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# Status of DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) in soils of Gandhinagar district of Gujarat

**DB Chavda, JR Jat, S Kumar, JK Malav, RP Pavaya and JK Patel**

**Abstract**
A study was undertaken to delineate the status of DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) and chemical properties of soils of Gandhinagar district of Gujarat. Total 160 representative surface soil samples (forty soil samples from each taluka) were collected from farmers' fields during April, 2016 using multistage stratified random sampling. The collected soil samples were analyzed for DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) and chemical properties viz., electrical conductivity (EC), soil reaction (pH) and organic carbon. Soils of Gandhinagar district are mildly to moderately alkaline in reaction (pH 7.94) with low soluble salt content (EC 0.52 dS/m). The organic carbon status of soils of Gandhinagar district was low (0.38%). The DTPA-extractable Fe, Mn, Zn and Cu content in these soils ranged from 3.10 to 16.6, 3.54 to 23.44, 0.16 to 1.62 and 0.37 to 1.78 mg/kg with mean value of 97.13, 12.38, 0.64 and 0.86mg/kg, respectively. Out of 160 soil samples, 49.38 per cent were found medium in available Fe status, 71.88 per cent were to be high in available Mn status, 46.88 per cent were found to be medium in available Zn status and 98.12 per cent were found to be high in available Cu status.

**Keywords:** DTPA-extractable micronutrients, Gandhinagar, Nutrient index, Gujarat

## Introduction
The basic objective of the soil-testing programme is to give farmers a service leading to better and more economic use of fertilizers and better soil management practices for increasing agricultural production. High crop yields cannot be obtained without applying sufficient fertilizers to overcome existing deficiencies. Soil survey is the process of classifying soil types and other soil properties in given area and geo-encoding such information. The information in a soil survey can be used by farmers and ranchers to help determine whether a particular soil type is suited for crops or livestock and what type of soil management might be required. As human population continue to increase, human disturbance of the earth's ecosystem to produce food and fiber will place greater demand on soils to supply essential nutrients. The practice of intensive cropping with hybrid varieties for boosting food production caused decline in the level of some essential plant nutrients in the soil at which productivity of crops cannot be sustained.

Soil surveying and mapping provide information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing crop yields. Soil fertility maps are meant for highlighting the nutrient needs, based on fertility status of soils (and adverse soil conditions which need improvement) to realize good crop yields. Obviously, a soil fertility map for a particular area can prove highly beneficial in guiding the farmers, manufacturers and planners in ascertaining the requirement of various fertilizers in a season/year and making projections for increased requirement based on cropping pattern and intensity.

Micronutrients are important for maintaining soil health and also increasing productivity of crops (Rattan *et al.*, 2009) [22]. Deficiency of micronutrients during the last three decades has grown in both, magnitude and extent. This has become a major constraint for production and productivity of rice, wheat and pulses. Plants grow in micronutrient deficient soils exhibit similar reductions in productivity as those grown in macronutrient deficient soils. The soil must supply micronutrients as a consequence of adoption of high yielding varieties (HYVs) and intensive cropping together with shifting 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 has led to emergence of multinutrient deficiencies in the Indian soils (Sharma, 2008) [23]. Analysis of 29,532 soil samples collected from different district of Gujarat showed that per cent deficiency of Zn, Fe, Cu and Mn were 20, 10, 4 and

4, respectively (Patel *et al.*, 1994) [18]. The present survey work was planned to conduct systematic soil survey to assess the DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) and chemical properties of soils of Gandhinagar district of Gujarat.

## Materials and Methods

In order to delineate the available major nutrients (N, P, K and S) status and chemical properties (EC, pH and OC) of soils of Gandhinagar district of Gujarat, the studies were carried out. The general information *viz.*, location, climate, land use pattern, soil, natural vegetation and cropping pattern of the district in general as well as experimental details are described as under. Geographically, Gandhinagar district is an administrative division of Gujarat, which is the state capital, organized in 1964. It is located at $23^0.01'$ to $23^0.56'$N (Latitude) and $72^0.33'$ and $73^0.73'$E (Longitude). It has an average elevation of 81 meters (265 feet), it is situated on the banks of the Sabarmati River and located in north-central Gujarat. The geology of the region is mainly composed of sandy loam soil. The total geographical area of the district is 2163.48 $km^2$. The district has been divided into 4 Talukas and 298 *Gram panchayat* spread in 303 villages. Gandhinagar district is surrounded by the districts of Sabarkantha and Aravalli to the North, Kheda to the south-east, and Ahmedabad to south-east, and Mehsana to the north-east.

According to climate, topography, soil characteristics and cropping pattern, Gandhinagar districts falls under North-Gujarat Agro-climatic zone-IV. The climate of the region is sub-tropical monsoon type and falls under semi-arid region. The annual rainfall in the district is received through the south-west monsoon which normally starts from middle of June, July and August are the major month of monsoon. The average annual rainfall of the district is 665 mm, however scanty and uneven rainfall pattern is common. The temperature varies from $7^0$C to $45^0$C. The soil is low in nitrogen, medium in phosphorus and high in potash content. However, in some areas the deficiency of phosphorus and potash is also noticed. The soils of Gandhinagar district is also deficient in sulphur, zinc and iron because the soils are course textured coupled with intensive farming, little use of farmyard manure and absence of legume crops in a cropping system.

To delineate the DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) status and chemical properties (EC, pH and OC) of soils of Gandhinagar district, total 160 representative surface soil samples were collected from farmer's fields. Forty soil samples were collected from each 4 talukas of Gandhinagar district during April-2016 using multistage stratified random sampling method (Singh *et al.*, 1982) [26]. Representative surface soil samples were collected from different fields' up to a depth of 0 to 15 cm by zigzag method. The standard analytical methods followed for estimating EC, pH, organic carbon and available micronutrients in soil are presented in table 1.

**Table 1:** The standard analytical methods

| Parameter | Method | Reference |
|---|---|---|
| pH (1: 2.5) | Potentiometric method | Jackson (1973) [8] |
| EC (1: 2.5) | Conductometric method | Jackson (1973) [8] |
| Organic carbon | Walkley and Black's titration method | Jackson (1973) [8] |
| DTPA-extractable Fe, Mn, Zn and Cu | Estimation: 0.005 M DTPA (pH 7.3) on Atomic Absorption Spectrophotometer | Lindsay and Norvell (1978) [10] |

### Nutrient index for fertility rating

Nutrient index was calculated utilizing the following formula suggested by Parker *et al.* (1951):

$$NI = \frac{[(N_l \times 1) + (N_m \times 2) + (N_h \times 3)]}{N_t}$$

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 weightage 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.* (2010) [28]. Classification of nutrient index is given in table 2.

**Table 2:** Classification of nutrient index

| Nutrient Index | Classes |
|---|---|
| <1.33 | Very low |
| 1.33 – 1.66 | Low |
| 1.66 – 2.00 | Marginal |
| 2.00 – 2.33 | Adequate |
| 2.33 – 2.66 | High |
| >2.66 | Very high |

### Statistical analysis

Correlation Coefficient (r) among different properties of soil was worked out using standard procedure (Panse and Sukhatme, 1967) [13].

## Result and Discussion

### Chemical properties of soils of Gandhinagar district

Soil samples were analyzed for different chemical properties viz., $EC_{2.5}$, $pH_{2.5}$ and organic carbon by using standard methods. The range and mean values of EC, pH and organic carbon of soil in different talukas of Gandhinagar district are presented in Table 3. Electrical conductivity of soils is a measure of the total concentration of soluble salts. The $EC_{2.5}$ of soil samples were determined by making use of 1:2.5 soil water ratios. The low EC of soil might be due to high leaching of soluble salts takes place from surface to sub-subsurface afforded by their light texture as well as high permeability. Similar findings were reported by Anon., 2008 [5] in the soils of oilseed farm of Junagadh district, Shirgire (2012) [25] in Jamnagar district of Gujarat and Mokala soil series of Rajasthan (Bhanvaria *et al.*, 2011) [5]. Similar results were also obtained for soils of Indo Gangetic alluvial plain in Amritsar district of Punjab (Sharma *et al.*, 2008) [24] and for soils of Mandvi talukas of Kutch district of Gujarat (Patel *et al.*, 2012c) [19].

Soil reaction is one of the most important properties of soil because it controls the availability of nutrients, microbial activities and physical conditions of soils up to a great extent. Soil reaction indicates the activities of $H^+$ and $OH^-$ ions in soil solution. In general, soils of this district are mildly alkaline and moderately alkaline in reaction. The pH values of soils for the entire district were ranging from 7.06 to 9.10 with a mean value of 7.94 (Table 3). The relative high pH in these soils might be due to the presence of high degree of base

saturation and medium to high degree of sodium saturation which on hydrolysis gives $OH^-$ ions and high component of carbonate and bicarbonate. Similar results were also obtained for soils of Girnar topo sequence of South Saurashtra region (Gandhi, 2013) [7], for oilseed farm of Junagadh district (Anon., 2008) [5] and for Tonk district of Rajasthan (Meena *et al.*, 2006) [11]. Similar results were obtained for soils of northern transition zone of Haveri, Gadag and Dharwad district of Karnataka (Nagaral *et al.*, 2016) [12].

In general, soils of Gandhinagar district are low in organic carbon status. Overall organic carbon content in soils ranged from 0.12 to 0.77 per cent with a mean value of 0.38 per cent (Table 3). The lowest mean OC status (0.28 per cent) was recorded in a soil samples collected from Gandhinagar taluka and the highest mean value of 0.42 per cent was recorded in samples collected from Dehgam taluka. The low organic carbon content of these soils may be attributed to occasional addition of organic materials, lack of natural vegetation, poor decomposition due to low rainfall, oxidation due to high summer temperature and wind erosion. Similar results were obtained by Meena *et al.* (2006) [11] in Rajasthan, Patel *et al.* (2012a) [17] in Gujarat and Kumar and Babel (2011) in Rajasthan. The results are strongly supported by the findings of Singh and Mishra *et al.*, (2012) [27] in soils of Chiraigaon block of Varanasi (U.P.).

**Table 3:** Talukawise range and mean values of EC, pH and OC in soils of Gandhinagar district

| Name of Taluka | $EC_{1:2.5}$ (dS/m) | $pH_{1:2.5}$ | OC (%) |
|---|---|---|---|
| Mansa | 0.11-1.13(0.44) | 7.24-8.98(8.04) | 0.27-0.55 (0.40) |
| Kalol | 0.28-1.90(0.73) | 7.11-9.00(8.05) | 0.19-0.57 (0.41) |
| Gandhinagar | 0.29-1.36(0.56) | 7.09-9.10(7.86) | 0.12-0.62 (0.28) |
| Dehgam | 0.09-1.64(0.36) | 7.06-8.82(7.81) | 0.14-0.77 (0.42) |
| District | 0.09-1.90(0.52) | 7.06-9.10(7.94) | 0.12-0.77 (0.38) |

Note: Value in parenthesis indicates mean value

**DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) content in the soils of Gandhinagar district**

For studying the fertility status of soils of Gandhinagar district, total 160 soil samples collected from the farmers' field were analyzed for available micronutrients (Table 4). The talukawise per cent distribution of samples falling in low, medium and high fertility classes for available micronutrients are presented in Table 5.

**Table 4:** Talukawise range and mean values for available micronutrients in soils of Gandhinagar district

| Name of Taluka | Fe (mg/kg) | Mn(mg/kg) | Zn (mg/kg) | Cu (mg/kg) |
|---|---|---|---|---|
| Mansa | 4.22-11.24 (6.65) | 4.82-23.44 (12.43) | 0.30-1.14 (0.58) | 0.39-1.25 (0.81) |
| Kalol | 3.12-16.64 (6.96) | 3.54-21.16 (11.59) | 0.30-1.37 (0.67) | 0.41-1.38 (0.83) |
| Gandhinagar | 3.40-13.76 (7.05) | 4.86-21.20 (12.44) | 0.33-1.12 (0.59) | 0.37-1.35 (0.88) |
| Dehgam | 4.15-12.89 (7.87) | 4.56-21.38 (13.07) | 0.16-1.62 (0.73) | 0.46-1.78 (0.94) |
| District | 3.10-16.64 (7.13) | 3.54-23.44 (12.38) | 0.16-1.62 (0.64) | 0.37-1.78 (0.86) |

Note: Value in parenthesis indicates mean value

**Table 5:** Per cent distribution of soil samples according to low, medium and high categories for available micronutrients in different talukas of Gandhinagar district

| Name of Taluka | Fe | | | Mn | | | Zn | | | Cu | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | M | H | L | M | H | L | M | H | L | M | H |
| Mansa | 30.0 | 62.5 | 7.5 | 2.5 | 27.5 | 70.0 | 45.0 | 45.0 | 10.0 | 0.0 | 2.5 | 97.5 |
| Kalol | 47.5 | 30.0 | 22.5 | 7.5 | 27.5 | 65.0 | 32.5 | 55.0 | 12.5 | 0.0 | 0.0 | 100 |
| Gandhinagar | 25.0 | 57.5 | 17.5 | 2.5 | 25.0 | 72.5 | 40.0 | 57.5 | 2.5 | 0.0 | 5.0 | 95.0 |
| Dehgam | 35.0 | 47.5 | 17.5 | 5.0 | 15.0 | 80.0 | 42.5 | 30.0 | 27.5 | 0.0 | 0.0 | 100 |
| District | 34.37 | 49.38 | 16.25 | 4.37 | 23.75 | 71.88 | 40.0 | 46.88 | 13.12 | 0.0 | 1.88 | 98.12 |

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

**DTPA-extractable Fe**

Overall available Fe status of soils of Gandhinagar district was medium. It ranged from 3.12 to 16.64 mg/kg with a mean value of 7.13 mg/kg. The soils of Dehgam taluka possess the highest mean value of DTPA-extractable Fe (7.87 mg/kg) and it was followed by Gandhinagar (7.05 mg/kg) and Kalol (6.96 mg/kg).The lowest mean value (6.65 mg/kg) of DTPA-extractable Fe (Table 4) was noted in soils of Mansa taluka. The medium Fe content in these soils may be due to presence of minerals like magnetite. Out of 160 soil samples, 55 samples (34.37 per cent) were found to be low, 79 (49.38 per cent) samples were medium and remaining 26 (16.25 per cent) samples were high in available Fe content (Table 5). Similar results were also reported for soils of Saurashtra region (Anon., 2004) [3], in Gandhinagar district by Patel *et al.*, (2017) [15] and for Patan district of Gujarat.

**DTPA-extractable Mn**

Most of the soil samples of Gandhinagar district were found high with respect to DTPA-extractable Mn. It was ranged from 3.54 to 23.44 mg/kg with a mean value of 12.38 mg/kg. Soils of Dehgam taluka have the highest mean value (13.07mg/kg) and it followed by Gandhinagar (12.44 mg/kg) and Mansa (12.43 mg/kg) talukas. The lowest mean value (11.59 mg/kg) was observed in Kalol taluka (Table 4). The 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. Out of 160 soil samples, 7 samples (4.37 per cent) were found to be low, 38 samples (23.75 percent) were medium and remaining 115 samples (71.88 per cent) were high in available Mn content (Table 3). Punithraj *et al.* (2012) [21] also observed similar results for tomato growing area of Hassan district of

Karnataka. Similar results were also reported by earlier workers for soils of Gandhinagar district (Patel *et al.,* 2017) [15], for Jamnagar district (Shirgire, 2012) [25].

**DTPA-extractable Zn**

The available Zn status of soils of Gandhinagar district was medium. It ranged from 0.16 to 1.62 mg/kg with a mean value of 0.64 mg/kg. Soils of Dehgam taluka possess the highest mean value (0.73 mg/kg) of available Zn followed by Kalol (0.67 mg/kg) and Gandhinagar (0.59 mg/kg) talukas. The lowest mean value (0.58 mg/kg) was observed in Mansa taluka (Table 4). Out of 160 soil samples, 64 samples (40 per cent) were found to be low, 75 samples (46.88 per cent) were medium and remaining 21 samples (13.12 per cent) were high in available Zn content (Table 5). Similar results were observed by Meena *et al*., 2006, Shirgire 2012, Patel *et al.*, 2017 and Hadiyal *et al.*, 2016 [15, 25, 11].

**DTPA-extractable Cu**

In general, the available Cu status of soils of Gandhinagar district was high. The available Cu ranged from 0.37 to 1.78 mg/kg with a mean value of 0.86 mg/kg. The highest mean value of available Cu was observed in Dehgam taluka soils (0.94 mg/kg) followed by soils of Gandhinagar (0.88 mg/kg) and Kalol (0.83 mg/kg) talukas. The lowest mean value (0.81 mg/kg) was observed in Mansa taluka (Table 4). The high status of available Cu in soils of Gandhinagar district might be due to the application of copper containing chemicals mostly as fungicides. Out of 160 soil samples, 3 samples (1.88 per cent) were medium and remaining 157 samples (98.12 per cent) were high in available Cu content (Table 5). Similar results were also obtained for soils of southern Saurashtra region (Patel, 2010) [16], for Gandhinagar district (Patel *et al.,* 2017) [15] and for Patan district of Gujarat (Annual Report, 2013) [1].

**Nutrient index of available micronutrients**

The nutrient indexes for available micronutrients are presented in Table 6. The fertility maps of available micronutrients in soils of Gandhinagar district (based on nutrient index) are presented in table 6. Overall, nutrient index for available Fe, Mn, Zn and Cu were 1.82, 2.68, 1.73 and 2.98 in soils of Gandhinagar district, respectively. The highest nutrient index 1.93 for iron was noted in Gandhinagar taluka, highest nutrient indexes for Mn (2.75) and Zn (1.85) were in Dehgam, and the highest nutrient index 3.0 for both Kalol and Dehgam in Cu. The lowest nutrient index of 1.77and 2.56 were reported for DTPA-extractable Fe and Mn in soils of Mansa and Kalol talukas, respectively. The Gandhinagar taluka have the lowest nutrient indexes for DTPA-extractable Zn (1.62) and Cu (2.95). Based on overall nutrient index of soils in Gandhinagar district and the criteria suggested by Stalin *et al.* (2010) [28], the soils of Gandhinagar district were very high in available Cu and Mn, marginal in available Fe and available Zn. Similar results were reported for available Fe and Mn in soils of Amreli district of Gujarat (Polara and Kabaria, 2006) [20], in available Zn and Cu in the soils of Patan district of Gujarat (Annual Report, 2013) [2].

**Table 6:** Talukawise nutrient index and fertility status of available micronutrients in soils of Gandhinagar district

| Name of Taluka | Nutrient index | | | | Fertility status | | | |
|---|---|---|---|---|---|---|---|---|
| | Fe | Mn | Zn | Cu | Fe | Mn | Zn | Cu |
| Mansa | 1.77 | 2.68 | 1.65 | 2.96 | Marginal | Very High | Low | Very High |
| Kalol | 1.80 | 2.56 | 1.80 | 3.00 | Marginal | High | Marginal | Very High |
| Gandhinagar | 1.93 | 2.70 | 1.62 | 2.95 | Marginal | Very High | Low | Very High |
| Dehgam | 1.82 | 2.75 | 1.85 | 3.00 | Marginal | Very High | Marginal | Very High |
| District | 1.82 | 2.68 | 1.73 | 2.98 | Marginal | Very High | Marginal | Very High |

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

The correlation among different properties of soils (EC, pH, OC, available Fe, Mn, Zn and Cu) were worked out and their values are presented in Table 7. It is seen from the data that the available Fe (r = -0.020), Zn (r = -0.018) and Cu (r = -0.065) showed negative correlation with soil pH. The micronutrient availability decreased with increasing soil pH. Similar results were recorded for soils of De was district of Madhya Pradesh (Chouhan *et al.,* 2012) [6] and for Nagpur district of Maharashtra (Wagh *et al.,* 2016) [29].

**Table 7:** Correlation coefficient (r) among different properties of soils of Gandhinagar district

| Soil properties | EC | pH | OC | Avail. Fe | Avail. Mn | Avail. Zn |
|---|---|---|---|---|---|---|
| pH | 0.019 | | | | | |
| OC | 0.085 | -0.610** | | | | |
| Avail. Fe | -0.155 | -0.020 | 0.062 | | | |
| Avail. Mn | -0.146 | 0.122 | 0.177* | -0.035 | | |
| Avail. Zn | -0.149 | -0.018 | 0.026 | 0.113 | 0.122 | |
| Avail. Cu | -0.164* | -0.065 | 0.087 | 0.241** | 0.149 | -0.070 |

*Significant at 5 per cent level

** Significant at 1 per cent level

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