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*Research Article*

# Status of Micronutrient Cations (Zn, Cu, Mn, Fe) in Soils and their Relationship with Soil Properties in Sabarkantha District of Gujarat

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**ABSTRACT**

*The present investigation was carried out to study the status of micronutrient cation in soils of Sabarkantha district of Gujarat. Total 320 representative surface soil samples (fourty soil samples from each taluka) were collected from farmers' fields during April-2016. Soil samples were collected and analysed for some chemical properties and status of available micronutrient cation viz., Zn, Fe, Mn and Cu in the laboratory. The correlation co-efficient between chemical properties and available nutrients were worked out. The study revealed that the soils are slightly neutral to mildly alkaline in reaction, safe in limit of electrical conductivity while the low in organic carbon content. The status of available Fe and Zn was medium while status of available Mn and Cu was high. The data indicates that pH showed significantly negative correlation with available Fe, Mn and Zn content.*

***Key words:*** *DTPA-extractable Micronutrients, pH, OC, EC.*

## INTRODUCTION

Soil fertility is one of the important factors controlling yields of the crops. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agriculture production. Because of imbalanced and inadequate fertilizer use coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years. Introduction of high yielding varieties (HYV) in Indian agriculture in mid- sixties compelled the farmers to use high doses of NPK fertilizers along with micronutrient fertilizers. Micronutrient plays a vital role in maintaining soil health and also productivity of crops. These are needed in very small amounts. The soil must supply micronutrients for desired growth of plants and synthesis of human food. Increased removal of micronutrients as a consequence of adoption of HYVs 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.

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The deficiencies of micronutrients have become major constraints to productivity, stability and sustainability of soils. Soils with finer particles and with higher organic matter can generally provide a greater reserve of these elements whereas, coarse textured soils such as, sand have fewer reserves and tend to get depleted rather quickly. The widespread need for the micronutrients observed in recent years can be accounted for in three ways *viz.*, naturally deficient in some soil types, their deficiency has been brought out by crop removal and widespread erosion together with destruction of soil organic matter has also brought about their removal from the soil. Considering all the above facts a study was made in soils of Sabarkantha district to know the status and theirs relationship with others soil properties.

## MATERIAL AND METHODS

Sabarkantha district covers an area of 3879.72 sq. km. and it is situated in Northern part of Gujarat state lying between 23.03° to 24.23°N latitude and 72.43° to 72.39°'E longitude situated at 127 meter above mean sea level. Eight taluka namely Himmatnagar, Idar, Prantij, Talod, Khedbrahma, Vadali, Vijaynagar and Poshina were selected for study. Total 320 representative surface soil samples (fourty soil samples from each taluka) were collected from farmers' fields during April-2016 using multistage stratified random sampling. Soil samples were air dried ground carefully with a porcelain mortar and pastel to break soil lumps and passed through 2 mm sieve. Soil pH was measured by glass electrode pH meter in 1:2.5 soil water suspension described by Jackson[2]. The electrical conductivity measured by conductometric method described by Jackson[2]. Organic carbon was estimated by Walkley and Black's[10] rapid titration method, while DTPA extractable micronutrients were determined by atomic absorption spectrophotometer as per method outline by Lindsay and Norvell.

Nutrient index was calculated utilizing the following formula suggested by Parker *et al.*[5]: Nutrient Index (NI) = $[(N_l \times 1) + (N_m \times 2) + (N_h \times 3)] / N_t$

Where, $N_l$, $N_m$ and $N_h$ are the number of samples falling in low, medium and high categories for nutrient status and are given weight age of 1, 2 and 3, respectively. $N_t$ is the total no. of sample. The nutrient index are rated into various categories *viz.*, very low, low, marginal, adequate, high, and very high as rating given by Stalin *et al.*[9].

## RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

**Electrical conductivity (EC):**

The electrical conductivity varied from 0.03 to 1.31 dS $m^{-1}$ with a mean value of 0.43 dS $m^{-1}$ at 25°C of the Sabarkantha district (table 2). Considering the soils having <1.0 dS $m^{-1}$as normal, 1.0-2.0 dS $m^{-1}$ as tending to become saline, 2.0-3.0 dS $m^{-1}$as saline and >3.0 dS $m^{-1}$ as highly saline in EC contents, the data revealed that the lowest mean value of 0.34 dS $m^{-1}$ was observed in the soils of Khedbrahma taluka and the highest mean value of 0.51 dS $m^{-1}$ was registered in the soils of Idar taluka. The data presented in table 2 revealed that 95.3 per cent soil samples have EC value less than 1.0 dS $m^{-1}$ i.e. soluble salts under safe limit. Only 4.7 per cent soil samples falls under slightly saline status. Similar results were also obtained for soils of Mandvi talukas of Kuchch district of Gujarat[7]. The low EC of soil might be due to proper management of soil and thereby leaching of salt takes place from surface to sub-subsurface.

**Soil reaction (pH):**

The data pertaining to soil pH presented in table 1 revealed that the soils of farmer's field were slightly neutral to mildly alkaline in soil reaction and pH ranged from 6.30 to 9.12 with an average value 7.67 in Sabarkantha district. Considering the soils having <6.0 as acid, 6.1-6.5 as slightly acid, 6.6-7.3 as neutral, 7.4-7.8 as mildly alkaline and >7.9 as moderately to strongly alkaline in pH contents. The lowest mean pH value of 7.35 was recorded in a soil samples collected from Vijaynagar taluka and the highest mean value of 8.10 was recorded in the samples collected from Himmatnagar

taluka. Out of 320 soil samples, 0.31, 29.69, 31.56, 31.56 and 6.25 per cent soil samples have slightly acid, neutral, mildly alkaline, moderately alkaline and strongly alkaline reaction, respectively (table 2). Similar results were also obtained for Tonk district of Rajasthan[4]. The relative high pH in these soils might be due to the presence of high degree of base saturation.

**Table 1: Talukawise range and mean values of EC and pH in soils of Sabarkantha district**

| Name of Taluka | $EC_{2.5}$ (dS/m) | | $pH_{2.5}$ | |
|---|---|---|---|---|
| | **Range values** | **Mean values** | **Range values** | **Mean values** |
| Himmatnagar | 0.09-1.23 | 0.47 | 6.79-9.12 | 8.10 |
| Idar | 0.07-1.19 | 0.51 | 6.68-8.32 | 7.47 |
| Prantij | 0.07-1.31 | 0.41 | 6.60-8.80 | 7.80 |
| Talod | 0.03-1.29 | 0.42 | 6.80-9.10 | 8.00 |
| Khedbrahma | 0.10-0.82 | 0.34 | 6.80-8.20 | 7.47 |
| Vadali | 0.06-1.15 | 0.40 | 6.80-8.32 | 7.58 |
| Vijaynagar | 0.08-1.09 | 0.43 | 6.30-8.37 | 7.35 |
| Poshina | 0.09-1.07 | 0.43 | 6.60-8.70 | 7.61 |
| **District** | **0.03-1.31** | **0.43** | **6.30-9.12** | **7.67** |

**Table 2: Per cent distribution of soil samples according to categories for EC and pH in different talukas of Sabarkantha district**

| Name of Taluka | $EC_{2.5}$ | | $pH_{2.5}$ | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Normal** | **Slightly saline** | **Slightly acid** | **Neutral** | **Mildly alkaline** | **Moderately alkaline** | **Strongly alkaline** | **Very strongly alkaline** |
| Himmatnagar | 92.5 | 7.5 | 0 | 5 | 27.5 | 47.5 | 17.5 | 2.5 |
| Idar | 92.5 | 7.5 | 0 | 42.5 | 30 | 27.5 | 0 | 0 |
| Prantij | 92.5 | 7.5 | 0 | 20 | 27.5 | 47.5 | 5 | 0 |
| Talod | 95.0 | 5.0 | 0 | 12.5 | 25 | 35 | 25 | 2.5 |
| Khedbrahma | 100 | 0 | 0 | 40 | 42.5 | 17.5 | 0 | 0 |
| Vadali | 97.5 | 2.5 | 0 | 37.5 | 25 | 37.5 | 0 | 0 |
| Vijaynagar | 97.5 | 2.5 | 2.5 | 47.5 | 35 | 15 | 0 | 0 |
| Poshina | 97.5 | 2.5 | 0 | 32.5 | 40 | 25 | 2.5 | 0 |
| **District** | **95.3** | **4.7** | **0.31** | **29.69** | **31.56** | **31.56** | **6.25** | **0.63** |

**Organic carbon (OC):**

Data presented in table 4 revealed that most of the soils were having low status of organic carbon. It ranged from 0.06 to 0.95 per cent with a mean value of 0.43 per cent in soils of Sabarkantha. The lowest mean OC value of 0.39 per cent was recorded in a soil samples collected from Talod taluka and the highest mean value of 0.47 per cent was recorded in samples collected from Khedbrahma taluka. In general, 68.4 per cent samples were deficient and 27.8 per cent medium. Such low values for organic carbon status of soils are expected because of the arid climate, less use of organic manure and negligible replacement of organic matter. Similar results were obtained for soils of Tonk district of Rajasthan[4].

**Table 3: Limits for the soil test values used for rating the soil**

| Parameters | **Low** | **Medium** | **High** |
|---|---|---|---|
| Organic carbon (%) | <0.50 | 0.50-0.75 | >0.75 |
| Available Fe (mg $kg^{-1}$) | <5 | 5-10 | >10 |
| Available Mn(mg $kg^{-1}$) | <5 | 5-10 | >10 |
| Available Zn (mg $kg^{-1}$) | <0.5 | 0.5-1 | >1 |
| Available Cu (mg $kg^{-1}$) | <0.2 | 0.2-0.4 | >0.4 |

**Table 4: Talukawise range, mean value and per cent distribution of organic carbon content in soils of Sabarkantha district**

| **Name of Taluka** | **Range value (%)** | **Mean value (%)** | **Per cent distribution of organic carbon** | | |
|---|---|---|---|---|---|
| | | | **Low** | **Medium** | **High** |
| Himmatnagar | 0.14-0.92 | 0.43 | 67.5 | 25 | 7.5 |
| Idar | 0.17-0.72 | 0.40 | 77.5 | 22.5 | 0 |
| Prantij | 0.14-0.87 | 0.42 | 75 | 17.5 | 7.5 |
| Talod | 0.14-0.77 | 0.39 | 77.5 | 20 | 2.5 |
| Khedbrahma | 0.18-0.95 | 0.47 | 57.5 | 37.5 | 5 |
| Vadali | 0.06-0.75 | 0.42 | 62.5 | 35 | 2.5 |
| Vijaynagar | 0.17-0.89 | 0.44 | 65 | 30 | 5 |
| Poshina | 0.15-0.71 | 0.43 | 65 | 35 | 0 |
| **District** | **0.06-0.95** | **0.43** | **68.4** | **27.8** | **3.8** |

**Available micronutrients status of soils:**

**DTPA-extractable Fe status:**

The DTPA-extractable Fe content in soils of Sabarkantha district ranged from3.18 to 25.80 mg $kg^{-1}$ with a mean value of 9.10 mg $kg^{-1}$ (table 5). Vijaynagar taluka soils possess the highest mean value of DTPA-extractable Fe (10.55 mg $kg^{-1}$) and soils of Talod taluka have the lowest mean value (7.90 mg $kg^{-1}$) of DTPA-extractable Fe. Out of 320 soil samples, 67.5 per cent soil samples were observed under medium status in Fe (table 6). Nutrient index values ranged from 2.08 to 2.38 with a mean value of 2.25. The overall fertility rating for available Fe was adequate (table 7). The medium Fe content in these soils may be due to presence of minerals like magnetite. Similar results were also reported for soils of Gandhinagar district[6].

**DTPA-extractable Mn status:**

The DTPA-extractable Mn content in soils of Sabarkantha district ranged from 2.31 to 29.31 mg $kg^{-1}$ with a mean value of 10.95 mg $kg^{-1}$ (table 5). Soils of Idar taluka have the highest mean value (12.37 mg $kg^{-1}$) and lowest mean value (10.10 mg $kg^{-1}$) was observed in Prantij taluka. Out of 320 soil samples, 43.1 per cent soil samples were found as low, whereas 50 per cent were medium in available Mn content in soils of Sabarkantha district (table 6). Nutrient index values ranged from 2.25 to 2.45 with a mean value of 2.36. The overall fertility rating for Mn was high (table 7). This high status of Mn might be due to less mobility of $Mn^{+2}$ in soils, which might have contributed for the accumulation of reducible and soluble forms of manganese in the surface soils. Punithraj *et al*.[8] observed similar results for tomato growing area of Hassan district of Karnataka.

**Table 5: Talukawise range and mean values for DTPA-extractable Fe, Mn, Zn and Cu in soils of Sabarkantha district**

| Name of Taluka | Available Fe (mg kg$^{-1}$) | Available Mn (mg kg$^{-1}$) | Available Zn (mg kg$^{-1}$) | Available Cu (mg kg$^{-1}$) |
|---|---|---|---|---|
| Himmatnagar | 3.88-18.46 (8.32) | 3.64-19.32 (10.37) | 0.27-1.41 (0.73) | 0.22-3.04 (0.91) |
| Idar | 4.82-18.45 (9.12) | 2.98-29.31 (12.37) | 0.13-2.46 (0.81) | 0.11-2.98 (0.93) |
| Prantij | 3.18-15.34 (8.07) | 2.72-19.34 (10.10) | 0.18-2.18 (0.77) | 0.09-2.41 (0.67) |
| Talod | 3.46-15.16 (7.90) | 2.31-22.19 (10.51) | 0.26-3.89 (0.74) | 0.34-2.38 (0.88) |
| Khedbrahma | 4.06-22.18 (9.36) | 3.26-28.41 (11.61) | 0.08-3.12 (0.76) | 0.16-3.57 (1.22) |
| Vadali | 4.32-21.37 (9.19) | 3.37-29.22 (11.02) | 0.14-3.97 (0.83) | 0.32-2.64 (1.48) |
| Vijaynagar | 4.29-25.80 (10.55) | 3.65-28.68 (11.22) | 0.16-3.01 (0.84) | 0.36-2.73 (1.13) |
| Poshina | 4.24-22.07 (10.26) | 2.79-25.87 (10.42) | 0.41-1.87 (0.78) | 0.19-2.36 (1.02) |
| **District** | **3.18-25.80 (9.10)** | **2.31-29.31 (10.95)** | **0.08-3.97 (0.78)** | **0.09-3.57 (1.03)** |

**Note:** Value in parenthesis indicates mean value

**DTPA-extractable Zn:**

The DTPA-extractable Zn content in soils of Sabarkantha district ranged from 0.08 to 3.97 mg kg$^{-1}$ with a mean value of 0.78 mg kg$^{-1}$ (table 5). Soils of Vijaynagar taluka possess the highest mean value (0.84 mg kg$^{-1}$) of available Zn followed by Vadali (0.83 mg kg$^{-1}$) and Idar (0.81 mg kg$^{-1}$) taluka and lowest mean value (0.73 mg kg$^{-1}$) was observed in Himmatnagar taluka. Out of 320 soil samples, nearly 67.5 per cent soil samples were observed under medium status in Zn (table 6). Nutrient index values ranged from1.68 to 2.08 with a mean value of 1.93. The overall fertility rating for DTPA-extractable Zn was marginal (table 7). Similar results were also reported by earlier workers for soils of Gandhinagar district[6].

**DTPA-extractable Cu:**

The DTPA-extractable Cu content in soils of Sabarkantha district ranged from 0.09 to 3.57 mg kg$^{-1}$ with a mean value of 1.03 mg kg$^{-1}$ (table 5). The highest mean value of available Cu was observed in Vadali taluka soils (1.48 mg kg$^{-1}$) followed by soils of Khedbrahma (1.22 mg kg$^{-1}$) and Vijaynagar (1.13 mg kg$^{-1}$) talukas. The lowest mean value (0.67 mg kg$^{-1}$) was observed in Prantij taluka. Out of 320 soil samples, 92.2 per cent soil samples were observed under high status in available Cu (table 6). Nutrient index values ranged from 2.78 to 2.98 with a mean value of 2.90. The overall fertility rating for Cu was very high (table 7). The high status of available Cu in soils of Sabarkantha district might be due to the application of copper containing chemicals mostly as fungicides. Similar results were also obtained for soils of Gir Somnath district of Gujarat[1].

**Table 6: Per cent distribution of soil samples according to low, medium and high categories for available micronutrients in different talukas of Sabarkantha district**

| Name of Taluka | Available Fe | | | Available Mn | | | Available Zn | | | Available Cu | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | M | H | L | M | H | L | M | H | L | M | H |
| Himmatnagar | 5.0 | 75.0 | 20.0 | 5.0 | 45.0 | 50.0 | 10.0 | 82.5 | 7.5 | 0.0 | 5.0 | 95.0 |
| Idar | 2.5 | 67.5 | 30.0 | 7.5 | 45.0 | 47.5 | 7.5 | 82.5 | 10.0 | 7.5 | 5.0 | 87.5 |
| Prantij | 5.0 | 80.0 | 15.0 | 10.0 | 55.0 | 35.0 | 22.5 | 67.5 | 10.0 | 5.0 | 12.5 | 82.5 |
| Talod | 7.5 | 77.5 | 15.0 | 5.0 | 52.5 | 42.5 | 40.0 | 52.5 | 7.5 | 0.0 | 7.5 | 92.5 |
| Khedbrahma | 2.5 | 60.0 | 37.5 | 7.5 | 52.5 | 40.0 | 30.0 | 55.0 | 15.0 | 2.5 | 2.5 | 95.0 |
| Vadali | 2.5 | 62.5 | 35.0 | 5.0 | 47.5 | 47.5 | 25.0 | 57.5 | 17.5 | 0.0 | 2.5 | 97.5 |
| Vijaynagar | 2.5 | 60.0 | 37.5 | 7.5 | 52.5 | 40.0 | 20.0 | 60.0 | 20.0 | 0.0 | 2.5 | 97.5 |
| Poshina | 2.5 | 57.5 | 40.0 | 7.5 | 50.0 | 42.5 | 5.0 | 82.5 | 12.5 | 2.5 | 7.5 | 90.0 |
| **District** | **3.8** | **67.5** | **28.7** | **6.9** | **50** | **43.1** | **20.0** | **67.5** | **12.5** | **2.2** | **5.6** | **92.2** |

Where, L=Low, M=Medium, H=High fertility class

**Correlation coefficient (r) among different properties of soils of Sabarkantha district**

Available Fe (r = -0.232**), Mn (r = -0.337**) and Zn (r = -0.190**) of soils of Sabarkantha district showed the highly significant and negative correlation with soil pH. The micronutrient availability was decreased with increase in pH of soil (table 8). Similar results were recorded for soils of Tonk district of Rajasthan[4].

**Table 7: Talukawise nutrient index and fertility status of available micronutrients in soils of Sabarkantha district**

| Name of Taluka | Nutrient values | | | | Fertility status | | | |
|---|---|---|---|---|---|---|---|---|
| | Fe | Mn | Zn | Cu | Fe | Mn | Zn | Cu |
| Himmatnagar | 2.15 | 2.45 | 1.98 | 2.95 | Adequate | High | Marginal | Very High |
| Idar | 2.28 | 2.40 | 2.03 | 2.80 | Adequate | High | Adequate | Very High |
| Prantij | 2.10 | 2.25 | 1.88 | 2.78 | Adequate | Adequate | Marginal | Very High |
| Talod | 2.08 | 2.38 | 1.68 | 2.93 | Adequate | High | Marginal | Very High |
| Khedbrahma | 2.35 | 2.33 | 1.85 | 2.93 | High | High | Marginal | Very High |
| Vadali | 2.33 | 2.43 | 1.93 | 2.98 | High | High | Marginal | Very High |
| Vijaynagar | 2.35 | 2.33 | 2.00 | 2.98 | High | High | Adequate | Very High |
| Poshina | 2.38 | 2.35 | 2.08 | 2.88 | High | High | Adequate | Very High |
| **District** | **2.25** | **2.36** | **1.93** | **2.90** | **Adequate** | **High** | **Marginal** | **Very High** |

**Table 8: Correlation co-efficient (r values) between chemical properties and available micronutrients**

| Chemical properties | Fe | Mn | Zn | Cu |
|---|---|---|---|---|
| **EC** | 0.033 | -0.021 | 0.039 | 0.006 |
| **pH** | -0.232** | -0.337** | -0.190** | -0.080 |
| **OC** | 0.142* | -0.040 | -0.077 | 0.056 |

## CONCLUSION

The soil analytical data of Sabarkantha district clearly indicates that soils are slightly neutral to mildly alkaline in reaction with low soluble salt content. The content of organic carbon classified in low category. The status of available Fe and Zn was medium while status of available Mn and Cu was high. Based on overall nutrient index in soils of Sabarkantha district, available Zn in marginal; available Fe in adequate; available Mn and Zn in high whereas available Cu in very high fertility status. Significant negative correlations observed between pH and available Fe, Mn and Zn content in soil.

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