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Case Study

GEOSTATISTICAL ANALYSIS OF SOIL MICRONUTRIENTS BASED ON GIS AND GEOSTATISTICS-A CASE STUDY

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Abstract- Understanding of spatial variability in soil fertility status is vital for application of site specific nutrient management. For this a total 25 number of Soil samples collected from Vandurga Village, Yadgir District of Karnataka and analysed for Sulphur(S), Calcium Carbonate ($CaCO_3$), Manganese (Mn), Zinc (Zn), and Iron (Fe). Here geostatistics used to execute conventional statistical analysis and ArcGIS and Geostatistical software GS+ to get the information about distribution and spatial variability of soil micronutrients. The S of collected soil samples varied from 23.98 ppm to 68.62 ppm with a mean of 42.48 ppm. The $CaCO_3$ ranged from 6.61 ppm to 19.85 ppm with an average of 12.02 ppm. Available Mn ranged from 0.52 ppm to 9.48 ppm with mean of 4.09 ppm. The CV for $CaCO_3$ was 34.28, while for Mg, Zn, and Fe it was 68.52, 104.35 and 96.60 respectively. Geostatistical analysis of study by GS+ (version 10.0) show the results based on the ratio of nugget and sill, soil micronutrient properties in study area, the exponential model is used well to show the spatial structure of Sulphur (S) and the ratio of nugget and sill is 97.2%. This shows the variability of S is weakly spatially dependent. Similarly for Ca and Fe fitted Semi variogram Spherical model and Mn and Zn fitted with Gaussian semivariogram model. For $CaCO_3$ and Fe the ratio of nugget and sill is 51.6 % and 57.5% respectively and for Mn and Zn the ratio of nugget and sill is 84.2 % and 99.8% respectively. This study also show the usefulness of GS+ (version 10.0) and ArcGIS 9.2 to know the spatial variability of soil micronutrients in the study area as well as for spatial interpolation, mapping and geostatistical analysis.

Keywords- Geographic Information System (GIS), Geostatistical analysis, Inverse Distance Weighted (IDW), Soil Micronutrients.

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Introduction

The conventional method of soil fertility management consider entire fields as a homogenous group of soil and also while calculating fertilizer requirement as a whole field. Recitation of soil spatial variability in the field has a great difficulty in the use of latest advanced tools and technologies *viz*. Global Positioning Systems (GPS), Geographic Information Systems (GIS) and many others were commenced. Many researchers demonstrated in various studies GIS is an effective set of tools for to collect, store, retrieve, transform and display spatial data [1,8]. It is also seen that the scientist working in earth sciences groups has extensively used GIS for the production of soil fertility map of an area that helps to understand the soil fertility status spatially and temporally, which will be useful to formulate the site-specific suggestion for application of the appropriate quantity of fertilizers [3,4]. Technologies like GPS and GIS allow fields to be mapped precisely and to help in understanding the complex spatial relationships between soil fertility factors [2]. Noticeably, a soil fertility map for a particular area can help in guiding the farmers, manufacturers and planners in finalizing the need of varying micronutrients in a different cropping season in the year and making projections for augmented requirement based on intensity of crops and cropping pattern[8].

[10] Collected an organized set of geo-referenced samples from the Muktsar district covering the entire area using GPS device and the micronutrient (*viz*. Zn, Cu, Mn and Fe) status maps generated using Arc Info GIS Software. The results of the study revealed that in Muktsar district of Punjab 39, 7, 8 and 34 per cent of the of the district found deficient in Zn, Cu, Mn and Fe respectively from given geographical area. [3] Stated that the soil properties can vary spatially due to a range of factors *viz*. parent material, topography, climate, vegetation, and land management. He also said that the spatial variability in soil is important to identify the nutrient limit zones in relation to production zones to lessen the nutrient use. The most important constraint for production in the precision agriculture is the management soil fertility status of spatially variable soils [11]. In this study geostatistical technique used to execute conventional statistical analysis and ArcGIS and Geostatistical software GS+ to get the information about distribution and spatial variability of soil micronutrients.

MaterialsandMethods

Study Area

The study carried out in Vandurga Village of Shahapur taluk lies between 16.640 N to 16.649 N latitude and 76.692 E to 76.701 E longitudes [Fig-1]. The total study area is 40 ha. This village come under the northern dry zone (Zone-3) of Karnataka and partly irrigated from Krishna River by Shahapur Branch Canal. A total of 25 soil samples (0-20 cm depth) collected from farmers' fields randomly. This is done on total number of 25 Soil samples collected and analysed from Vandurga Village, Yadgir District of Karnataka area concurrently, from all the sampling points' global positioning data recorded by GPS device before sowing of Kharif crops to assess the spatial variability in the soil fertility status.

All collected soil samples from different locations were taken for laboratory analysis. Before analysis of micronutrients (*viz.* Sulphur(S), Calcium Carbonate ($CaCO_3$), Manganese (Mn), Zinc (Zn), and Iron (Fe) all the collected soil samples air dried and sieved through a 2 mm size sieve by following the standard laboratory procedures described by [8, 13].

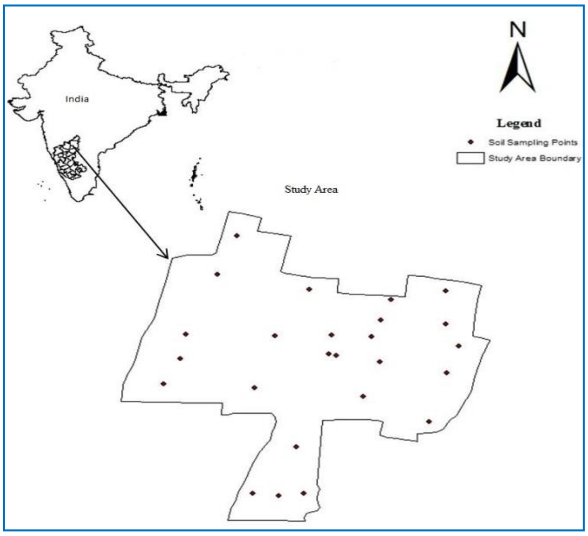

Fig-1 Sampling points and location of study area

The Laboratory analysis was done to know the fertility status of all soil samples for chemical characteristics. Further the entire analysed data further processed in different computer software. Firstly, conventional statistical and geostatistical analysis performed using SPSS (version 19) and GS+ (version 10.0) respectively, while the spatial analysis is carried out using ArcMap GIS (version 9.2) [14]. The various maps produced in Arc Map GIS presented in [Fig-1 and 2]. In few datasets of soil micronutrients in the study area distorted, was essential to execute data transformation to accomplish a good investigation results. To overcome the skewed datasets performed special types of transformations *viz.* logarithmic transformation, Box-Cox transformation and the permutation of every two are tried. At last, it gives the impression that it is effective to use Box-Cox transformation after the domain processing.

Results and Discussion

Descriptive statistics

The descriptive statistics values of all analyzed soil samples from study area for various micronutrients in terms of Sulphur(S), Calcium Carbonate ($CaCO_3$), Manganese (Mn), Zinc (Zn), and Iron (Fe) and are presented in [Table-1]. Mean, maximum, minimum, standard deviation (SD) and coefficient of variation (CV) of all micronutrients of soil of 25 locations in the study area are presented. The S content mean values, SD and CV found 42.46 ppm, 10.48 and 24.67 respectively. The CV for $CaCO_3$ was 34.28, while for Mg, Zn, and Fe it was 68.52, 104.35 and 96.60 respectively. The obtained results were in line with those of [7, 12] in mukona, Uganda study area. They observed that because of regular application of micro nutrients in the past the elevated mean values of K and Ca is 0.44 and 5.35 cmol/kg respectively could be attributed .

Table-1 *Descriptive statistics of micronutrient of study area*

Parameters Values	Micronutrients				
	S	$CaCO_3$	Mg	Zn	Fe
Mean, ppm	42.46	12.02	4.09	0.4188	1.65
Maximum, ppm	68.62	19.85	9.48	1.782	6.09
Minimum, ppm	23.98	6.61	0.52	0.108	0.28
Median	43.73	10.77	3.77	0.256	1.13
SD	10.48	4.12	2.81	0.44	1.59
CV	24.67	34.28	68.52	104.35	96.60

Spatial Structural Analysis

Due to anomaly of most factor data, which are through Box-Cox transformation and domain processing, all the data are firstly processed through the same course as a disparity, and then are conducted spatial analysis [14]. The reports of spatial structural analysis on various micronutrients the Skewness and kurtosis after box-cox transformation in comparison with original data presented in [Table-2].

Table-2 *Skewness and kurtosis values for the original and transformed data*.

Soil Micro nutrients	Original Data		Logarithmic or Box-Cox Transformation	
	Skewness	kurtosis	Skewness	kurtosis
S	0.33	-0.23	-0.2	-0.58
$CaCO_3$	0.47	-1.25	0.19	-0.137
Mn	0.42	-1.06	-0.47	-0.96
Zn	2.11	3.27	0.94	0.24
Fe	1.64	1.82	0.27	-.071

To explore the nature of soil micronutrients variability, a geostatistical analysis executed based on Geostatistics. Major geostatistical parameters values presented in [Table-3]. Where, nugget is denoted by C0 and when Semi-variogram is in zero point, it state the variable condition. Partial sill is denoted by C0+C and it state the total variable in the system as well as the constitutive variation and the random variation. When the total variation is higher, Partial sill is higher. The ratio of nugget to sill enables comparison of the relative magnitude of the nugget effect among soil properties [4], in particular if sampled at similar scales. If the nugget to sill ratio was <25%, the variable was considered strongly spatially dependent; if the ratio was between 25%-75%, the variable was considered moderately spatially dependent; and if the ratio was >75% the variable was considered weakly spatially dependent. Based on the ratio of nugget and sill, soil micronutrient properties in study area, the Exponential model is used well to show the spatial structure of Sulphur (S) and the ratio of nugget and sill is 97.2%. This shows the variability of S is weakly spatially dependent. Similarly for $CaCO_3$ and Fe fitted Semi variogram Spherical model and Mn and Zn fitted with Gaussian semivariogram model. For $CaCO_3$ and Fe the ratio of nugget and sill is 51.6 % and 57.5% respectively and for Mn and Zn the ratio of nugget and sill is 84.2 % and 99.8% respectively.

Table-3 *Geostatistical parameters for soil micronutrients*

Soil Nutrients	Semi-variogram Model	Nugget	Sill	Range	Nugget/Sill %
S	Exponential	0.0016	0.0568	0.00111	97.2
$CaCO_3$	Spherical	9.59	19.99	0.0022	51.6
Mn	Gaussian	0.122	0.77	0.000225	84.2
Zn	Gaussian	0.001	0.53	0.000485	99.8
Fe	Spherical	1.153	2.716	0.00206	57.5

Spatial variability maps of various micronutrients prepared after kriging of point values by Inverse Distance Weighted (IDW) method and presented in [Fig-2] (i to v). Classification presented in various micronutrients maps clearly shows the specific locations, where management of micronutrients nutrients is required. Similar results also observed by various scientists viz. [5] used geostatistical interpolation technique of kriging to prepare the landslide susceptibility analysis map of Kota Kinabalu in Malaysia to locate areas prone to landslides. [6,9] reported that the degree of accuracy of kriging technique in the prediction of soil properties and the descriptive tools of semi variogram to characterize the spatial patterns of continuous and categorical soil attributes.

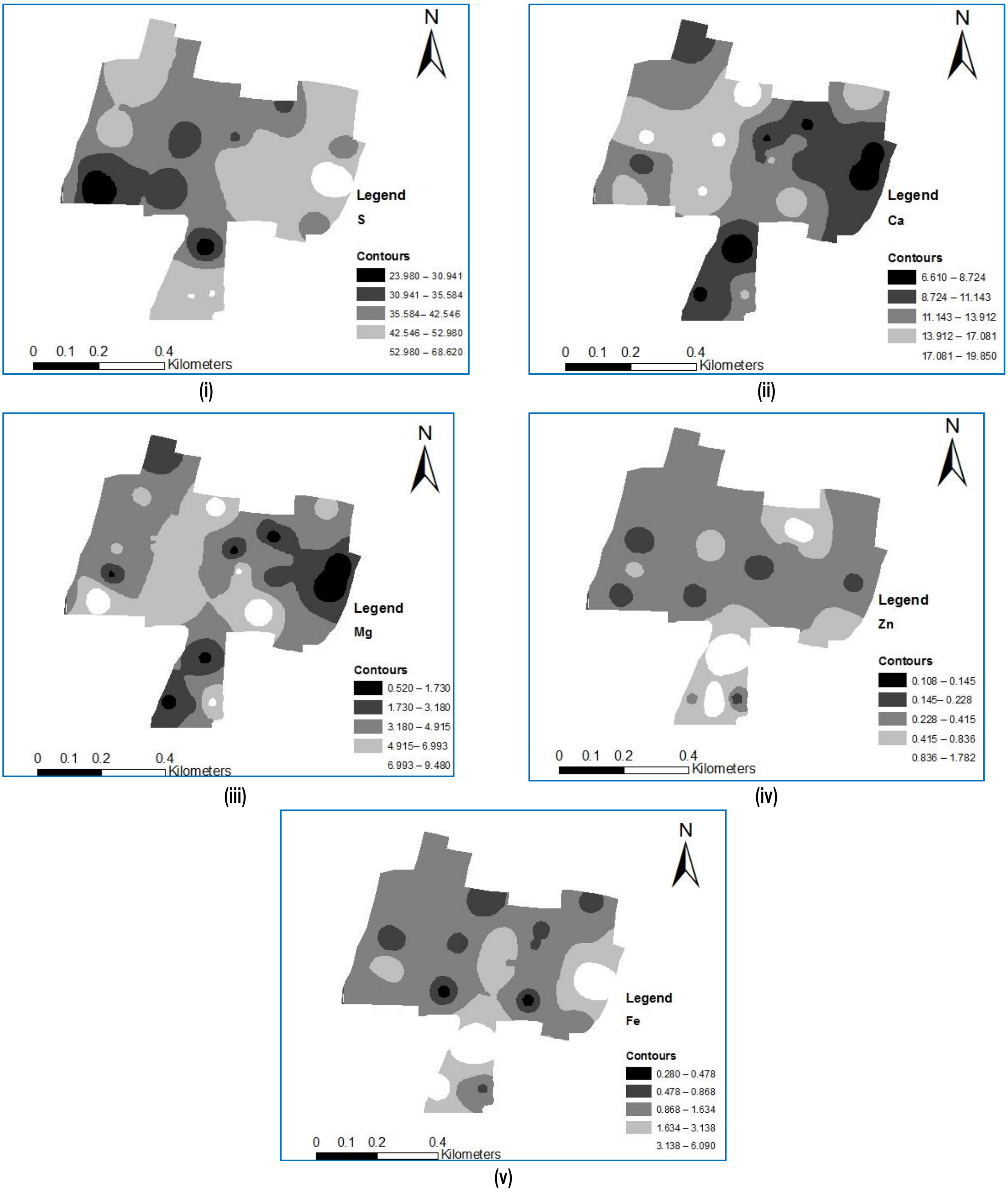

Fig-2 Spatial distribution map of S (i), $CaCO_3$ (ii), Mg (iii), Zn (iv) and Fe (v) in Study area.

Conclusions

This study showed that soils of almost low in available micronutrients in most of the farmer's field. This deficiency has appeared due to lack of balanced application of micronutrients by most of the farmers. Thus suggesting that, the appropriate nutrients applications needed for based of soil test values. Geostatistical analysis of study by GS+ (version 10.0) show the results based on the ratio of nugget and sill, soil micronutrient properties in study area, the Exponential model is used well to show the spatial structure of Sulphur (S) and the ratio of nugget and sill is 97.2%. This shows the variability of S is weakly spatially dependent. Similarly for $CaCO_3$ and Fe fitted Semi variogram Spherical model and Mn and Zn fitted with Gaussian semivariogram model. For Ca and Fe the ratio of nugget and sill is 51.6 % and 57.5% respectively as well for Mn and Zn the ratio of nugget and sill is 84.2 % and 99.8% respectively. The present study reveals that usefulness of GS+ (version 10.0) and ArcGIS 9.2 know the spatial variability of soil micronutrients in the study area as well for spatial interpolation, mapping and geostatistcal analysis.

Conflict of Interest: None declared

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