www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(10): 1491-1498

www.thepharmajournal.com
Received: 03-07-2023
Accepted: 07-08-2023

Yashwant Gehlot
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Indore, Madhya Pradesh, India

Rakesh Mewada
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Indore, Madhya Pradesh, India

Priyanka Jadon
Department of Soil Science and Agricultural Chemistry, Gwalior, Madhya Pradesh, India

Shweta Jamra
Department of Horticulture Narsingpur, Madhya Pradesh, India

Corresponding Author:
Priyanka Jadon
Department of Soil Science and Agricultural Chemistry, Gwalior, Madhya Pradesh, India

GIS based mapping of spatial variability of available macronutrients in soil of district Indore, Madhya Pradesh, India

Yashwant Gehlot, Rakesh Mewada, Priyanka Jadon and Shweta Jamra

Abstract
In the years 2020-2021, research was carried out in the Indore District of Madhya Pradesh to determine the soil reaction, electrical conductivity, organic carbon content, and primary nutrient status. A cadastral map of the study region was used to grid-in the collection of surface soil samples, which were analyzed for fertility. The pH, electrical conductivity, and organic carbon levels varied from 6.38 to 8.49, 0.19 to 0.99 dSm^{-1}, and 0.14 to 0.76%, respectively. Available nitrogen, phosphorus, potassium, and sulfur concentrations varied from 95,2 to 246,4 kg ha^{-1}, 8,12 to 22,92 kg ha^{-1}, and 250 to 700 kg ha^{-1}, 3,29 to 34,21 mg kg^{-1}, respectively. Available nitrogen was low, phosphorus varied from low to high, and potassium was medium to high, and sulfur varied from low to high. Using the field survey and the results of laboratory analyses, the units of soil heterogeneity were determined using Arc-GIS 10.4.1. Based on the data obtained after the analysis; maps of all parameters were prepared, which will be successfully used for site-specific nutrient management in the future.

Keywords: Arc-GIS, spatial variability, soil fertility, site-specific nutrient management, soil reaction

Introduction
The soil is a vital part of the earth system because it plays a role in maintaining the local, regional, and global environmental quality as well as in the production of food, fiber, and fodder. For many years, Indian farmers have followed a cultural method that ensured small but constant yields while maintaining the desired level of soil fertility. The drive to boost productivity through the introduction of high yielding varieties, excessive use of chemical fertilizers and pesticides, and widespread tillage upset this equilibrium. There are currently questions over the sustainability of the productivity surge that followed the Green Revolution. Because of the heterogeneous nature of soil, ecological mechanisms that regulate the cycling of nutrients are influenced by the condition of the soil (Fitter, 2005) [3]. Avoiding soil degradation and improving soil health and fertility level could be achieved by performing sustainable soil management with an appropriate understanding of soil properties (Thapa and Yila, 2012 & Zhao *et al*, 2013) [14, 20].

Characteristics of the soil Farming management techniques like fertilization and irrigation as well as soil formation elements like soil parent materials have an impact on geographical variability (Ferguson *et al*., 2002) [4]. In order to create site-specific balanced fertilizer recommendations and comprehend the condition of soil fertility both spatially and temporally, it is necessary to determine the availability of nutrients in the soil in a given area using the Global Positioning System (GPS). Prepare a fertility map in this situation and use it as a decision support tool for nutrient management. This will not only help you adopt a more sensible strategy than farmer practices or the general application of state-recommended fertilization, but it will also eliminate the need for labor-intensive plot-by-plot soil testing procedures. Using a geographic information system (GIS) is a useful technique, 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) [12] Furthermore, GIS generated soil fertility maps may serve as a decision support tool for nutrient management.

Materials and Methods
Description of the study area
Geographically, Indore is located at 22°43'4.51" N 75°49'59.88" E in M.P with a 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 area has Verticals and related soil orders. These soils are montmorillonite, neutral to slightly alkaline, and have a high shrinkage potential.

Soil sampling and processing
GPS based on 100 surface soil samples collected from various locations of Indore District. Approx. A 1.0 kg representative sample of the composite soil was taken and placed in a properly labeled sample bag. Then, the soil samples were air-dried and crushed with a wooden pestle and mortar and sieved through a 2-mm sieve. These samples were used to determine various soil characteristics.

Laboratory analysis of soil samples
Soil pH was determined in a 1:2 soil:water suspension using a glass electrode Beckman pH meter (Piper, 1950) [7]. The soil suspension used for pH determination was allowed to settle and the electrical conductivity (EC) of the liquid above the sediment was determined using a conductivity meter (Piper, 1950) [7]. Results are expressed in dSm-1 at 25 ºC. The content of organic carbon in the soil was determined by the Walkley and Black rapid titration method. A 5 gram soil sample was taken to which 10 ml of potassium dichromate ($K_2Cr_2O_7$) and 20 ml of commercial sulfuric acid (H_2SO_4) were mixed. Available nitrogen was determined by a modified alkaline permanganate method as described in Subbiah and Asija (1956) [8], Available phosphorus was determined using Olsen's extractant (0.5 N sodium bicarbonate solution, pH 8.5) Olsen *et al*. (1954) [6] and available potassium was extracted with neutral normal ammonium acetate (pH 7.0) and the potassium content of the solution was estimated using a Flame Photometer (Jackson, 1973) [5].

Preparation of soil fertility maps
Soil fertility maps were prepared using Arc-GIS 10.4.1 using kriging as an 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
Soil reaction/pH
With a mean of 7.51, a standard deviation of 0.36, and a coefficient of variation of 4.81%, the pH of the soils in the Indore district ranged from 6.38 to 8.49 (Table 2). Table 3 shows that out of the 190 soil samples, 51.6% were neutral and 47.9% were alkaline. In Fig. 2, the extent of the soil pH's geographical distribution is represented. The soil pH variability map (Fig. 2) showed that category II covered the majority of the area. Class (6.5 to 7.5), category III (> 7.5), and the least area to category I (6.5) are shown in that order in Table 1. Parent material that is naturally alkaline and has high to moderate calcium and magnesium content in a state that is easily released by weathering may be the source of a neutral to alkaline reaction (Dudal, 1965) [1].

Electrical conductivity
With a mean value of 0.56 dSm-1 and a range of 0.10 to 0.99 dSm-1 depending on the type of soil topography, the electrical conductivity of the soil water suspension (1:2) showed significant variances. As can be noted from Table 1, Category II represents the majority of the area (0.8), followed by Category I (0.8-1.6). The majority of the soil samples revealed a normal concentration of total soluble salt. Figure 3 shows the range of the spatial distribution of soil electrical conductivity (EC). In the Indore District, EC appeared within 1 dSm-1 at 25 °C. Dilliware *et al*. (2014) [2] and Singh *et al*. (2014) [10] found findings that were similar.

Organic Carbon (OC)
With a mean value of 0.46%, a standard deviation of 0.16%, and a coefficient of variation (CV) of 34.84%, the organic carbon content of the soils in the Indore district ranged from 0.14 to 0.76% (Table 2). The soils in the Indore district fulfil the criteria for all three of the OC content classifications that are available. In general, out of 190 samples, 58.4% of the samples had low levels of organic carbon, 40% of the samples have medium levels, and 1.5% of the samples have high levels (Table 3). The organic matter was incorporated into the topsoil through the roots of other plants and manure, which resulted in higher amounts of organic carbon in the surface samples. Singh *et al*. (2014) [10] and Shrivas *et al*. (2020) [20] found results that were almost same. To maintain the soil health in the district of Indore, the land has a poor to medium organic carbon status, which requires quick attention. According to Singh *et al*. (2016) [11], high temperature and good aeration caused a fast rate of oxidation of organic matter while causing agricultural residues to accumulate less and less each year without significantly diminishing the organic carbon content. Map of Spatial Variability Figure 4 shows a map of the district's soil organic carbon. Soils were divided into three groups in order to generate a map of the variability of organic carbon (Table 1). In the Indore district, the highest area falls into group I (0.5), followed by category II (0.5–0.75), while the least area falls into category III (>0.75), which has low to medium organic carbon content and requires immediate remedy.

Table 1: Category of various parameters and their range

Category	Parameters and range						
	pH	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ ha^{-1}$)	Available K ($kg\ ha^{-1}$)	Available S ($mgkg^{-1}$)
I	<6.5	<0.8	<0.5	<250	<10	<250	<10
II	6.5-7.5	0.8-1.6	0.5-0.75	250-400	10-20	250-400	10-20
III	>7.5	>1.6	>0.75	>400	>20	>400	>20

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

Particulars	pH	EC(dSm^{-1})	OC (%)	N(kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Available S (mgkg^{-1})
MIN	6.38	0.10	0.14	95.2	8.12	250	3.29
MAX	8.49	0.99	0.76	246.4	22.92	700	34.21
MEAN	7.51	0.56	0.46	174.41	16.02	433.47	14.07
SD	0.36	0.25	0.16	41.48	3.93	100.78	5.22
CV (%)	4.81	44.47	34.84	23.79	24.53	23.25	37.13

Table 3: Percentage of pH, EC and OC samples falls under variousrange

Soil pH	Samples (%)	EC (dS m^{-1})	Samples (%)	Organic carbon (%)	Samples (%)
acidic (<6.5)	0.5%	<0.8	76.3%	Low (<0.5)	58.4%
Neutral (6.5-7.5)	51.6%	0.8-1.6	23.7%	Medium (0.5-0.75)	40.0%
Alkaline (>7.5)	47.9%	>1.6	-	HIgh (>0.75)	1.5%

Table 4: Percentage of NPK samples falls under various range/rating

Available-N (kg ha^{-1})	Samples (%)	Available-P (kg ha^{-1})	Samples (%)	Available-K (kg ha^{-1})	Samples (%)	Available S (mgkg^{-1})	Samples (%)
Low (<250)	100 %	Low(<10.0)	3.2%	Low (<250)	-	Low (<10)	20%
Medium (250-400)	-	Medium (10-20)	75.3%	Medium (251-400)	39.5%	Medium (10-20)	64.2%
High (>400)	-	High (>20)	21.5%	High (>400)	60.5%	High (>20)	15.8%

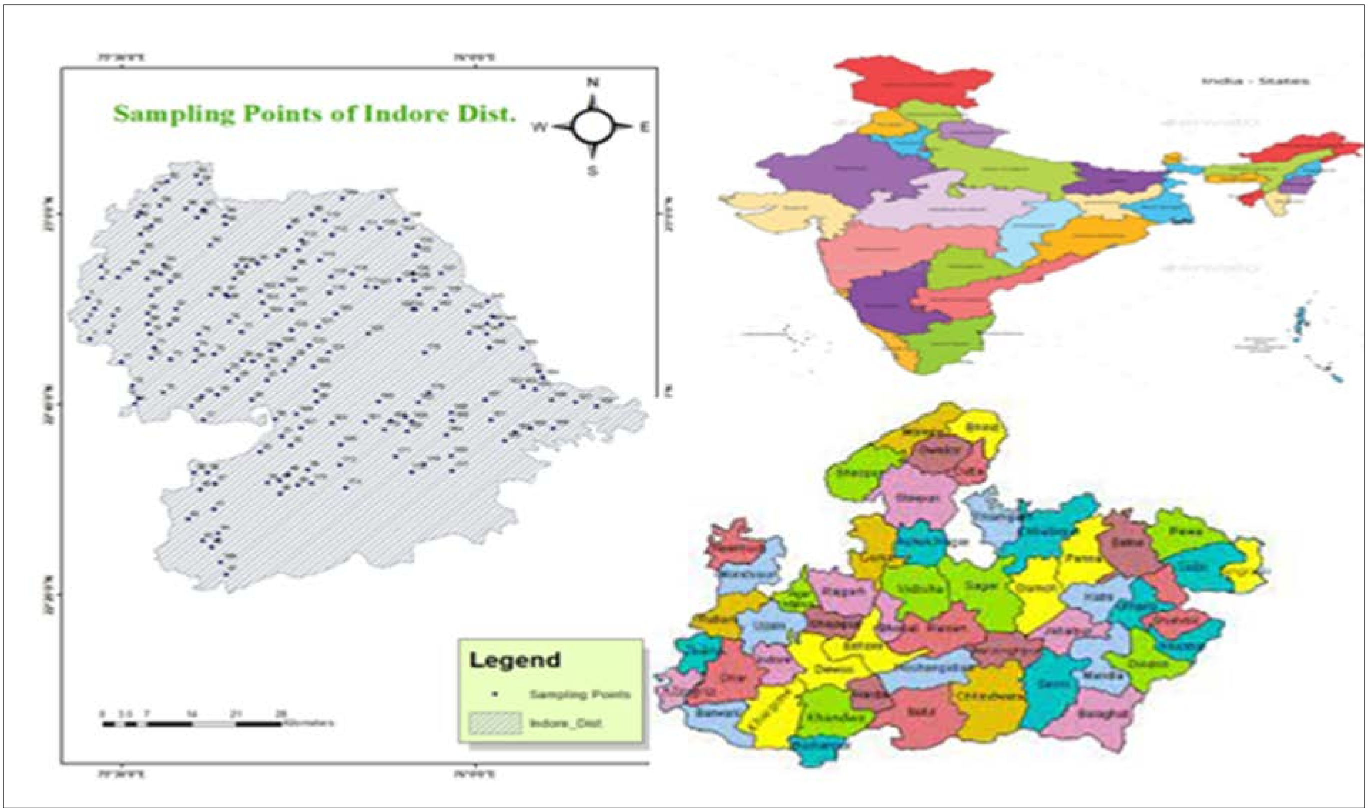

Fig 1: Sampling point as per GPS location of Indore District

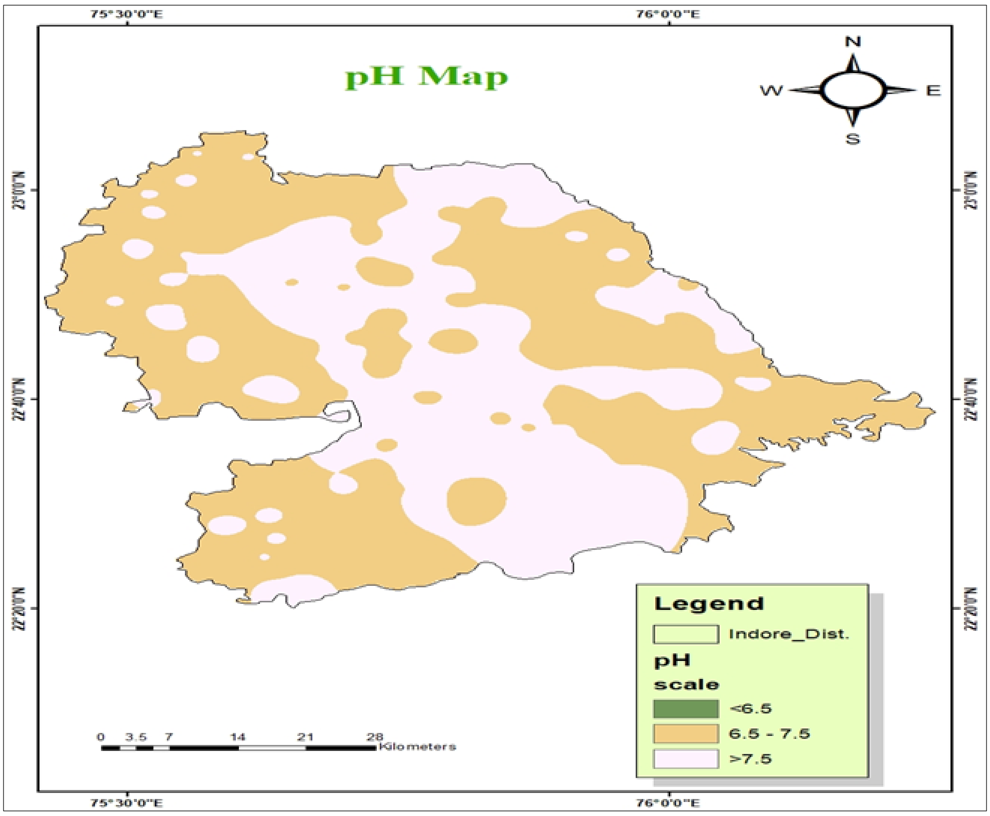

Fig 2: Spatial distribution of pH in the soils of Indore District

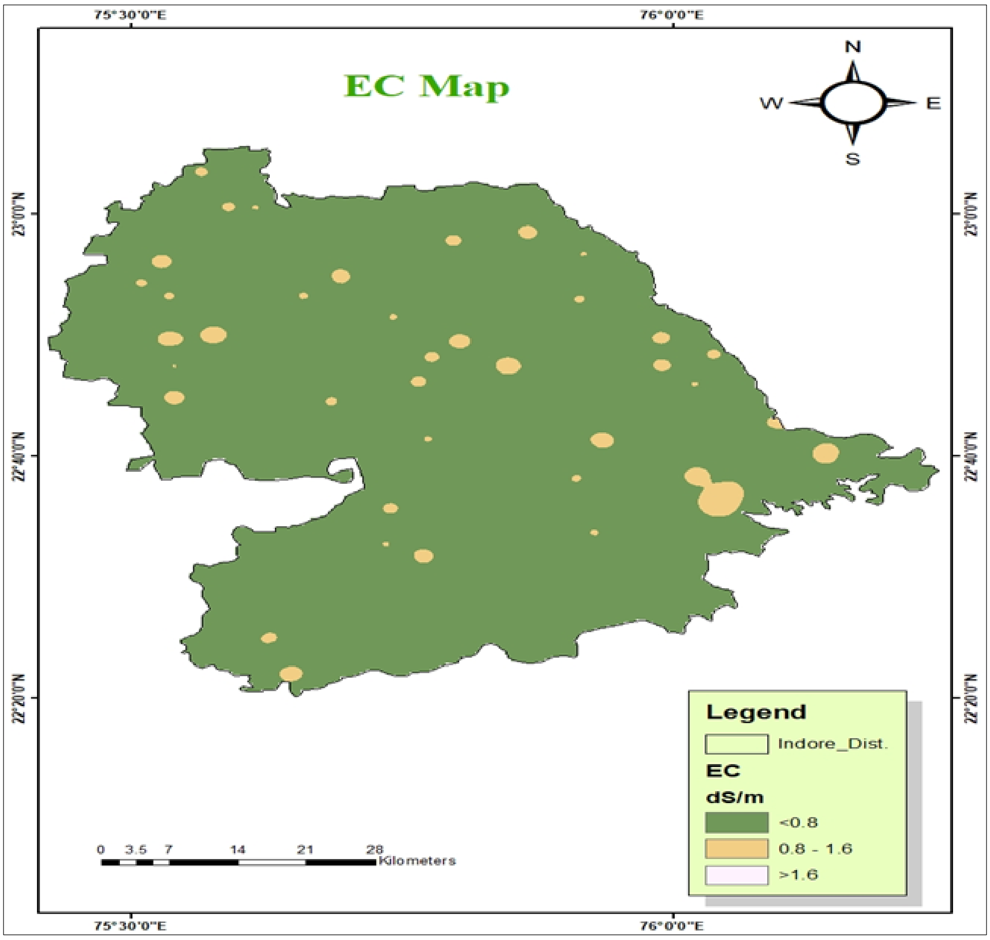

Fig 3: Spatial distribution of EC in the soils of Indore District

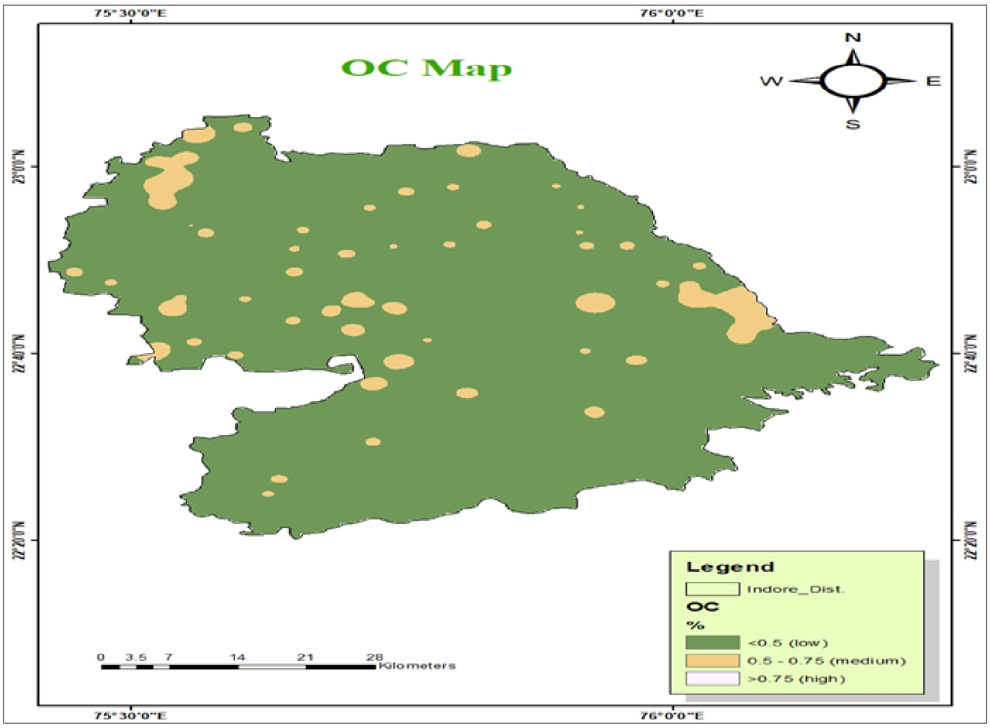

Fig 4: Spatial distribution of organic carbon in the soil of Indore District

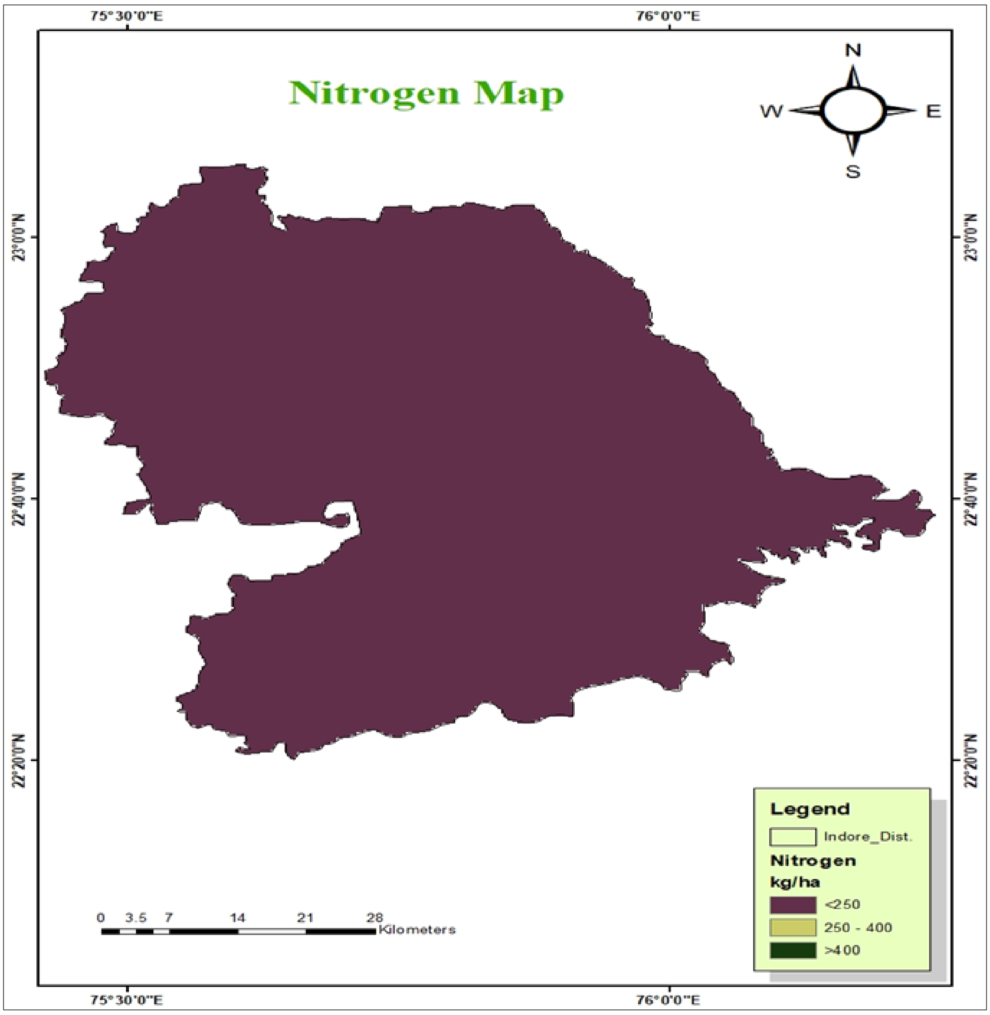

Fig 5: Spatial distribution of available –N in the soils of Indore District

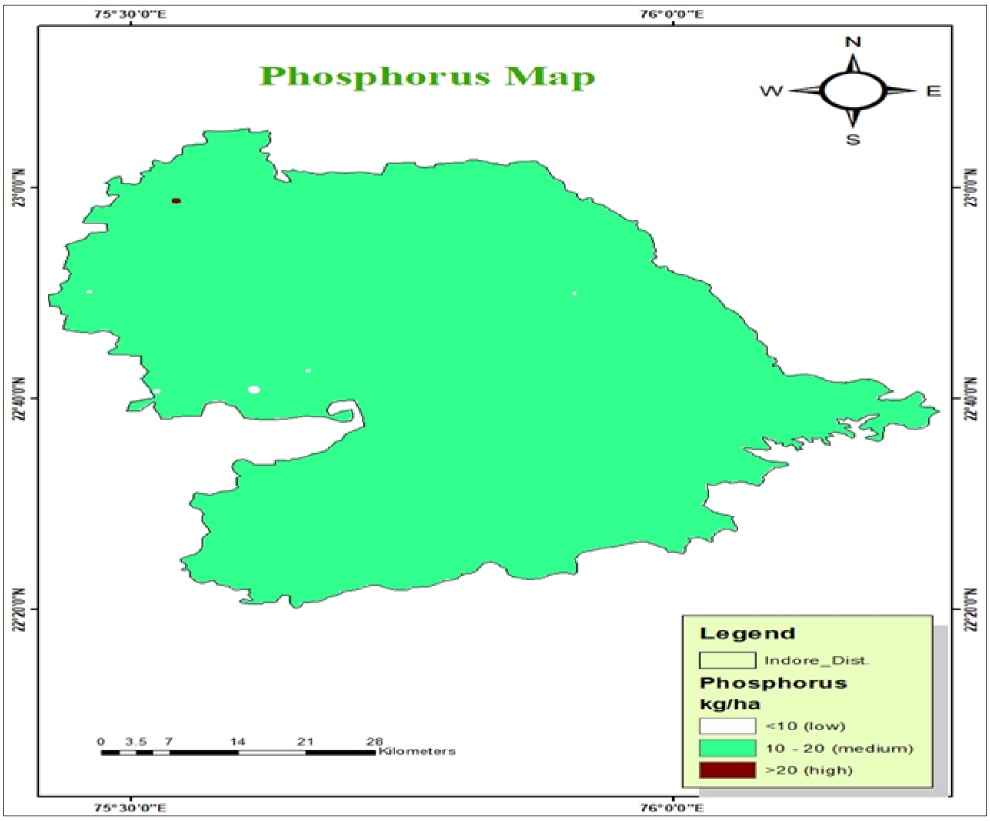

Fig 6: Spatial distribution of available–P in the soils of Indore District

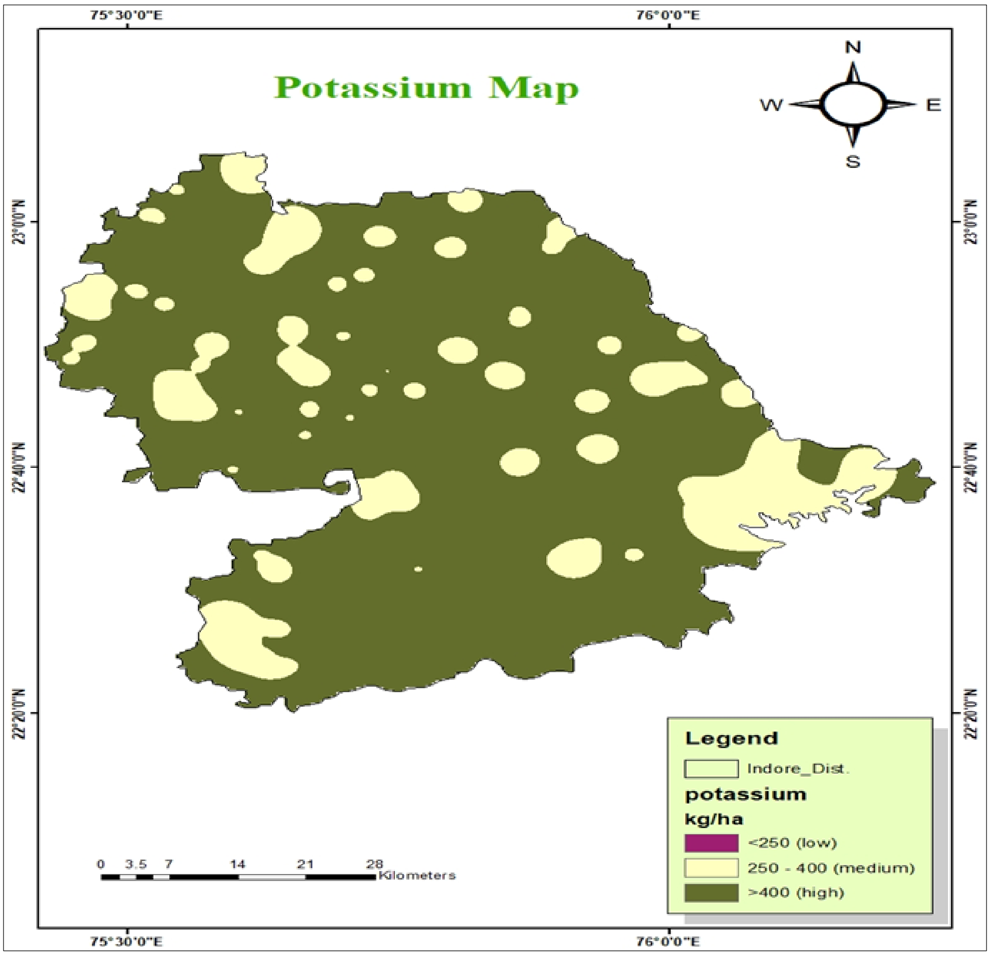

Fig 7: Distribution of available K status in the soils of Indore District

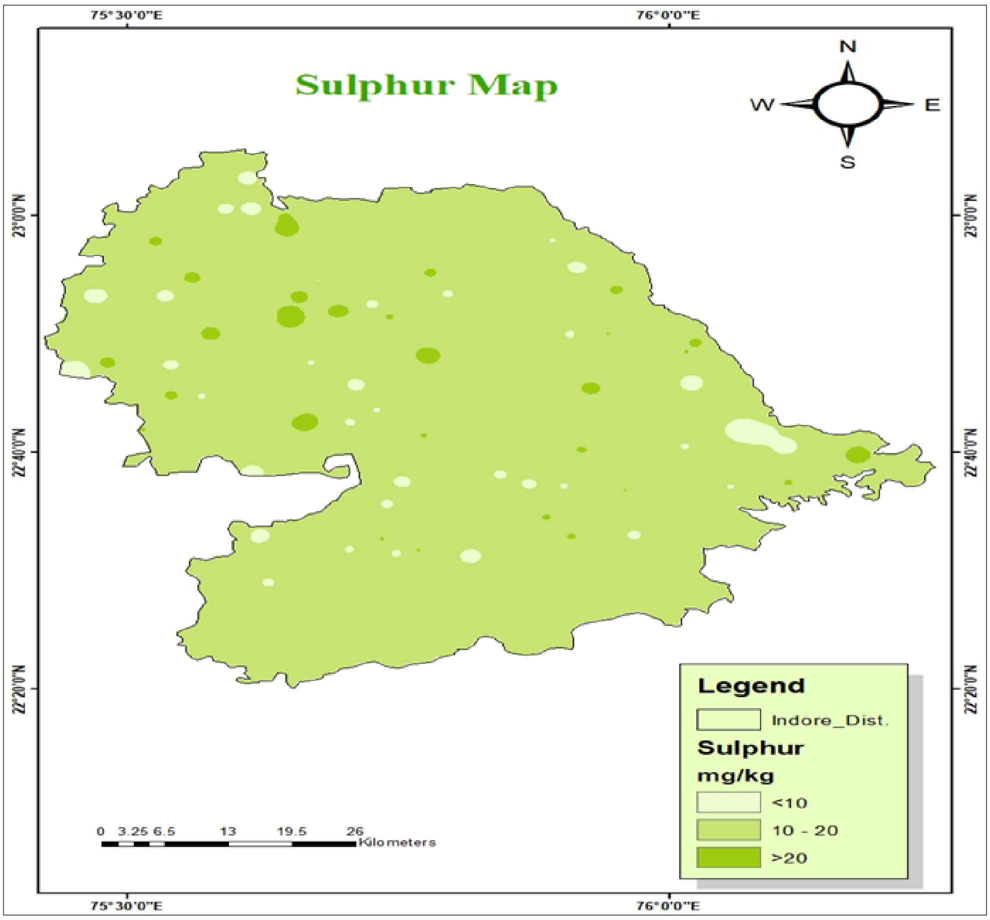

Fig 8: Distribution of available S status in the soils of Indore District

Available macronutrients

Available nitrogen

With a mean value of 174.41 kg ha^{-1}, a standard deviation of 41.48 kg ha^{-1}, and a coefficient of variation (CV%) of 23.79%, the available N content of the soils in the Indore district ranged from 95.2 to 246.4 kg ha^{-1}. Out of 190 samples, 100% are considered to have low status, on average (Table 4). The available N content of the soils in the Indore area is of low quality (250 kg ha^{-1}). This could be caused by the low levels of organic matter in these soils. N loss through several types of processes, including volatilization, nitrification, denitrification, microbial fixation, leaching, and runoff, may be the cause of the low available N in the soil. The map indicates that the Maximum Area (250 kg ha^{-1}) belongs to category I (Table 1). Based on the results of the soil test, this type of map will assist farmers in managing nutrients for a particular location. Both Kashiwar *et al.* (2018) [17] and Kumar *et al.* (2009) [18] found a similar trend in the nutrient content of the soils in their research areas, the Agricultural Farm of Rajiv Gandhi South Campus in Mirzapur, Uttar Pradesh.

Available phosphorus

Table 2 shows the range of available P content for soils in the Indore district, with a mean value of 16.02 kg ha^{-1}, a standard deviation of 3.93 kg ha^{-1}, and a coefficient of variation (CV %) of 24.53. The available P content varied from 8.12 to 22.92 kg ha^{-1}. The soils in the Indore district have a medium to high available P concentration. 75.3 % of samples had a medium P status, 3.2% had a low P status, and 21.5% had a high P status. According to Verma *et al.* (2005) [15], the factors that may have the most impact on the medium to high range of soil accessible P in the research region include previous fertilization, pH, organic matter content, texture, various soil management techniques, and agronomic practises. The soils are divided into three groups (Table 4) in order to create the P variability map. The spatial variability Map of the district of Indore is shown in Giant 6. According to the data in Table 1, the largest area is found in Category II (10 to 20 kg ha-1), followed by Category III (> 20 kg ha-1), and the smallest area is found in Category I (10 kg ha-1).

Available potassium

With a mean value of 433.47 kg ha^{-1}, a standard deviation of 100.78 kg ha^{-1}, and a coefficient of variation (CV), the available K content in soils in the Indore district ranged from 250 to 700 kg ha-1. 23.25%. The soils in the Indore district have a medium to high K status. Out of 190 samples, on average, 39.5% had a medium K status and 60.5% had a high K status (Table 4). Map of the available K soils' geographical variation for the Indore area (Fig. 7). The largest region estimated to fall under category III (>400 kg ha-1) is followed by category II (250-400 kg ha-1). The presence of potassium-rich minerals like illite and feldspar is responsible for the adequate (moderate or high) available K in these soils (Sharma *et al.*, 2008) [9]. Similar results were also noted by Kumar *et al.* (2015) [19] in soils of Raipur district Chhatisgarth and Kumar *et al.* (2017) [21] in soils of Jaisalmer district of western Rajasthan.

Sulfur available

As shown by the data in Table 2, soils in the Indore district have an available S content that ranges from 3.29 to 34.21 $mgkg^{-1}$, with a mean value of 14.07 $mgkg^{-1}$, a standard deviation of 5.22 mgkg^{-1}, and a coefficient of variation (CV) of 37.13%. In general, out of 190 samples, 20% of samples fall into low status, 64.2% of samples were medium, and 15.8% of samples were high S status (Table 4). Due to a lack of sulphur addition and continuous S removal by crops, low and medium levels of available sulphur were noted Chauhan *et al*. (2012) [22]. In the western Himalayan Garhwal area, Singh *et al*. (2013) [23] similarly observed similar outcomes. Map of the available-S soils' variation in spatial distribution for the Indore district (Fig. 8). According to information, Category II (10–20 mg kg–1) has the largest area, followed by Category III (>20 mg kg–1), while Category I has the lowest area.

Conclusion

A summary of the study mentioned above, the soils in the Madhya Pradesh district of Indore are low in available OC and N, medium in available P, medium to high in available K, and low to medium in available S. These soils are classified as neutral to alkaline according to soil reaction (pH), and the safe limit of EC was found in every sample. For future crop output to be improved, it also requires attention to better nutrient management techniques and routine soil health monitoring.

References

1. Dudal R. Dark Clay Soils of Tropical and subtropical Regions.Agric. Dev. Paper 83, FAO, Rome, Italy; c1965, 161.
2. Dilliwar P, Puri G, Singh R, Amule FC, Choudhary BK. To evaluate the soil quality of Kheriseries under Jawaharlal Nehru Krishi Vishwa Vidyalaya soil of Maharajpur Farm. National conference on soil health: A key to unlock and sustain production potential September 3-4 held at Department of Soil Science and Agricultural Chemistry, College of Agriculture, JNKVV, Jabalpur (M.P.); c2014.
3. Fitter AH, Gilligan CA, Hollingworth K, Kleczkowski ARM, Twyman JW, Pitchford. Functional Ecology. 2005;19:369-377.
4. Ferguson RB, Hergert GW, Schepers JS, Gotway CA, Cahoon JE, Peterson TA. Site-specific nitrogen management of irrigated maize: Yield and soil residual nitrate effects; c2002.
5. Jackson ML. Soil chemical analysis prentice hall of India Private Limited New Delhi; c1973.
6. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA, Circ; c1954, 939.
7. Piper CS. Soil and Plant analysis.Inter-Science Publication., New York; c1950.
8. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soils Current Science. 1956;25:259-260.
9. Sharma PK, Sood A, Setia RK, Tur NS, Mehra D, Singh H. Mapping of macronutrients in soils of Amritsar district (Punjab) A GIS approach. J Indian Soc. Soil Sci. 2008;56(1):34-41.
10. Singh A, Adak T, Kumar K, Shukla SK, Singh VK. Effect of integrated nutrient management on dehydrogenase activity, soil organic carbon and soil moisture variability in a mango orchard ecosystem. J Animal & Plant Sci. 2014;24(3):843-849.
11. Bharat S, Bhagat D, Sharma AK, Jat N. Assessment of decade wise temperature trends in Malwa region. Progressive Res. An Int. J Special-V. 2016;(6):144-149.
12. Bharat S, Singh S, Sharma AK, Thakur NS, Shrivas R, Pawar S. Study of wheat crop growth and productivity monitoring for Hoshangabad district in MP using geospatial technology. Bull. Env. Pharmacol. Life Sci. Special. 2017;5(11):3153-3157.
13. Shrivas R, Singh B, Thakur NS, Sharma AK, Pawar S. Reduced tillage and use of organics: A progressive manoeuvre towards conservation of resources and improvement in soil intrinsic properties. Int. J Curr. Microbiol. App. Sci. Special Issue. 2020;(10)24-35.
14. Thapa GB, Yila OM. Farmers' Land Management Practices and Status of Agricultural Land in the Jos Plateau, Nigeria. Land Degradation & Development. 2012;23:263-277.
15. Verma VK, Setia RK, Sharma PK, Singh C, Kumar A. Pedospheric variations in distribution of DTPA-extractable micronutrients in soils developed on different physiographic units in central parts of Punjab, India. Int. J Agric. Biol. 2005;7:243-246.
16. Walkley A, Black CA. An examination of the degrjareff method of determining soil organic matter and a proposed modification of chromic acid titration method. Soil Science. 1934;37:29-38.
17. Kashiwar SR, Nath T, Kumar D, Kundu MC, Usha R, Rajput D, *et al*. Evaluation of Soil Fertility Status of Rajiv Gandhi South Campus (Banaras Hindu University), Mirzapur, Uttar Pradesh. Int. J Curr. Microbiol. App. Sci 2018;7:3825-3836.
18. Kumar R, Sarkar AS, Singh KP, Agarwal BK, Karmakar S. Appraisal of available nutrients status in Santhal Paraganas region of Jharkhand. J of Indian Soc. of Soil Sci. 2009;57(3):366-369.
19. Kumar AV, Mishra N, Srivastava LK. Evaluation of soil fertility status of available N, P and K in Inceptisol of Raipur district of Chhattisgarh. International Journal of Interdisciplinary and Multidisciplinary Studies. 2015;2(6):98-104.
20. Zhao XJ, Zhao PS, Xu J, Meng W, Pu WW, Dong F, *et al*. Analysis of a winter regional haze event and its formation mechanism in the North China Plain. Atmospheric Chemistry and Physics. 2013 Jun 13;13(11):5685-96.
21. Kumar S, Soukup M, Elbaum R. Silicification in grasses: variation between different cell types. Frontiers in Plant Science. 2017 Mar 28;8:438.
22. Chauhan BS, Opeña J. Effect of tillage systems and herbicides on weed emergence, weed growth, and grain yield in dry-seeded rice systems. Field Crops Research. 2012 Oct 20;137:56-69.
23. Jat MK, Purohit HS, Singh B, Garhwal RS, Choudhary M. Effect of integrated nutrient management on yield and nutrient uptake in sorghum (Sorghum bicolor). Indian Journal of Agronomy. 2013;58(4):543-7.