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GIS Based Spatial Variability of Available Micro Nutrients in Soil of District Indore, Madhya Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The investigation was conducted in 2020-21 at Indore, District Madhya Pradesh, to know the DTPA-extractable micronutrientsviz., Zn, Fe, Mn, Cu and $CaCO_3$. Surface soil samples were collected grid wise by using cadastral map of the study area and were analyzed for their fertility status. The DTPA-extractable micronutrients viz., Zn, Fe, Mn, and Cu ranged from 0.24 to 1.61mg kg^{-1}, 3.9 to19.95 mg kg^{-1}, 1.25 to 9.85 mg kg^{-1}, 0.18 to 2.58 mg kg^{-1} respectively and $CaCO_3$from 1.25 to 12.5 %. Out of 190 samples, analyzed, 51% samples having less than 6.0%$CaCO_3$ content, 49% samples were having between 6 to 18 %. $CaCO_3$ content. About 42.1% samples of the district is deficient in Zn, and Deficiency of Fe, Mn and Cu is negligible. spatial variability Soil fertility maps of soil attributes could be used as a guide for site-specific nutrient management in similar soils.The

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available nitrogen was low, phosphorus content ranged from low to medium, and potassium content ranged from medium to high. Using the results of the field survey and laboratory study, the soil heterogeneity units were calculated using Arc-GIS 10.4.1.

Keywords: GIS; micronutrients; soil properties; spatial variability.

1. INTRODUCTION

"Soil fertility refers to the inherent capacity of a soil to supply essential nutrients to plants in an adequate amount and in the correct proportion at the right time for their optimum growth.Evaluating the spatial variability of soil properties, including micronutrients, and mapping such variations are very useful and applicable techniques for the precise determination of soil behavior fluctuations. Such evaluations can be used for optimum fertilization recommendation because appropriate use of nutrients can contribute to enhanced crop quantity and quality, while being environmentally sustainable" [1]. With respect to the great significance of micronutrients for human health, plant growth.

"In Indore soil spatial variability in soil nutrient availability is presumed to high due to small farm and varied management. Such variation decreases the effectiveness of uniformly applied soil management practices thus reducing the productive potential of given area. Majority of soil maps are prepared by convenient methods and very little work has been done so far to use the modern spatial prediction techniques in this regard" [2-4]. GIS can be used to create a soil fertility map of a region, which aids in understanding the spatial and temporal state of soil fertility and aids in the formulation of site-specific balanced fertilizer recommendations. These tools enable accurate field mapping as well as the computation of intricate spatial connections between soil fertility parameters. "Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site-specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally. Under this context, prepare a fertility map and of such map as a decision support tool for nutrient management, will not only be helpful for adopting a rational approach compared to farmer practices or blanket use of state recommended fertilization, but will also reduce the necessity for elaborate plot-by-plot soil testing activities. Geographic information system (GIS) is a powerful tool, which helps to integrate many types of spatial information such as agroclimatic zone, land use, soil management, etc. to derive useful information" [5] "Furthermore, GIS generated soil fertility maps may serve as a decision support tool for nutrient management" [6].

"Soil is the main source of macro and micronutrients; hence determination of how soil factors can affect micronutrient solubility and availability is of great significance. The availability of soil micronutrients for plant growth and yield production is a function of different parameters, including soil salinity and acidity, soil organic matter and texture, and soil biological activities" [7]. "Hence, determination of such parameters is important for evaluating micronutrient behavior in the soil and for suggesting appropriate e methods of enhancing micronutrient availability to plant" [7].

The accurate estimation of spatial distribution of soil properties is important in precision agriculture and is one of the bases for decision and policy maker to make plans and strategies. Therefore, it is imperative to map the fertility status of the soil and promote the recommendation of soil test for balanced nutrition to maintain soil health.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Geographically location of the Indore is at 22°43'4.51" N 75°49'59.88" E in M.P having temperature range of 23°C to 43°C in summer and 7°C to 23°C in winter. Based on soil taxonomy (USDA, 2010), this region has Vertosols and associated soil orders. These soils are montmorillonite, neutral to slight alkaline and having high swell shrink potential.

2.2 Soil Sampling and Processing

The one hundred ninety surface soil samples with GPS were collected from different location of four block of Indore district. "Approx. 1.0 kg of representative composite soil sample was collected from and logged into properly labeled sample bag. Then soil samples were air dried

Table 1. Category of various parameters and their range

Category	Parameters and range				
	Zn(mgkg^{-1})	Fe(mgkg^{-1})	Mn(mgkg^{-1})	Cu(mgkg^{-1})	$CaCO_3$(%)
I	<0.6	<4.5	<2.0	<0.2	<6
II	0.6-1.2	4.5-9.0	2.0-4.0	0.2-0.4	6-18
III	>1.2	>9.0	>4.0	>0.4	>18

and crushed with wooden pestle and mortar and sieved through 2 mm sieve. These samples were used for determination of various characteristics of soil" [6].

2.3 Laboratory Analysis of Soil Samples

The micronutrients (Zn, Cu, Fe and Mn) were extracted by using 0.005M di ethylene tri amine penta acetic acid (DTPA),0.01M calcium chloride dehydrate and 0.1 m trithanol amine buffered at pH 7.3 [8] and concentrations were analyzed by atomic absorption spectrophotometer.The soil $CaCO_3$ was determined by wet chemistry titration method as described by Richards (1954).

2.4 Preparation of Soil Fertility Maps

Soil fertility maps were prepared using Arc- GIS 10.4.1 employing krigging as the interpolation method.

2.5 Category Defined

The categories were defined based of sample analyzed values obtained and presented in Table 1.

2.6 Statistical Analysis

Variability of data was assessed using mean and standard deviation for each set of data.

3. RESULTS AND DISCUSSION

3.1 DTPA- Zn Status of the Soils of Indore District

The available Zn status of the soils of Indore district ranged from 0.24 to 1.61 mg kg^{-1} with an average value of 0.81 mg kg^{-1} with standard deviation 0.37 mg kg^{-1} and coefficient of variation (CV) 45.99% (Table 2). Out of 190 samples, 42.1% samples fall under deficient status, 38.4 % each sample was sufficient and 19.5% sample under high in Zn status (Table 3).

Spatial distribution of available–Zn in the Indore district soils: The variability Map (Fig. 2) of soils was divided into threecategories (Table 1). It is evident from thespatial variability Map of available-Zn of Indore district the maximum area falls under the category I (<0.6 mg kg^{-1}) followed by category II (0.6-1.2 mg kg^{-1}) and minimum under category III (>1.2mgkg^{-1}) The results are in conformity with the finding of Sharma and Chaudhari [9] in soils of Solan district in North-West Himalayas. Similar findings were also reported by Rajeswaret al*.* [10] and Singh et al*.* [11].

3.2 Available Fe Status of the Soils of Indore District

The available Fe content (Table 2) of the soils of Indore district ranged from 3.9 to 19.9 mg kg^{-1} with an average value of 9.1 mg kg^{-1} with standard deviation 2.8 mg kg^{-1} and coefficient of variation (CV%) 30.9 (Table 2). out of 190 samples, 50% samples fall under sufficient status and 49.5% sample under high Fe Status. Only 0.5% soil sample were recorded under deficient Fe status (Table 3).

3.3 Spatial Distribution of Available–Fe in the Indore district soils

The Fe variability map for Indore district, the soils were divided in to three categories (Table 1). The spatial variability Map (Fig. 3) of available-Fe of Indore district observed that the maximum area falls under the category II (4.5- 9mg kg^{-1}) followed by category III (>9.0) and minimum was under category I(>4.5mg kg^{-1}). Similar results were also observed by Sharma et al*.* [12]. The available iron in surface soils has no regular pattern of distribution as reported by Nayak et al*.* [13].

3.4 Available Mn Status of the Soils of Indore District

The available Mn content (Table 2) of the soils of Indore district ranged from 1.25 to 9.85 mg kg^{-1} with an average value of 4.43 mg kg^{-1} with standard deviation 1.29 mg kg^{-1} and coefficient of variation (CV%) 29.20 (Table 2). out of 190 samples, 59% of soil samples fall under high status followed by 40.5% in sufficient status and 0.5% comes under deficient status (Table 3).

Table 2. Minimum, maximum, mean, standard deviation and coefficient of variance values of all the samples

Particulars	Zn(mgkg^{-1})	Fe(mgkg^{-1})	Mn(mgkg^{-1})	Cu(mgkg^{-1})
MIN	0.24	3.9	1.25	0.18
MAX	1.61	19.95	9.85	2.58
MEAN	0.81	9.13	4.43	0.86
SD	0.37	2.82	1.29	0.38
CV (%)	45.99	30.96	29.20	44.79

Table 3. Percentage of Zn, Fe and Mn samples falls under various range

Zn(mgkg^{-1})	Samples%	Fe(mgkg^{-1})	Samples%	Mn(mgkg^{-1})	Samples%
Deficient (<0.6)	42.1	Deficient (<4.5)	0.5	Deficient <2.0	0.5
Sufficient (0.6-1.2)	38.4	Sufficient (4.5-9.0)	50.0	Sufficient 2.0-4.0	40.5
High (>1.2)	19.5	High (>9.0)	49.5	High level >4.0	59.0

Table 4. Distribution of $CaCO_3$ status in the soils of Indore district

$CaCO_3$(%)	No. of Samples	Samples%
Under <6.0 status	97	51
Between 6 to 18	93	49
High level >18	-	-

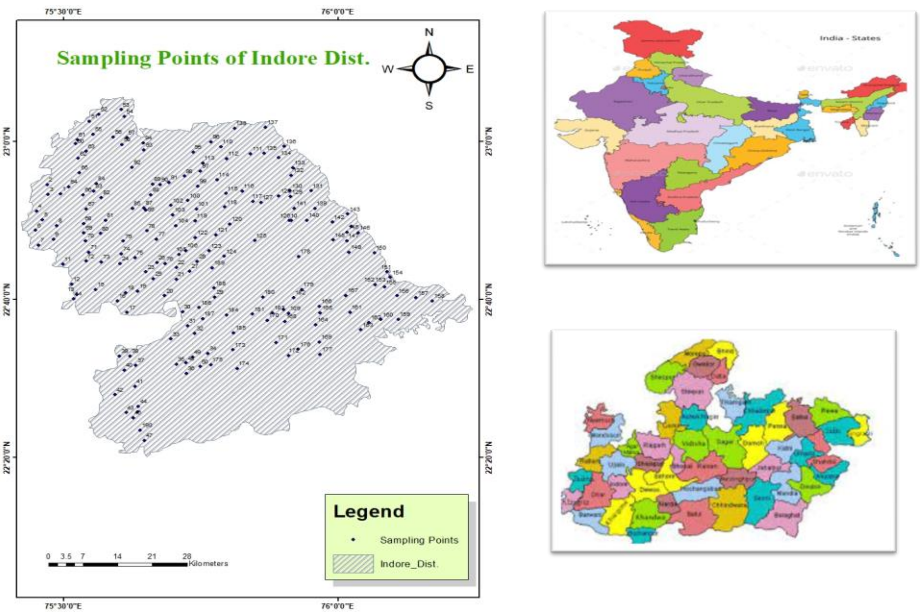

Fig. 1. Sampling point as per GPS location of Indore District

3.5 Spatial Distribution of Available–Mn in the Indore District Soils

Spatial variability Map (Fig. 4) of Available Mn of the Indore district soils is prepared as per the categories given in Table 1. It is evident from the map that the maximum area falls under the category III (>4.0 mg kg^{-1}) and minimum area under category I (<2mgkg^{-1}). the available manganese was sufficient in most of the samples analyzed. This may be due to neutral pH and nature of the parent material as reported by Meena et al. [14].

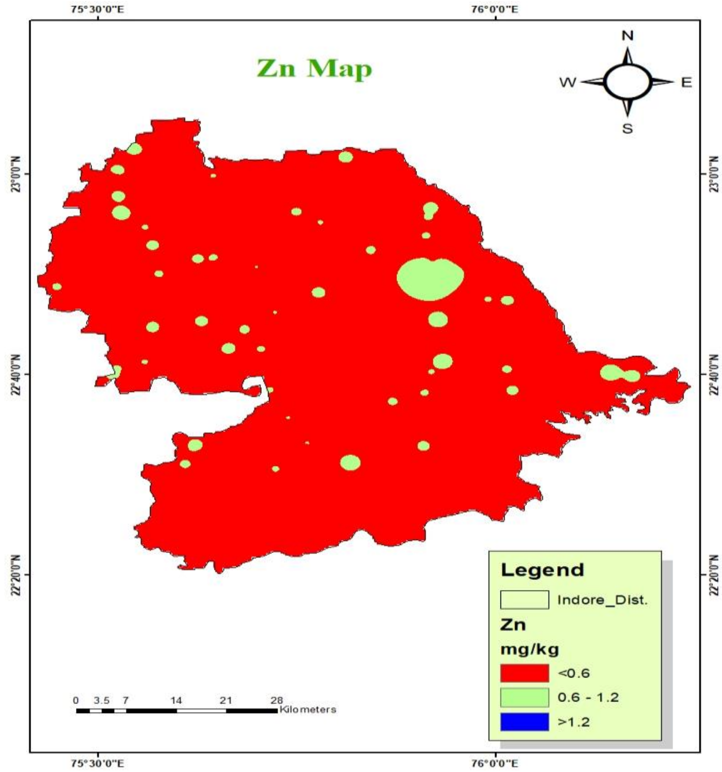

Fig. 2. Spatial distribution of Zn in the soils of Indore District

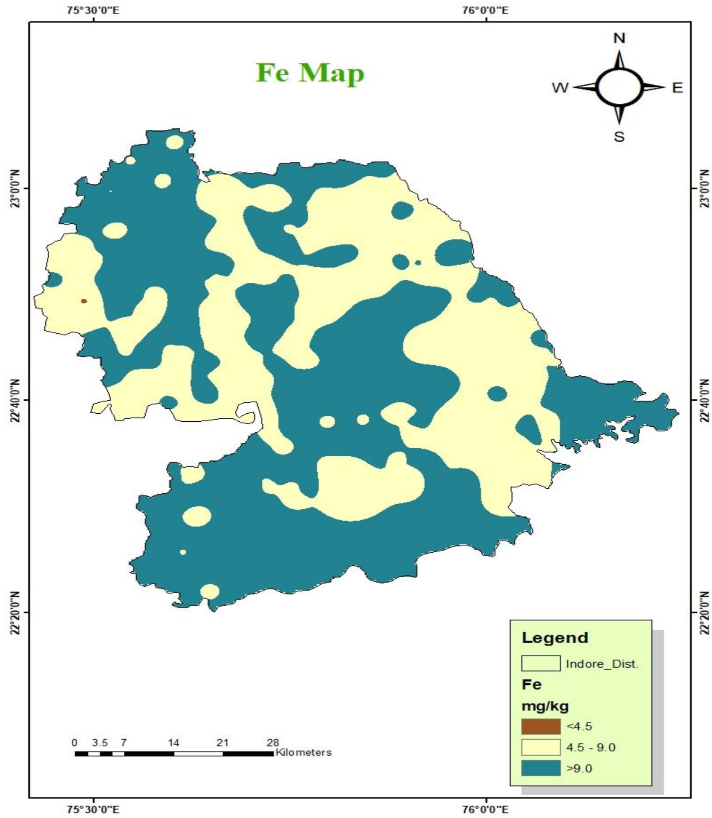

Fig. 3. Spatial distribution of Fe in the soils of Indore District

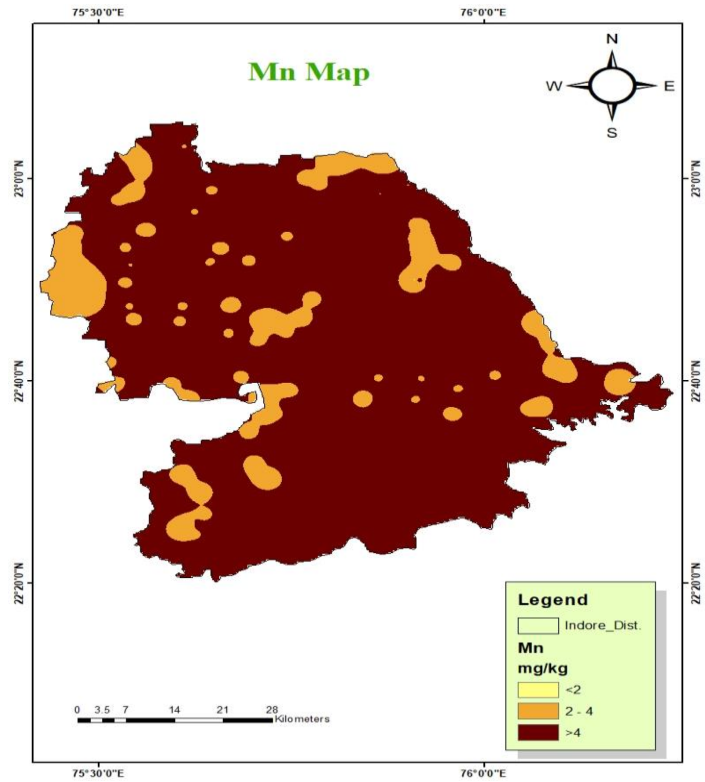

Fig. 4. Spatial distribution of organic Mn in the soil of Indore District

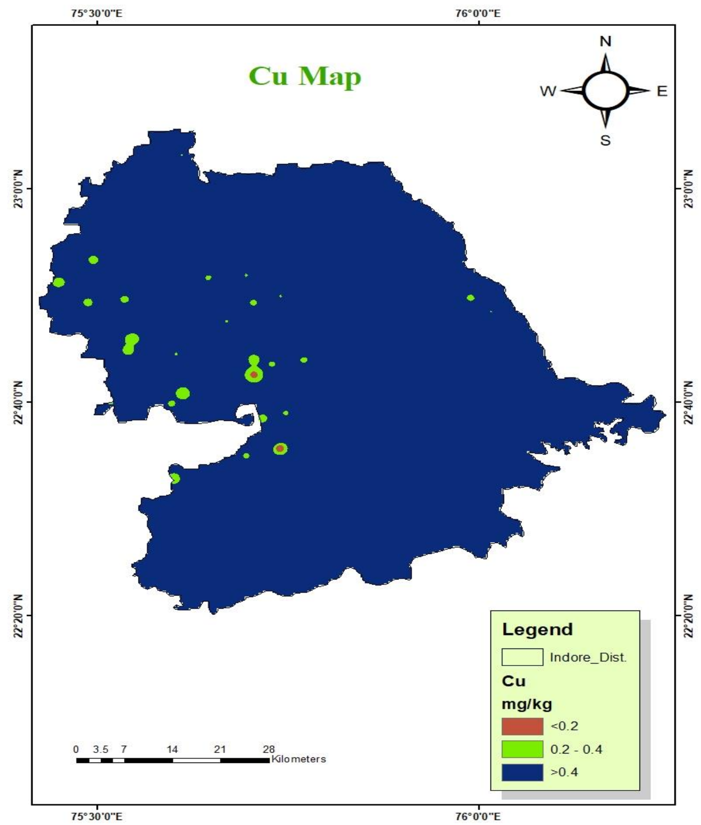

Fig. 5. Spatial distribution of available Cu in the soils of Indore District

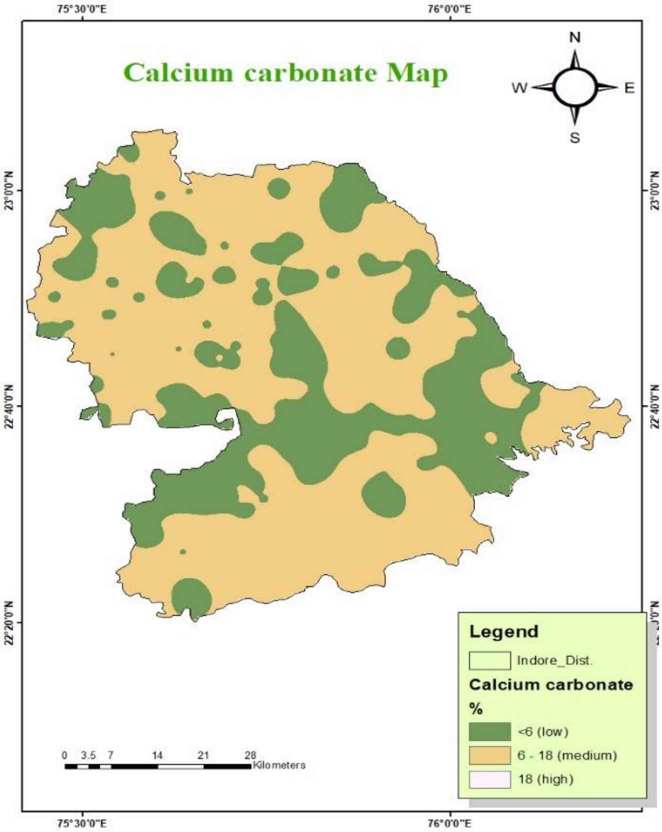

Fig. 6. Spatial distribution of available $CaCO_3$ in the soils of Indore District

3.6 Available Cu Status of the Soils of Indore District

The available Cu content (Table 2) of the soils of Indore district ranged from 0.18 to 2.58 mg kg^{-1} with an average value of 0.86 mg kg^{-1} with standard deviation 0.4 mg kg^{-1} and Coefficient of Variation (CV%) 44.8%. Out of 190 samples, analyzed, 1% samples falls under deficient status 10.5% soil under sufficient status and 88.5% samples were high in Cu status (Table 4).

3.7 Spatial Distribution of Available–Cu in the Indore District Soils

Spatial variability Map of Available Cu of the soils of Indore district is presented in Map (Fig.5). To prepare the Cu variability Map soils were divided into three categories (Table 1). It is evident from the Map that the maximum area falls under the category III (> 0.4 mg kg^{-1}) followed by sufficient category II (0.2-0.4mg kg^{-1}) and minimum area under category I (<0.2 mg kg^{-1}) the result same as reported that available copper content in Madhya Pradesh soils ranged from 0.12 to 5.77 mg kg^{-1} Singh et al.[15].

3.8 Calcium Carbonate ($CaCO_3$) Status of the Soils of Indore District

Out of 190 samples, analyzed, 51% samples having less than 6.0% $CaCO_3$ content, 49% samples were having between 6 to 18 % $CaCO_3$ content. (Table 4).

3.9 Spatial Distribution of Calcium Carbonate ($CaCO_3$) in the Soils of Indore

Spatial variability Map of calcium carbonate ($CaCO_3$) of the soils of Indore presented in Fig.6 To prepare the calcium carbonate variability Map soils were divided into three categories (Table 1). It is evident from the Map that the maximum area falls under the category I (<6.0%) followed by category II (6.0 to18%).

4. CONCLUSION

Out of total 190 soil samples tested of DTPA-extractable, low to sufficient level of Zn and Sufficient level of Fe, Cu and Mn. 51% samples having less than 6.0% $CaCO_3$ content, 49% samples were having between 6 to 18% $CaCO_3$ content. Hence, the soils require major attention regarding micronutrient deficiency of Zn and further addition of organic matter in soil. It also needs attention regarding better nutrient management practices and regular monitoring of soil health for better crop production in future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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