra region were delineated and categorized into six tier standard classification (Fig. 6). So as per categorization, soils of the region was classified with their per cent distribution as per following sequence, 53.87 per cent (Deficient) > 20.40 per cent (Acute deficient) > 12.93 per cent (Latent deficient) > 6.27 per cent (Marginal sufficient) > 4.40 per cent (High) > 2.13 per cent

(Adequate) in range. This criteria showed alarming status of soil boron, therefore STCR status is required in respect of boron for different crops underedapho-climatic condition.

Conclusion

It can be concluded that by using GIS based soil nutrient mapping shown considerable spatial variability into this presented study area. In the present study, status of available boron in soils of different ten districts of Saurashtra noted in range of 0.03-3.09 with average of 0.41 mg kg^{-1}. On the basis of per cent distribution of samples, the 72.25 per cent samples were found medium followed by 25.62 per cent samples found high and 2.13 per cent samples were noted low in respect of available boron. Among, different districts, districts like Porbandar and Surendranagar were found in sufficient marginal, whereas the remaining districts like, Rajkot, Junagadh, Bhavnagar, Amreli, Girsomnath, Jamnagar, Morbi and Devbhumi Dwarka were acute to latent deficient in range in respect of available boron. The results gained from research area potentially practicable used for determining site specific nutrient management practices, that considerably would help in improving fertilizer use efficiency, reducing cost for cultivation and prevent environmental pollution.

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