International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(4): 112-117

Received: 16-07-2017
Accepted: 17-08-2017

**Dameshwar**
Department of soil science and agricultural chemistry, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India

**RN Singh**
Department of soil science and agricultural chemistry, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India

**K Tedia**
Department of soil science and agricultural chemistry, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India

**Mo Navaz**
Department of Agronomy Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India

**Rahul Kumar**
Department of soil science and agricultural chemistry, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India

**Correspondence**
**Dameshwar**
Department of soil science and agricultural chemistry, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India

# Evaluation of available zinc status in the soils of Kasdol block under Baloda bazar district of Chhattisgarh

**Dameshwar, RN Singh, K Tedia, Mo Navaz and Rahul Kumar**

**Abstract**
A study was undertaken to evaluate the available zinc status in the soils of Kasdol block under Balodabazar district of Chhattisgarh. The GPS based 1384 soil samples were collected from 52 villages of Kasdol block by stratified multi stage random sampling method. The soil analysis showed the available boron status is sufficient to high; it ranges between 0.80-2.30, 0.60-2.90, 0.60-2.40 and 0.60-2.80 mg $kg^{-1}$ with mean value of 1.57, 1.44, 1.38 and 1.43 mg $kg^{-1}$ in *Entisols*, *Inceptisols*, *Alfisols* and *Vertisols* respectively. The pH and organic carbon ranges 5-7.5, 3.9-8.6, 4.9-8.6, and 4.9-8.8 with mean value of 5.8, 6.38, 6.28 and 6.4; and 0.49; 0.30-0.77, 0.28-0.88, 0.28-0.81, and 0.28-0.85 per cent with mean value of 0.55, 0.45, 0.49 and 0.49 per cent in *Entisols*, *Inceptisols*, *Alfisols* and *Vertisols* respectively. The electrical conductivity was found under normal range (<1 $dSm^{-}1$). The non-significant positive relationship of available B with pH and EC and negative correlation with OC was found. The soil fertility map has been prepared based on the result and there is need to correct the deficiencies of available nutrients by applying balanced fertilizer doses.

**Keywords:** Physico-chemical properties, Boron and soil fertility maps.

## Introduction
Agriculture, the backbone of Indian economy, contributes to the overall economic growth of the country and determines the standard of life for more than 50% of the Indian population. The population of the country is increasing day by day and the land holding is decreasing. The increasing population does not want to face the problem of food-grains; therefore, it is necessary to enhance the agricultural production and productivity by sustainable system. A system is sustainable when it improves or at least maintains the quality of soil, water and atmosphere. Application of chemical fertilizers has been rated as one of the most important production factor that affecting the sustainability. The increasing population has forced on farmers to make use of high doses of chemical fertilizers. Its unscientific use (imbalance dose or incorrect doses) is a serious threat to sustainable agricultural production system.

Soil fertility and plant nutrition are two closely related subjects that emphasize the forms and availability of nutrients in soils, their movement to and their uptake by roots, and the utilization of nutrients within plants reported by Foth and Ellis, (1997) [6] that without maintaining soil fertility, one cannot talk about increment of agricultural production in feeding the alarmingly increasing population. Therefore, to get optimum, sustained-long lasting and self-sufficient crop production, soil fertility has to be maintained. Continued removals of nutrients, with little or no replacement have aggravated the potential for future nutrient related plant stress and yield loss. Therefore, evaluating the fertility status of a soil is important to know the productivity of a soil as soil fertility is one of the parameters of soil productivity. (Gebeyaw and Tilahun, 2007) [7].

In soils, concentration of total B is reported to be in the range of 20 to 200 mg B $kg^{-1}$ soil and its available concentrations also vary greatly from soil to soil. Boron deficiency has been realized as the second most important micronutrient constraint in crops after that of zinc (Zn) on global scale. In India, based on 74,000 GPS soil samples analysed from 193 districts, 84 districts were found to have B deficiency less than 10 %. About 35 districts fall in B deficiency range of 10-20% and 15 to 16 districts each comes in range of 20-30, 30-40 and 40-50% deficiency range. Indian soils are very poor in organic carbon and B deficiency is linked with low organic matter level in the fields. Soils of Jharkhand, Odisha, West Bengal, Karnataka and part of Bihar, Tamil Nadu and four districts in Gujarat are highly deficient

(more than 50%) in Boron. Boron deficiency has been commonly encountered in soils which are highly leached and/or developed from calcareous, alluvial and loess deposits. However, calcareous part of the country does not exhibit boron deficiency in crops due to sufficient B in irrigated water. Underground water used for irrigation purpose has been reported to contain toxic amounts of B in many parts (Uttar Pradesh, Rajasthan, Haryana, Punjab, and Gujarat) of India. (Nazir *et al*., 2016) [15]. The present research work was taken as efforts to evaluate the soil fertility status of Kasdol block under Balodabazar district of Chhattisgarh with the help of GIS and GPS techniques and their interrelationships with some phisico-chemical properties of soil.

**Materials and methods**

Kasdol is situated between 21˚37'N, 82˚25' E. The total agricultural land of the block is 86833.84 hectare and elevation/altitude is 259 m above the mean sea level. Kasdol block comes under Chhattisgarh plain zone and this zone has an increase in soil depth, water holding capacity, cation exchange capacity and preponderance of calcium and magnesium ions. The soils have been classified in to four soil orders that widely differ in their production potential and physical characteristics. They are locally called, bhata (*Entisols*), matasi (*Inceptisols*), dorsa (*Alfisols*) and kanhar (*Vertisols*). The climate of Kasdol comes under tropical and often varies from moist sub-humid to semi-arid. The annual temperature is 21.43 °C-33.02 °C. The highest temperature of 42.8°C was recorded in May and lowest temperature of 13.5 °C was recorded in December. May is the hottest and December is the coolest month of the year. The soil samples were collected from the field on GPS based. The soil samples have been taken in a zig-zag pattern from the depth of 15-20 cm. systematically across a grid from each of 10 ha arid area for rainfed and 2.5 ha for irrigated land. Within each of such sample point, five samples were randomly taken for further analysis, to represent the 10 hectares for rainfed and 2.5 ha for irrigated area. The collected soil sample should be thoroughly mixed and air dried at 20-25 °C and 20 % to 60 % relative humidity. After air drying soil samples were crushed gently in pestle and mortar and sieved through a 2 mm Sieve. The material larger than 2 mm is discarded.

The selected samples were analysed for soil pH (1:2.5) soil: water suspension after stirring for 30 minutes by glass electrode pH meter as suggested by Piper (1967) [16], Organic Carbon as referred by Walkley and Black's rapid titration method (1934) [26] and the most suitable and widely used method for estimation of available boron was determined by Hot water method given by (Burger and Troug 1939) [2]. These samples were analyzed for available boron status to categorize them into low, medium and high and correlated with pH and organic carbon level. Standard statistical procedure for correlation study was followed. The categorization of the soils of the individual blocks as a whole into the three fertility classes was done according to the nutrient index values calculated from the soil test summarized giving their percentage distribution into low, medium and high categories. The nutrient index (Muhr *et al.* (1965) [14] was given by-

Nutrient index = [% samples in high category × 3 + % in medium

Category × 2 + % in low category × 1] / 100

In this percent assessment, a nutrient index less than 1.65 denotes low category and that falling between 1.65 and 2.33 represents the medium fertility class. Value of 2.34 and above (maxi 3.00) signifies a high fertility class in respect of the particular nutrient (Ghosh and Hasan, 1976) [8]. Delineation of boron status of soil is extracted by hot water bath method. The contents of nutrients, nutrients index, fertility classes and their ranges as observed in respect to chemical characteristics of soils are likely to influence appreciably, directly/indirectly the available nutrients content. Fertility mapping for nutrients status at block level was prepared using Arc GIS software.

**Result and Discussion**

The soil samples were collected from 52 villages of Kasdol block based on stratified multi stage random sampling method. GPS based 1384 (*Entisols* 18, *Inceptisols* 464, *Alfisols* 67, and *Vertisols* 835) surface soil samples were collected. The status of available boron in the soils of Kasdol block is varied from 0.60 to 2.90 mg $kg^{-1}$ with an average 1.43 mg $kg^{-1}$ (Table 3). The boron status ranges 0.80-2.30, 0.60-2.90, 0.60-2.40 and 0.60-2.80 mg $kg^{-1}$ with mean value of 1.57, 1.44, 1.38 and 1.43 mg $kg^{-1}$ in *Entisols*, *Inceptisols*, *Alfisols* and *Vertisols* respectively. The soil test rating for available boron is (<0.5 as deficient, 0.5-1 as sufficient and >1 mg $kg^{-1}$ as high level) as critical limit for boron. Distribution of samples with respect to available B indicated that no sample found to be deficient, 28.18 per cent samples sufficient and 71.82 per cent samples were found to be under higher level in available content of B (Table 1). The lowest status of boron (0.60 mg $kg^{-1}$) is found in 14 villages (Amodi, Bareli, Barbaspur, Baijnath, Borsi, Bilari (K), Darri, Kharri, khaira, Matiya, Madwa, Navrangpur, rikokalan and Turkindih) and the higher values (2.90 mg $kg^{-1}$) of available boron found in Baijnath village of the study area. Similar results were observed by Deshmukh *et al.* (2012) [3] on Sangamner area of Ahmednagar district, Maharashtra, India as 0.02 to 14.42 ppm boron. The pH value (Table 1) ranges 5-7.5, 3.9-8.6, 4.9-8.6, and 4.9-8.8 with mean value of 5.8, 6.38, 6.28 and 6.4 in *Entisols*, *Inceptisols*, *Alfisols* and *Vertisols* respectively. The pH value recorded minimum in Pikari village i.e. 3.9 however, the higher value of pH i.e. 8.8 was observed in Amodi and Chhechhar village of Kasdol block. Similar results were also found in soils of Katol tahsil in Nagpur district of Maharashtra, in which pH ranges from 7.1 to 8.1 and the alkaline reaction of soils is probably due to the presence of sufficient free lime content as reported by Jibhakate *et al.* (2009) [12].

Singh *et al.* (2009) [21] reported that surface and subsurface soils were normal to slightly alkaline in reaction in the soils of district Ghazipur, Uttar Pradesh. Considering in Table:1 the soils having <5.0 as strongly acidic, 5.1 to 6.0 as moderately acidic, 6.1 to 6.5 as slightly acidic, neutral as 6.6 to 7.5, slightly alkaline as 7.6 to 8.5 and moderately alkaline as > 8.5. In general out of 1384 samples 0.94 per cent soil samples were found in strongly acidic, 39.45 per cent soils samples were in moderately acidic, 18.57 per cent in slightly acidic, 27.96 per cent neutral, 12.14 per cent slightly alkaline and 0.94 per cent in moderately alkaline in reaction. The electrical conductivity ranges 0.1-0.79, 0.08-0.9, 0.1-0.59, and 0.07-0.95 with mean value of 0.55, 0.45, 0.49 and 0.49 in *Entisols*, *Inceptisols*, *Alfisols* and *Vertisols* respectively. These soils are denoted as non-saline and it was reported by Bali *et al.* (2010) [1]. The normal EC may be ascribed to leaching of salts to lower horizons due to continuous tillage practices and cropping. The average value of EC of the soil was found minimum i.e. 0.07 dS $m^{-1}$ in the village Kumhari (Rajadeori) and maximum 0.95 dS $m^{-1}$ in Nawagaon village. All the soil samples have safe range of electrical conductivity with

respect to crop growth and development. Data presented in Table: 2 revealed that most of the soils are having low to medium status of organic carbon. It ranged from 0.30-0.77, 0.28-0.88, 0.28-0.81, and 0.28-0.85 with mean value of 0.55, 0.45, 0.49 and 0.49 in Entisols, Inceptisols, Alfisols and Vertisols respectively. Nearly 60.48 per cent soil samples of Kasdol block of Baloda Bazar district were low in organic carbon content. Considering the soils having <0.25 per cent as very low, 0.25- 0.50 per cent as low, 0.50- 0.75 per cent medium and >0.75 per cent as high in OC status. The overall organic carbon ranges from 0.28 to 0.88 per cent. The soils of Kasdol block were found 60.55 per cent in low, 35.77 per cent in medium and only 3.68 per cent soil samples in high organic carbon status.

High temperature and good aeration in the soil increased the rate of oxidation of organic matter resulting reduction of organic carbon content. The high temperature prevailing in the area is responsible for the rapid burning of organic matter, thus resulting low to medium in organic carbon content of these soils. Similar results were also reported by Sharma *et al.* (2008) [18] in soil of Amritsar district of Punjab state. An average value of OC of the soil was found minimum i.e. 0.28 per cent in 17 villages (Amodi, Barpani, Baijnath, Baldakachar, Borsi, Chanhat, Darri, Dhamalpur, Hasuwa, Kharwe, Navrangpur, Rikokhurd, Rikokalan, Kumhari, Sandi, Tundara and Turkindih) and maximum 0.88 per cent in Bhusdipali village of Kasdol block. The above findings also corroborate with the results of Jatav (2010) [11] in the soils of *Inceptisols* group of Baloda block of Janjgir-Champa district of Chhattisgarh, Vaisnow (2010) [24] in soil of *Vertisols* of Dhamtari block under Dhamtari district in Chhattisgarh and Shukla (2011) [19] in soils of Pamgarh block in Janjgir-Champa district (C.G.). Devdas (2012) [4] "in black soil of Navagarh block under Janjgir district of Chhattisgarh"

Relationship between soil characteristics and available boron

The non-significant positive relationship of pH with available B (r = 0.060) was found. Similar result were also found by some researchers, soluble boron content in soils has been found to be significantly and positively correlated with solution solution pH (Elrashidi & O'Connor, 1982) [5]. Boron adsorption by soils increased as a function of solution pH in the range of pH 10 to 11.5 (Goldberg & Glaubig, 1986) [9]. A significant positive correlation between pH of soils and hot water soluble boron has been recorded by Vaughan and Howe (1994) [25]. However, pH effect on soil boron availability is complicated by the fact that high soil pH minimizes boron leaching from the soil profile and can, thereby maintain higher boron level in soil. Similar relationships were also observed in irrigated soils of western Rajasthan (Mathur *et al*., 1964) [13] and north-west Rajasthan (Talati & Agarwal, 1974) [23]. The non-significant positive correlation of EC with available B was found. Water soluble boron content increased with an increase in electrical conductivity (Hadwani *et al*., 1989; Sakal & Singh, 1995) [10, 17]. Working with two saline-alkali soils of Punjab, Singh and Randhawa (1977) [20] showed that water soluble boron constituted 3.8 per cent of total boron content in Kolti Duman soil, whereas in Ghabdan soil, which is in advanced stage of deterioration, water soluble boron was as much as 21 per cent of total boron. This high value of boron in the latter soil was attributed to higher content of soluble salts (EC = 48 dS $m^{-1}$).The non-significant negative correlation of OC with B (r = -0.038) was found.

**Soil fertility maps**

Soil fertility maps for all parameters analysed under the study for kasdol block have been prepared and depicted in figs 1 to 3. Maps have been prepared for soil physico-chemical parameters (pH and OC) and available B status. The status of soil reaction (pH) of Kasdol block is depicted in fig.1. Out of total sampled area 0.94 per cent sampled area were strongly acidic, 39.45 per cent moderately acidic, 18.57 per cent slightly acidic, 27.96 per cent neutral, 12.14 per cent slightly alkaline and 0.94 per cent sampled area were moderately alkaline. It is resulted that the soil of the study area is moderately acidic to slightly alkaline in nature. Organic carbon status (%) rating as >0.25 Very low, 0.25-0.50 Low, 0.50-0.75 Medium and >0.75 High, where 60.55 per cent sampled area fell in low, 35.77 per cent medium and 3.68 per cent under high category. The available boron status shown using soil test rating <0.5 Deficient, 0.5-1.0 Sufficient and >1.0 High (mg $kg^{-1}$), map has shown that 71.82 per cent sampled area found under high and 28.18 per cent sampled area found under sufficient category.

**Conclusion**

It can be concluded from the above results that the soils of Kasdol block in Baloda Bazar district of Chhattisgarh has showed the status of available boron content was medium (28.18 %) to high level (71.82 %). and characterized under moderately acidic to slightly alkaline in soil reaction (pH) and less than 1 dS $m^{-1}$ soluble salt content (EC) comes under safe limit for soils. The 60.55 per cent soils of Kasdol were found under medium and 35.77 per cent soils under low organic carbon status. Hence, the soils of the study area need proper attention for balanced fertilization so that optimum level of crop production can be achieved. The soils of the study area need regular monitoring to avoid any possible deficiency of the plant nutrients. The soil test results obtained under study must be correlated with crop response.

**Table 1:** Category of soils samples under different pH rating of Kasdol block

| Classes | Limit | Entisols | | Inceptisols | | Alfisols | | Vertisols | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples |
| Strongly acid | <5.0 | 0 | 0.00 | 6 | 1.29 | 1 | 1.49 | 6 | 0.72 | 13 | 0.94 |
| Moderately acid | 5-6.0 | 11 | 61.11 | 166 | 35.78 | 34 | 50.75 | 335 | 40.12 | 546 | 39.45 |
| Slightly acid | 6.1-6.5 | 4 | 22.22 | 122 | 26.29 | 5 | 7.46 | 126 | 15.09 | 257 | 18.57 |
| Neutral | 6.6-7.5 | 3 | 16.67 | 111 | 23.92 | 16 | 23.88 | 257 | 30.78 | 387 | 27.96 |
| Slightly alkaline | 7.6-8.5 | 0 | 0.00 | 58 | 12.50 | 9 | 13.43 | 101 | 12.10 | 168 | 12.14 |
| Moderately alkali | >8.5 | 0 | 0.00 | 1 | 0.22 | 2 | 2.99 | 10 | 1.20 | 13 | 0.94 |

**Table 3:** Category of soils samples under different B rating of Kasdol block

| Classes | B (mg kg$^{-1}$) | Entisols | | Inceptisols | | Alfisols | | Vertisols | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples |
| Deficient | <0.5 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Sufficient | 0.5-1 | 3 | 16.67 | 125 | 26.94 | 21 | 31.34 | 241 | 28.86 | 390 | 28.18 |
| High | >1 | 15 | 83.33 | 339 | 73.06 | 46 | 68.66 | 594 | 71.14 | 994 | 71.82 |

**Table 2:** Category of soils samples under different OC rating of Kasdol block

| Classes | Limit (%) | Entisols | | Inceptisols | | Alfisols | | Vertisols | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples | No. of samples | % of samples |
| Very Low | <0.25 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Low | 0.25-0.50 | 5 | 27.78 | 314 | 67.67 | 39 | 58.21 | 480 | 57.49 | 838 | 60.55 |
| Medium | 0.5 – 0.75 | 12 | 66.67 | 139 | 29.96 | 24 | 35.82 | 320 | 38.32 | 495 | 35.77 |
| High | >0.75 | 1 | 5.56 | 11 | 2.37 | 4 | 5.97 | 35 | 4.19 | 51 | 3.68 |

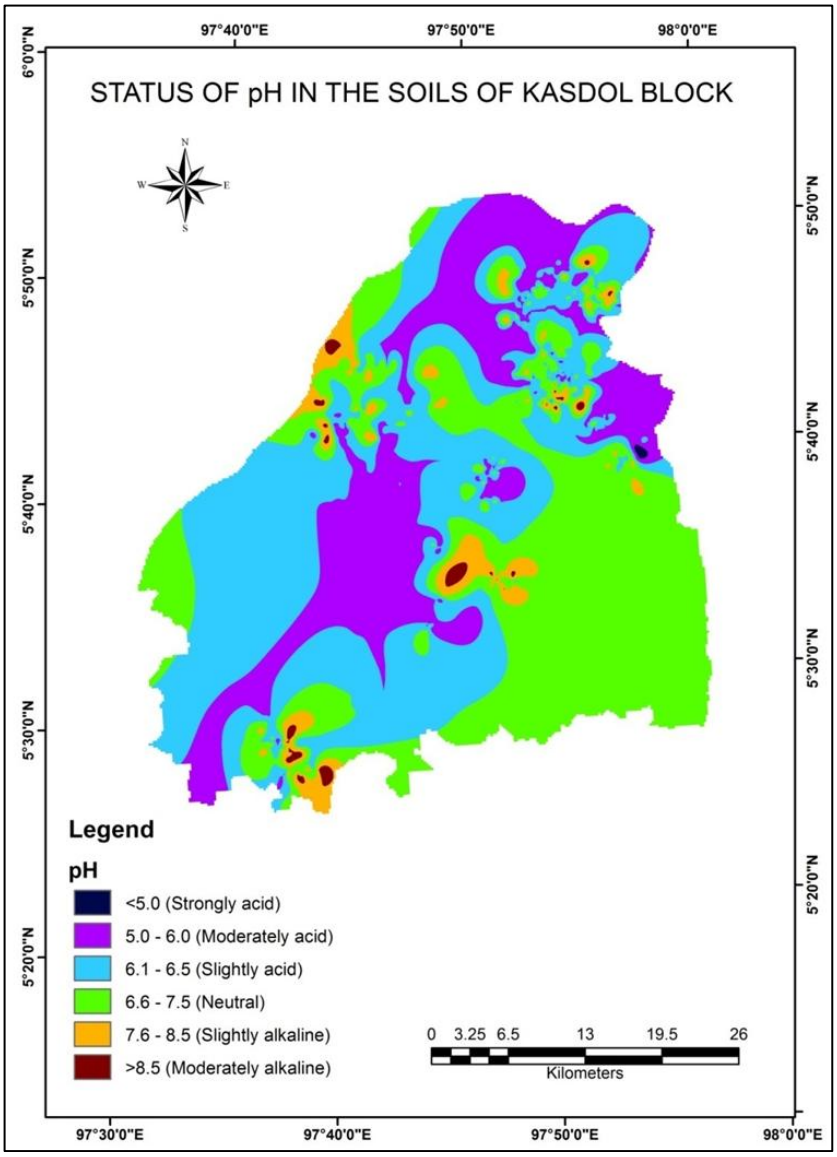


**Fig 1:** Status of pH in the soil of Kasdol block under Balodabazar district

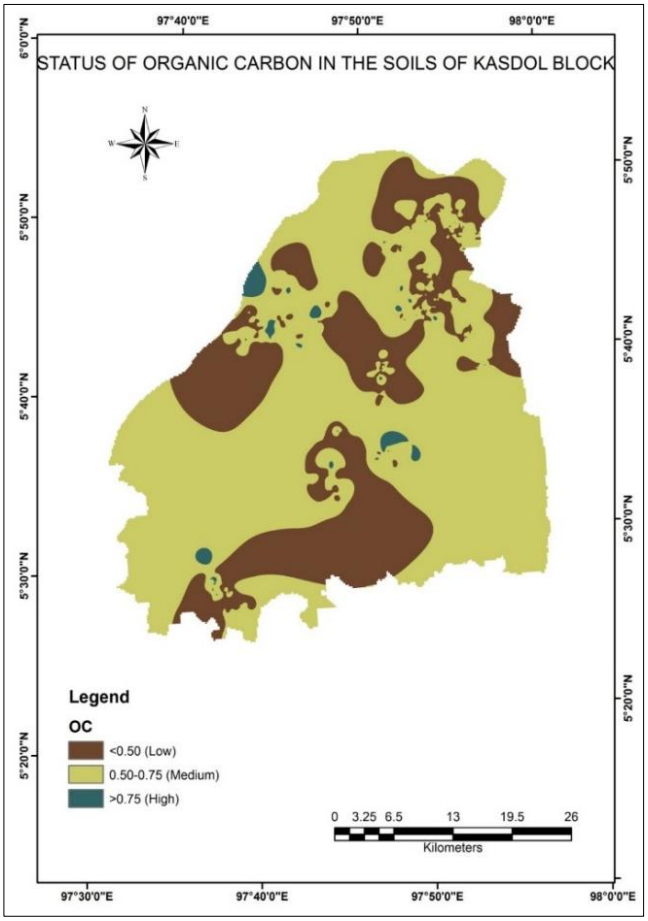


**Fig 2:** Status of OC in the soil of Kasdol block under Balodabazar district

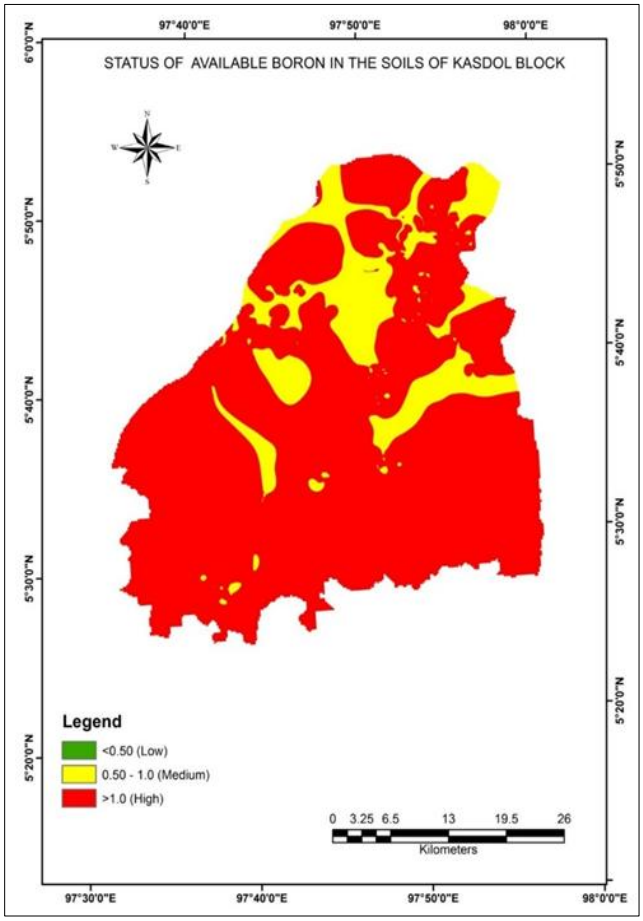


**Fig 3:** Status of available B in the soil of Kasdol block under Balodabazar district

## References


1. Bali SK, Kumar R, Hundal HS, Singh K, Singh B. GIS-aided Mapping of DTPA Extractable Zinc and soil characteristics in the status of Punjab. J. Indian Soc. Soil Sci. 2010; 58(2):189-199.
2. Berger KC, Truog E. Boron determination in soils and plants. Ind. Eng. Chem.Anal. Ed. 1939; 11:540-545.
3. Deshmukh KK, Malpani DJ, Sarda BN. Evaluation of soil fertility status from Sangamner area, Ahmednagar district, Maharashtra, India. Rasayan J. Chem. 2012; 5(3):398-406.
4. Devdas D. Evaluation of soil fertility status in black soil of Navagarh block under Janjgir district of Chhattisgarh M.Sc. (Ag.) thesis, IGKV, Raipur (C.G.), 2012.
5. Elrashidi MA, O'Connor GA. Boron sorption and desorption in soils. Soil Sd. Soc. Am, J. 1982; 46:27-31.
6. Foth HD, Ellis BG. Soil fertility, 2nd Ed. Lewis CRC Press LLC., USA. 1997, 290.
7. Gebeyaw, Tilahun. soil fertility status as influenced by different land uses in maybar areas of south wello zone, north ethiopia, M.Sc. thesis. Faculty of the Department of Plant Sciences, School of Graduate Studies Haramaya university. 2007, 02.
8. Ghosh AB, Hasan R. Available potassium status of Indian soil. Bull. Indian Soc. of Soil Sci. 1976; 12:1-18.
9. Goldberg S, Glaubig RA. Boron adsorption on California soils. Soil Sd. Soc. Am. J 1986; 50:1173-1176.
10. Hadwani GJ, Gandhi AP, Patel MS, Yadav BS. Depthwise distribution of different forms of boron in relation to soil properties in medium black calcarcous soil of western Gujarat. J. Indian Soc. Soil Sd. 1989; 37:295-300.
11. Jatav GK. Evaluation of soil fertility status in Inceptisol of Baloda blocks in Janjgir district of Chhattisgarh, M.Sc. (Ag.) Thesis, I.G.K.V. Raipur, (Chhattisgarh). 2010, 73.
12. Jibhkate SB, Bhende SN, Kharche VK, Selvalakshmi V. Physico-chemical status of Katol tahsil in Nagpur district. J. Soils and Crop. 2009; 19(1):122-128.
13. Mathur CM, Moghe VB, Talati RA. Distribution of boron in soils of western Rajasthan irrigated with high boron water. J Indian Soc. Soil Sd. 1964; 12:319-324.
14. Muhr GR, Datta NP, sankarasubramoney H, Leley VK, Donahue RL. Soil testing in India. 2nd Ed. USAID Mission to India, New Delhi, 1965.
15. Nazir G, Sharma U, Kumar P. Boron-its importance in crop production, status in Indian soils and crop responses to its application. Inter. J, of Advanced Res. 2016; 4(5):654-660.
16. Piper CS. Soil and plant analysis. Asian publishing House, Bombay, New Delhi. 1967, 85-102.
17. Sakal R, Singh AP. Boron research and agricultural production. In: Micronutrient Research and Agricultural Production (I-LLS. Tandon, ed.), Fertiliser Development and Consultation Organisation, New Delhi, India. 1995, 1-31.
18. Sharma PK, Sood A, Setia RK, Tur NS, Mehra D, Singh H. Mapping of macronutrients in soils of Amritsar district (Punjab) A GIS approach. J. Indian Soc. Soil Sci., 2008; 56(1):34-41.
19. Shukla AG. Evaluation of soil fertility in soils of Pamgarh blocks, district Janjgir Champa of Chhattisgarh, M.Sc. (Ag.) Thesis, I.G.K.V. Raipur, (Chhattisgarh), 2011, 63-64.

20. Singh J, Randhawa NS. Boron fractionation and mineral composition of saline-alkali soils. J Indian Soc. Soil Sd. 1977; 25:433-435.
21. Singh RK, Aulakh SS, Toor AS. Soil fertility status of Faridkot District. J. of Res. of Punjab Agricultural University. 2009; 46(3/4):145-152.
22. Singh VS, Agrawal HP, Prasad S. Distribution of DTPA-extractable micro nutrients in the soils of District Ghazipur, Utter Pradesh. J Indian Soc. Soil Sci., 2009; 57(3):370-372.
23. Talaati NR, Agarwal SK. Distribution of various forms of boron of north-west Rajasthan soils. J. Indian Soc. Soil Sci. 1974; 22:262-268.
24. Vaisnow B. Evaluation of soil fertility status in vertisol of Dhamtari block, under Dhamtari district in Chhattisgarh, M.Sc. (Ag.) Thesis, I.G.K.V. Raipur (Chhattisgarh), 2010, 118-119.
25. Vaughan B, Howe J. Evaluation of boron chelates in extracting soil boron. Commun. Soil Sci. Plant. Anal. 1994; 25:1071-1084.
26. Walkley A, Black CA. Estimation of organic carbon by the chromic acid titration method. Soil Science. 1934; 47:29-38.