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# Assessment of nutrients and heavy metal status in soils of Akola, Maharashtra

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**Abstract**
The soil survey was carried out during 2017-19 in Akola district (M.S) by using GPS technique in Agro-Ecological-Sub-Region (AESRs) of Akola district namely, AESR 6.3 a (K5Dm4). For this purpose soil samples (0-20 cm) were collected from different villages of three tehsils of Akola district. These soil samples were analysed for micro, secondary nutrients and heavy metal status of soil. The soils under the study were neutral to strongly alkaline in nature, safe in limit of electrical conductivity and calcareous in nature.The deficiencies of Zn, Fe, and B in these soils were 40, 20 and 27 per cent respectively whereas, exchangeable Ca, Mg and S were found adequate in all the soils. The organic carbon were significantly correlated with micronutrients except that DTPA-Mn. Available S was significantly and negatively relationship with organic carbon (r=-0.726**). The values of Co, Cd, Pb, Cr and Ni in soil were observed below than the permissible limit.

**Keywords:** Physico-chemical properties, correlation, micro and secondary nutrients, heavy metal

## Introduction

Micronutrients have emerged as a wide spread deficiency in Indian soils particularly Zn deficiency in Maharashtra, due to continual cropping, soil and water losses, percolation losses and with the use of high analysis fertilizers in exhaustive cropping system with minimum use of organic manures.

In India widespread deficiencies of Zn, Fe and B are associated with specific soil correctives and cropping schemes. Boron and zinc deficiencies are becoming increasingly important in Indian soil mostly because of decrease in soil, low soil organic matter and non-addition of deficit minerals on the basis of soil test. Moreover, steady growth of crop yield specifically through green revolution, actually compounded the problem by progressively depleting micronutrients pool. The importance of secondary minerals and micronutrients has been realized during the past three decades and widespread minerals deficiencies are observed in most of the soils of Maharashtra. Such minerals are playing an important role in increasing food grain production to fulfill the ever growing demand.

Soil pollution composes the pollution of soils with substances, mostly chemicals that are out of place or are current at concentrations more than normal which may have detrimental impacts on humans or other organisms. It is difficult to define soil pollution exactly because different opinions exist on how to characterize a pollutant; while some consider the use of pesticides admissible if their effect does not exceed the intended result, others do not consider any use of pesticides or even chemical fertilizers admissible. However, soil pollution is also caused by means other than the directly addition of man-made chemicals such as agricultural runoff water, erosion, industrial wastage substances, acidic components and radioactive fallout. Keeping these in view and also lack of information on micronutrients status to identify the emerging micronutrient deficiency or toxicity in the soils, therefore a comprehensive study was undertaken to know the micronutrient indices and its fertility status in soils of Akola, Maharashtra.

## Materials and Methods

Akola (AESR 6.3 a (K5Dm4) situated at Deccan Plateau in between 21° 07' 19"N latitude and 77° 03' 34" E longitude at an altitude of 307 m above msl of Akot, 20° 4243"N latitude and 77° 27' 30" E longitude at an altitude of 282 m above msl of Murtijapur and 20° 54' 33"N latitude and 76° 50' 17" E longitude at an altitude of 254 m above msl of Telhara tehsil has been classified under hot semi-arid ecosystem. Geo-referenced representing surface (0-20 cm depth) soil samples were collected tehsil wise during 2017-18 and 2018-19 of Akola district.

The latitude, longitude and altitude of sampling sites in the study area were recorded with the help of Geographical Positioning System (GPS). The grid survey (5 km interval) of district was carried out, and soil samples from different cropping systems in homogeneous area were selected. The villages were selected randomly in each district. So the sampling sites scattered uniformly in each tahsil of the district.

Soil pH was determined with the help of pH meter in 1:2.5 soils: water suspension as described by Jackson (1973) [6]. Organic carbon was determined by Walkley and Black wet-oxidation method (1947) [21]. Calcium carbonate was determined by rapid titration method (Piper, 1966) [13]. The micronutrients and heavy metal in these soil samples were extracted with DTPA solution (Lindsey and Norvell, 1978) [9]. Available boron was determined by 0.01 M $CaCl_2$extract with Azo-Methane –H method (Berger and Troug, 1939) [3]. Exchangeable Calcium and Magnesium were determined by $NH_4OAc$ extract using Atomic Absorption Spectrophotometer (Hesse, 1971) [5]. The DTPA- micronutrients and heavy metal status areas were delineated into low, medium and high based on their limits.

## Results and Discussions

### Physico-chemical properties

In Table 1, the soils were neutral to strongly alkaline (7.38 to 8.54) in reaction. The electrical conductivity ranged from 0.22 to 0.55 dS m$^{-1}$ with a mean value of 0.32 dS m$^{-1}$ indicating non-saline in nature. The organic carbon ranged from 1.84 to 8.70 g kg$^{-1}$ with a mean value of 5.02 g kg$^{-1}$ soil. The soil samples of Akola district were found low to medium in organic carbon. The $CaCO_3$ ranged from 2.13 to 10.22% with a mean value of 5.97%. The soils were slightly calcareous to calcareous in nature. The variation in calcium carbonate content may be attributed due to the difference in the type of parent material from which these soils have been formed. Taje *et al*., (2022) [20] reported similar results.

### Micronutrients

### Available zinc

The available zinc varied from 0.37 to 2.34 mg kg$^{-1}$ with mean value of 0.99 mg kg$^{-1}$ (Table 1). Similar results were reported by Meena *et al*., (2021) [12]. On the basis of critical limit (0.6 mg kg$^{-1}$), 40% soil samples were deficient, 53% soil samples were marginal and 7% soil samples were adequate in available zinc. The deficiency of available zinc, might be due to low organic matter content in soil, which acts as natural chelating agent, washing the uppersoil surface and excess of pH in soil. The similar observation was also noted by Kumar *et al*., (2014) [8] in soils of Vertisol of Kabeerdham district of Chattisgargh.

### Available copper

Available copper content in soils varied from 0.78 to 4.98 mg kg$^{-1}$ with a mean value of 2.95 mg kg$^{-1}$ (Table 1). Srivastava *et al*., (2016) [19] reported the similar results. Considering 0.2 mg kg$^{-1}$ soil as a critical limit, 7% soil samples were medium (0.2-0.4 mg kg$^{-1}$) and 93% soil samples were high in available Cu. The sufficiency of Cu in soils it might be due to synergistic effect of soil parameters like soil pH, EC and OC which have dominant role in the availability of Cu. Brar *et al*. (2008) [4] also, showed the status of available copper from low to sufficient with wide variation in Indian soils.

### Available iron

Available iron content in soils of Akola district ranged from 2.45 to 28.37 mg kg$^{-1}$ with a mean value of 12.64 mg kg$^{-1}$ (Table 1). Srivastava *et al*. (2016) [19] also reported similar results. Considering 4.5 as the critical limit, 20% soil samples were deficient (< 4.5 mg kg$^{-1}$), 60% soil samples were marginal (4.5-7.5 mg kg$^{-1}$) and 20% soil samples fall in the category of adequate (> 7.5 mg kg$^{-1}$). The differentiation was occur due to various soil types and their characteristics, vegetation, nature of chemical extractants and agro-ecological condition of the particular region. Yadav and Meena (2009) [22] found that, 56 per cent soil samples were deficit in DTPA-Fe content in soil series of Degana, Rajasthan. The increase in iron deficiency in the soils of Akola district might be attributed to intensive cultivation of high yielding hybrids of almost all crops as well as high calcium carbonate content in soils.

### Available manganese

Available manganese varied from 5.89 to 23.47 mg kg$^{-1}$ with a mean value of 14.56 mg kg$^{-1}$ (Table 1). Singh and Yadav (2017) [17] also reported similar results. Considering 2 as the critical limit, 20% soil samples were marginal (2.0-4.0 mg kg$^{-1}$) and 80% soil samples fall in the category of adequate (> 4 mg kg$^{-1}$). The availability of Mn decreased with increase in $CaCO_3$ content and pHof soils which might due to the formation of less soluble compounds like $MnCO_3$ or Mn $(OH)_2$. The higher pH favors the formation of less soluble organic complexes of Mn, which reduces the availability of Mn and the activity of soil micro-organism which oxidizes soluble $Mn^{2+}$ (Singh *et al*., 2013) [17].

### Available boron

The available boron in the soils of Akola district (Table 1) varied from 0.32 to 1.37 mg kg$^{-1}$ with a mean of 0.75 mg kg$^{-1}$. Basumatary *et al*. (2021) [2] reported similar results. On the basis of 0.5 mg kg$^{-1}$ as the critical limit, 27% soil samples were deficient (<0.5 mg kg$^{-1}$), 53% soil samples were marginal (0.5-0.75 mg kg$^{-1}$) and 20% soil samples were recorded in the category of adequate (>0.75 mg kg$^{-1}$). Similar observations were recorded by Arora and Chahal (2014) [1].

### Secondary nutrients

### Available Sulphur

The available sulphur in different tehsils of Akola district (Table 1) varied from7.54 to 29.90 mg kg$^{-1}$ with a mean value of 19.64 mg kg$^{-1}$. Similar results were reported by Meena *et al*., (2021) [12]. On the basis of critical limit (<10mg kg$^{-1}$), 7% soil samples were observed in deficient while, 33% were found marginal and 60% were adequate in nature. The majority of soils were high in range, might be due to moderate to high content of organic carbon and fine texture of soils. Srinivasan *et al*. (2013) [18] examined available macro and micronutrients in cashew growing soils of South Kannada district of coastal Karnataka and reported that, available sulphur in the soils varied from 6.25 to 20 mg kg$^{-1}$.

### Exchangeable calcium

The exchangeable calcium (Table 1) in soil of Akola district ranged between 8.76 and 21.13 cmol $(p^+)$ kg$^{-1}$ with a mean value of 12.83 cmol $(p^+)$ kg$^{-1}$. Similar results were reported by Basumatary *et al*., (2021) [2]. The higher amount of exchangeable Ca in soils under study, might be due to high clay content in soil and calcareous in nature. The availability of exchangeable Ca is due to no leaching losses of bases and moderate to high organic carbon content in the soils. Shetty *et al.* (2008) [15] found that the exchangeable calcium ranged from 1.9 to 5.5 cmol ($p^+$) $kg^{-1}$ in maize growing areas of Southern Karnataka, while Srinivasan *et al.* (2013) [18] noticed that exchangeable calcium varied from 0.49 to 1.90 cmol ($p^+$) $kg^{-1}$ in cashew growing soils of coastal Karnataka.

**Exchangeable magnesium**

The exchangeable magnesium (Table 1) in soils of Akola district ranged from 5.68 to 14.25 cmol ($p^+$) $kg^{-1}$ with a mean value of 9.31 cmol ($p^+$) $kg^{-1}$. Similar results were reported by Basumatary *et al.*, (2021) [2]. On the basis of critical limit (10 cmol ($p^+$) $kg^{-1}$), 67% soil samples were deficient and 33% soil samples were sufficient in exchangeable magnesium. The deficiency of magnesium occurs due to coarse texture of soils. Shetty *et al.* (2008) [15] stated that exchangeable magnesium varies from 0.9 to 3.7 cmol ($p^+$) $kg^{-1}$ in maize growing areas of southern transition zone of Karnataka.

**Heavy metal status**

In Table 3, the concentration of Co, Cd, Pb, Cr and Ni varied from 0.011 to 0.170, 0.001 to 0.0450.01 to 0.42, 0.04 to 0.42 and 0.03 to 0.87 mg $kg^{-1}$ with mean values of 0.038, 0.015, 0.11, 0.24 and 0.44 mg $kg^{-1}$, respectively. The high Co and Cd were recorded in Akot tehsil and lowest value in Dhamangaon Akot tehsil. The highest value of Pb was recorded in the village of Sheri of Telhara tehsil and lowest value in the village of Akoli Jaha of Murtijapur tehsil. The maximum and low values of Cr status could be noticed in the village of Khodad and Rajur Sarode of Murtijapur tehsil. In Akot tehsil, Ramapur village recorded maximum value of Ni (0.87) and lowest value (0.03) was observed in Talegaon wadner village of Telhara tehsil. The concentration of heavy metals in the soils of the studied sites developed from different parent materials showed significant variation. Sandy soils from granite rocks generally contain lower concentration of heavy metals than clay soils derived from mafic rocks. Kumar *et al.*, (2021) [7] reported similar results in forest soil of Dehradun.

**Correlationship among soil properties with nutrient status in soils of Akola, Maharashtra**

The correlation between pH and Fe was found significantly but negatively correlated (r = -0.461**), while positive correlation was observed with organic carbon (r = 0.628**). Similar results of correlation were reported by Meena *et al.* (2012) [11]. pH is highly significant and negative correlation with S (r=-0.639**) followed by Fe (r=-0.461**) and Cu (r=-0.339*). This might be due to organic carbon forms soluble complexes with micronutrients which subsequently become available to plants (Shah and Andrabi, 2010) [14]. It could be observed that iron and micronutrients are decline with the rise in pH of the soil. pH also non-significantly negative correlated with Mn (r=-0.044).

Correlationhip of micronutrient with organic carbon in soil noticed that availability of micronutrients improve significantly with rise in organic carbon. Thus, regular application of organic matter to the soil is important for maintaining the level of organic carbon in soil to optimum level, which ultimately helps in supply of micronutrient continuously to the crops. Availability of DTPA-extractable micronutrients in presence of higher content of organic carbon is due to chelation of this metallic cation with humic substances in organic matter (Mandal *et al.* 2005) [10].

**Table 1:** Physico-chemical properties and nutrient status in soils of Akola, Maharashtra

| AESR | Sample No. | Soil Properties | | | | Micronutrients (mg $kg^{-1}$) | | | | | Secondary Nutrients | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | pH | EC dS $m^{-1}$ | OC (g $kg^{-1}$) | $CaCO_3$ (%) | Zn | Cu | Fe | Mn | B | S (mg $kg^{-1}$) | Ex. Ca | Ex. Mg |
| | | | | | | | | | | | | cmol ($p^+$) $kg^{-1}$ | |
| Akot | Ramapur-11 | 8.23 | 0.26 | 4.90 | 2.13 | 1.37 | 0.98 | 4.50 | 7.77 | 1.10 | 20.93 | 17.21 | 14.25 |
| | Dhamangaon-6 | 7.52 | 0.34 | 5.78 | 3.50 | 0.81 | 3.10 | 13.78 | 10.21 | 0.70 | 16.99 | 21.13 | 12.32 |
| | Kawsa-14 | 8.01 | 0.33 | 3.57 | 8.13 | 0.56 | 1.68 | 17.52 | 16.42 | 0.32 | 14. 00 | 12.10 | 8.18 |
| | Umara-82 | 7.68 | 0.30 | 5.21 | 10.22 | 0.96 | 4.10 | 28.37 | 19.65 | 0.80 | 21.12 | 9.87 | 7.79 |
| | Wadali-Satwai-12 | 8.17 | 0.22 | 4.58 | 4.24 | 1.42 | 1.59 | 21.11 | 23.47 | 0.48 | 27.97 | 10.36 | 8.70 |
| Murtijapur | Akoli Jaha-5 | 8.18 | 0.30 | 3.67 | 4.58 | 0.76 | 4.56 | 2.45 | 20.23 | 0.96 | 28.48 | 13.48 | 7.74 |
| | Rajur Sarode-6 | 7.93 | 0.30 | 8.70 | 2.38 | 1.38 | 0.78 | 3.74 | 18.45 | 0.69 | 10.40 | 12.16 | 8.14 |
| | Malkapur-3 | 8.04 | 0.44 | 3.77 | 4.88 | 0.54 | 1.74 | 11.78 | 22.52 | 1.25 | 26.20 | 8.76 | 5.68 |
| | Pingla-6 | 7.89 | 0.55 | 4.48 | 5.20 | 1.59 | 2.19 | 27.41 | 5.89 | 0.79 | 12.22 | 10.52 | 7.32 |
| | Khodad-5 | 8.04 | 0.32 | 5.10 | 3.71 | 1.47 | 3.11 | 14.24 | 9.98 | 0.44 | 7.54 | 9.78 | 8.19 |
| Telhara | Sadarpur-14 | 8.04 | 0.23 | 4.29 | 8.13 | 0.44 | 3.42 | 4.42 | 14.44 | 1.37 | 22.94 | 11.20 | 10.13 |
| | Talegaon Wadner-4 | 8.54 | 0.30 | 5.28 | 6.83 | 0.38 | 4.58 | 7.89 | 18.24 | 0.54 | 29.90 | 15.22 | 11.32 |
| | Khel Mukadam-2 | 8.11 | 0.29 | 1.84 | 9.63 | 0.59 | 4.00 | 13.14 | 13.47 | 0.91 | 11.15 | 19.28 | 14.15 |
| | Adsul-12 | 7.44 | 0.33 | 8.18 | 8.89 | 0.37 | 4.98 | 10.45 | 9.98 | 0.60 | 20.54 | 10.22 | 7.78 |
| | Sheri-15 | 7.38 | 0.31 | 6.00 | 7.12 | 2.34 | 3.52 | 8.88 | 7.69 | 0.42 | 18.65 | 11.23 | 8.10 |
| | Min. | 7.38 | 0.22 | 1.84 | 2.13 | 0.37 | 0.78 | 2.45 | 5.89 | 0.32 | 7.54 | 8.76 | 5.68 |
| | Max. | 8.54 | 0.55 | 8.70 | 10.22 | 2.34 | 4.98 | 28.37 | 23.47 | 1.37 | 29.90 | 21.13 | 14.25 |
| | Mean | 7.94 | 0.32 | 5.02 | 5.97 | 0.99 | 2.95 | 12.64 | 14.56 | 0.75 | 19.64 | 12.83 | 9.31 |
| | S.D | 0.31 | 0.08 | 1.72 | 2.63 | 0.57 | 1.37 | 8.12 | 5.75 | 0.31 | 7.22 | 3.73 | 2.55 |

**Table 2:** Per cent sample deficient, nutrient status and nutrient indices in soils of Akola, Maharashtra

| AESR | No. of Sample | Per cent sample Deficient | Number of samples | | | Nutrient Indices | Fertility Rating |
|---|---|---|---|---|---|---|---|
| | | | Low | Medium | High | | |
| Available-Zn | 15 | 40 | 6 (40) | 8 (53) | 1 (7) | 1.66 | Low |
| Available-Cu | | 0 | 0 (0) | 1 (7) | 14 (93) | 2.93 | High |
| Available-Fe | | 20 | 3 (20) | 9 (60) | 3 (20) | 2.00 | Medium |
| Available-Mn | | 0 | 0 (0) | 3 (20) | 12 (80) | 2.80 | High |
| Available-B | | 27 | 4 (27) | 8 (53) | 3 (20) | 1.93 | Medium |
| Available-S | | 7 | 1 (7) | 5 (33) | 9 (60) | 2.53 | High |

**Table 3:** DTPA-extractable heavy metal status (mg $kg^{-1}$) in soils of Akola, Maharashtra

| AESR | Sample No. | Co | Cd | Pb | Cr | Ni |
|---|---|---|---|---|---|---|
| Akot | Ramapur-11 | 0.170 | 0.045 | 0.09 | 0.28 | 0.87 |
| | Dhamangaon16 | 0.011 | 0.003 | 0.06 | 0.35 | 0.38 |
| | Kawsa-14 | 0.015 | 0. 021 | 0.07 | 0.21 | 0.29 |
| | Umara-82 | 0.049 | 0.001 | 0.09 | 0.20 | 0.66 |
| | Wadali-Satwai-12 | 0.023 | 0.031 | 0.15 | 0.30 | 0.63 |
| Murtijapur | Akoli Jaha-5 | 0.018 | 0.024 | 0.01 | 0.33 | 0.55 |
| | Rajur sarode-6 | 0.033 | 0.003 | 0.37 | 0.04 | 0.34 |
| | Malkapur-3 | 0.015 | 0.004 | 0.02 | 0.24 | 0.51 |
| | Pingla-6 | 0.023 | 0.037 | 0.07 | 0.17 | 0.38 |
| | Khodad-5 | 0.029 | 0.010 | 0.08 | 0.42 | 0.60 |
| Telhara | Sadarpur-14 | 0.046 | 0.002 | 0.09 | 0.29 | 0.48 |
| | Talegaon wadner-4 | 0.080 | 0.022 | 0.08 | 0.05 | 0.03 |
| | Khel mukadam-2 | 0.014 | 0.004 | 0.07 | 0.23 | 0.21 |
| | Adsul-12 | 0.018 | 0.012 | 0.04 | 0.22 | 0.37 |
| | Sheri-15 | 0.026 | 0.018 | 0.42 | 0.38 | 0.44 |
| | Min | 0.011 | 0.001 | 0.01 | 0.04 | 0.03 |
| | Max | 0.170 | 0.045 | 0.42 | 0.42 | 0.87 |
| | Mean | 0.038 | 0.015 | 0.11 | 0.24 | 0.44 |
| | S.D | 0.040 | 0.014 | 0.11 | 0.10 | 0.20 |

**Table 4:** Correlation among physico-chemical properties with nutrient status in soils of Akola, Maharashtra

| | pH | OC | $CaCO_3$ | Zn | Cu | Fe | Mn | B | S |
|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | |
| OC | 0.628$^{**}$ | 1 | | | | | | | |
| $CaCO_3$ | -0.279$^{*}$ | -0.283$^{*}$ | 1 | | | | | | |
| Zn | 0.471$^{**}$ | 0.710$^{**}$ | -0.317$^{*}$ | 1 | | | | | |
| Cu | -0.339$^{*}$ | -0.371$^{**}$ | 0.230$^{NS}$ | -0.373$^{**}$ | 1 | | | | |
| Fe | -0.461$^{**}$ | -0.596$^{**}$ | 0.079$^{NS}$ | -0.485$^{**}$ | 0.288$^{*}$ | 1 | | | |
| Mn | -0.044$^{NS}$ | 0.048$^{NS}$ | -0.172$^{NS}$ | 0.125$^{NS}$ | 0.100$^{NS}$ | 0.318$^{*}$ | 1 | | |
| B | 0.647$^{**}$ | 0.742$^{**}$ | -0.344$^{*}$ | 0.632$^{**}$ | -0.432$^{**}$ | -0.529$^{**}$ | 0.039$^{NS}$ | 1 | |
| S | -0.639$^{**}$ | -0.726$^{**}$ | 0.198$^{NS}$ | -0.725$^{**}$ | 0.415$^{**}$ | 0.537$^{**}$ | -0.082$^{NS}$ | -0.774$^{**}$ | 1 |
| n = 55 (n= number of observations) | | | | | | | | | |

## Conclusion

From the study it could be concluded that the soil of Akola district were neutral to strongly alkaline in nature (7.38 to 8.54), low to medium in organic carbon status and calcareous in nature. The DTPA-Zn, Cu, Fe, Mn and B varied from 0.37-2.34, 0.78-4.98, 2.45-28.37, 5.89-23.47 and 0.32-1.37 mg $kg^{-1}$ respectively, indicating wide spread deficiencies of zinc 40%, Fe- 20%, B-27% and S-7%. The soils of Akola were high in Ca and Mg and available sulphur. The organic carbon was significantly correlated with all micronutrients except DTPA-Mn. High nutrient index was observed in Cu (2.93), Mn (2.80) and S (2.53), while medium in Fe (2.00) and B (1.93).

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