Original Research Article

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

Abstract

Soil properties including micronutrients and their balanced use can significantly affect plant growth and crop production. this research was spatial variation of different soil properties including micronutrients The investigation was conducted in 2020-21 at Indore District Madhya Pradesh, Basedon 190 geo referenced surface soil samples, the spatial variability of DTPA-extractable micronutrients viz., Zn, Fe, Mn, and Cu, in have been mapped in a GIS environment, and The iradequacy determined as per the criteria followed in the soil testing laboratories. Zn content in soils varied from 0.24 to 1.61mg kg-1, Fe from 3.9 to19.95 mg kg-1, Mn from 1.25 to 9.85 mg kg-1 and Cu from 0.18 to 2.58 mg kg-1. About 42.1% samples of the district is deficient in Zn, and Deficiency of Fe, Mn and Cu is negligible. Individual micronutrient deficiency is more prominent than deficiency of micronutrients in combinations. A broad positive correlation of the DTPA-extractable micronutrients is found with soil organic carbon and clay, while soil pH and CaCO3 has negative influence on the availability of Zn, Mn and Fe. Using the field survey and laboratory analysis results, the soil heterogeneity units were determined using Arc-GIS 10.4.1. Based on data obtained after analysis; the maps of all parameters were prepared which will be successfully used in the future for site-specific nutrient management.

Comment [a1]: How the relationsihip with the GIS or spatial analysis?

Comment [a2]: The use of this tools can be described at methodology. Not in abstract.

Comment [a3]: - In abstract, it has NOT been explained/decribed the result of spatial variability.
- Please briefly add the objective of this study. (what is the benefit of using the GIS tools

Keywords GIS, micronutrients, soil properties, spatial variability,

Introduction

Comment [a4]: - In the beginning, please describe about the problem as the background og this study.
-In the end of introduction, please provide briefly the objective of this study and also the benefit and the implication in farming practices.

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 (Miransari and Mackenzie 2010).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 (Shah *et al.,* 2012; Pal *et al*., 2014; Behara and shukla 2014) GIS can be used in producing soil fertility map of an area that helps to understand the status of soil fertility spatially and temporally, which will help in formulating site-specific balanced fertilizer recommendation. These technologies allow fields to be mapped accurately and also allow complex spatial relationships between soil fertility factors to be computed.

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 (Singh *et al.,* 2017) Furthermore, GIS generated soil fertility maps may serve as a decision support tool for nutrient management.

Soil is the main source of micronutrients; hence determination of howsoilfactorscanaffect micronutrient solubility and availability is of great significance. The availability ofsoil micronutrients for plant growth and yield production is a function of different parameters, including s oilsalinityandacidity,soilorganicmatterandtexture,andsoilbiologicalactivities(Karaca2004).Hence, determinationofsuchparametersisimportantforevaluatingmicronutrientbehaviorinthesoilandforsug gestingappropriate emethodsofenhancingmicronutrientavailabilitytoplant.

Comment [a5]: Please provide also the macro-nutrient in order to explain soil fertility thoroughly.

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

Comment [a6]: What kind of plans and strategies? Please provide some implementations or examples.

of soil test for balanced nutrition to maintain soil health.

Materials and Methods

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.

Comment [a7]: At methodology, the spatial approach has not been explained, while in the abstract and title the use of GIS tool is important.

Soil sampling and processing

GPS based one hundred surface soil samples collected from different location 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 and crushed with wooden pestle and mortar and sieved through 2 mm sieve. These samples were used for determination of various characteristics ofsoil.

Comment [a8]: Why only 0ne hundred soil samples? Have they represent the areas of Indore district?

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 (Lindsay and Norvell,1978) and concentrations were analyzed by atomic absorption spectrophotometer

Preparation of soil fertility maps

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

Category defined

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

Statistical analysis

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

Results and Discussion

Comment [a9]: For maps, please provide the general discussion about spatial analysis because the title is about spatial variability.

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).

The variability Map (Fig. 2)of soils was divided into three categories (Table 1). It is evident from the spatial 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 (2007) in soils of Solan district in North-West Himalayas. Similar findings were also reported by Rajeswar*et al.* (2009) and Singh *et al.* (2009)

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).

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.* (2001). The available iron in surface soils has no regular pattern of distribution as reported by Nayak*etal.*(2002).

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).

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 (<2$mgkg^{-1}$). 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.* (2006)

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

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 Percentage of Cu, $CaCO_3$ samples falls under various range/rating

Cu(mgkg^{-1})	**Samples%**	**$CaCO_3$(%)**	**Samples%**
Deficient <0.2	1.0	under <6.0 status	51
Sufficient 0.2-0.4	10.5	between 6 to 18	49
High level >0.4	88.5	High level >18	-

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

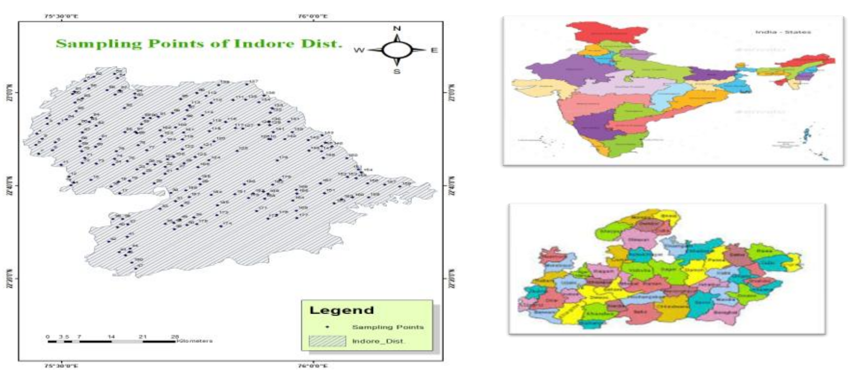


Fig.2 Spatial distribution of Zn in the soils of Indore District

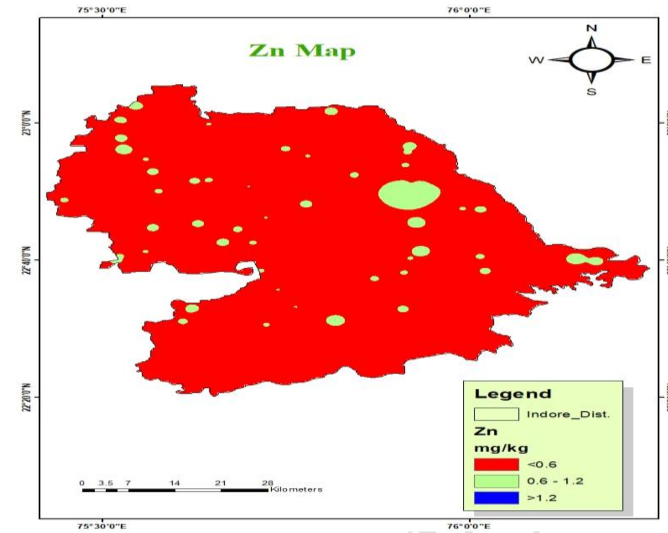


Fig.3 Spatial distribution of Fe in the soils of Indore District

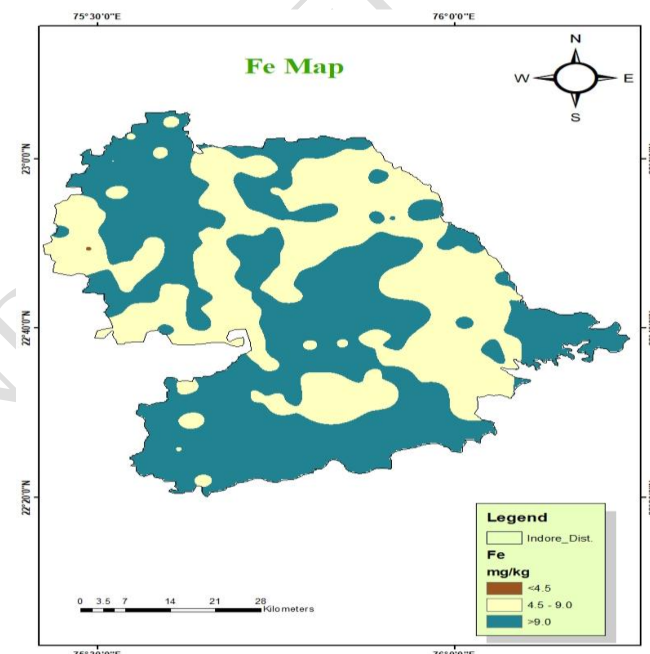


Fig.4 Spatial distribution of organic Mn in the soil of Indore District

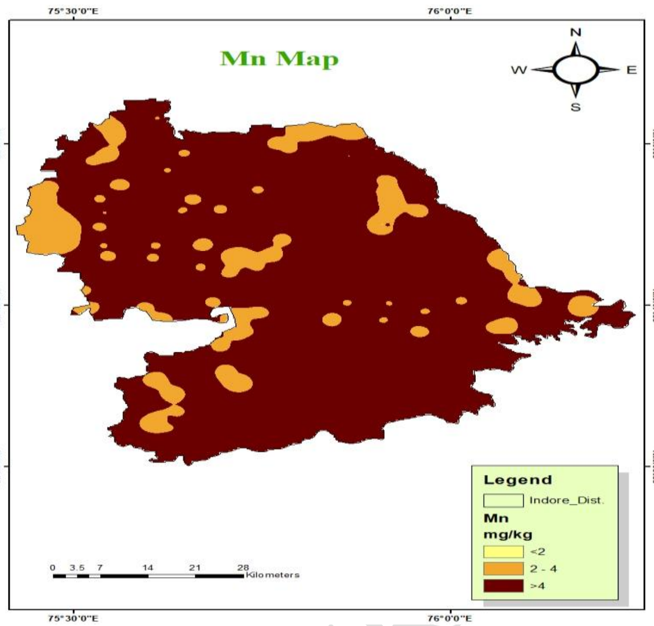


Fig.5 Spatial distribution of available Cu in the soils of Indore District

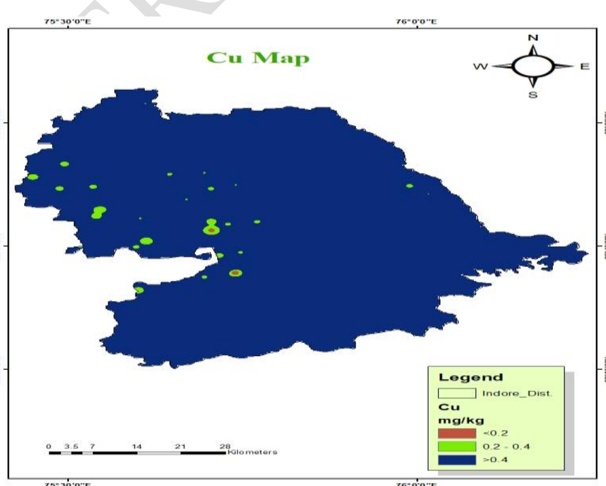
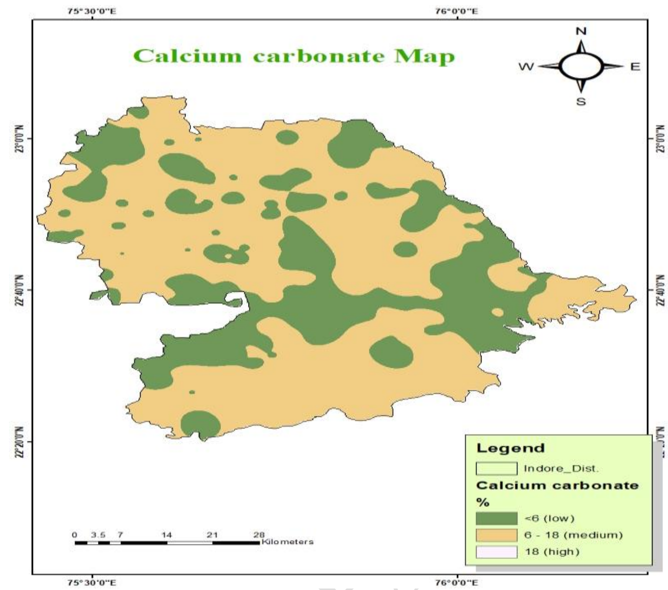


Fig.6 Spatial distribution of available $CaCO_3$ in the soils of Indore District



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).

Spatial variability Mapof 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.* (2008)

Calcium Carbonate ($CaCO_3$) contentof the soils of Indore district

The calcium carbonate ($CaCO_3$) content (Table 2) of the soils of Indore district ranged from 1.25 to 12.5 % with an average value of 6.2 % with standard deviation 2.5 and Coefficient of Variation (CV%) 39.7. 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) Spatial variability Map of calcium carbonate ($CaCO_3$) of the soils of Indore presented in Map (Fig.6). To prepare the calcium carbonate variability Map soils were dividedinto 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%).

Conclusion

Comment [a10]: There is NO conclusion.

References

Comment [a11]: There are only 14 references. Additional references are required in order to meet the minimum requirement of general manuscript.

Behera, S.K. and Shukla, A.K. (2014). Total and extractable manganese and iron in some cultivated acid soils of India - status, distribution and relationship with some soil properties Pedosphere.24(2):196-208.

Karaca,A.2004.Effectoforganicwastesontheextractabilityofcadmium,copper,nickel,andzincinsoil.*Geoderma*122:297–303.

Lindsay,W.L.andNorvell,W.A.(1978). Development of DTPA soil test for zinc,iron, manganese and copper. SoilSci. Soci.America J.42:421-428.

Miransari,M.,andA.F.Mackenzie.2010.Wheat(*Triticumaestivum*L.)grainNuptakeasaffectedby soil total and mineral N, for the determination of optimum N fertilizer rates for wheatproduction.*CommunicationsinSoilScienceandPlantAnalysis*41:1644–1653.

Meena, H.B., Sharma, R.P. and Rawat, U.S. (2006). Status of Macro and Micronutrients in some soils of Tonk District of Rajasthan.J. India Soc. Soil Sci.54(4):508-512.

Nayak,R.K.,Sahu,G.C.andNanda,S.S.K.(2002). Characterization and classification of the soils of Central Research Station, Bhubaneswar Agropedology. 12:1-8.

Pal, Dilip&Wani, Suhas&Sahrawat, Kanwar. (2014). Carbon Sequestration in Indian Soils: Present Status and the Potential. Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci. 5(10)50-52

Rajeswar, M., Rao C.S., Balaguravaiah D. and Khan M.A.A. (2009). Distribution of Available Macro and Micronutrients in Soils Garikapadu of Krishna District of Andhra Pradesh.J.Indian.Soc.SoilSci.57(2):210-213.

Sharma,J.C.,andChaudhary,S.K.(2007). Vertical distribution of micronutrient cations in relation to soil characteristics in lower Shiwaliks of Solan District in North–WestHimalayas.J.Indian Soc Soil Sci.55(1),40-44.

Sharma, R.K. and Jaggi, R.C. (2001). Relationships of forms and availability indices of sulphur with properties of soils of Kangra.HimachalPradesh.J.Indian.Soc.Soil Sci.49(4):698-702.

Singh,S.P., Singh, R., Srivastava,P.C.andSingh,P.(2009).Different forms of sulphur in soils of Udham Singh Nagar district, Uttarakhand and their relationship with soil properties.Agropedology19(l):68-74.

Singh,K.K.andSingh,R .(2008). Distribution of nitrogen and sulphur forms in soil profiles of Mid-western Uttar Pradesh. J.Ind.Soc.Soil Sci.55(4):476-480

Singh Bharat, S. Singh, A.K., Sharma, N.S. Thakur R. Shrivas and S. Pawar 2017. Study of wheat crop growth and productivitymonitoringforHoshangabad district in MP using geospatial technology. *Bull. Env. Pharmacol. Life Sci.* Special Issue5(11) 3153-3157.

Shah Mohammad, W., Shehzadi S.S. & Shah, S. A. (2012). Effect of tillage, rotation and crop residues on wheat crop productivity, fertilizer nitrogen and water use efficiency and soil organic carbon status in dry area (rainfed) of north-west Pakistan. Journal of soil science and plant nutrition, 12(4), 715-727.