International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM January 2024, 15(1): 01-14

Article AR4988a

Research Article

Natural Resource Management

DOI: HTTPS://DOI.ORG/10.23910/1.2024.4988a

Geospatial Variability of Soil Properties of the Different Villages in Arajiline Block of Varanasi District of Uttar Pradesh

Shivam Kumar Maurya[1], Prem Kumar Bharteey[1], G. R. Singh[1], Ayush Bahuguna[1], Nidhi Luthra[1], Sudhir Pal[1], Surajyoti Pradhan[2] and Sumit Rai[3]

[1]Dept. of Agricultural Chemistry & Soil Science, C.C.R (P.G.) College, Muzaffarnagar, Uttar Pradesh (251 001), India
[2]Dept. of Agronomy, Krishi Vigyan Kendra (OUAT), Mayurbhanj-2, Orissa (757 049), India
[3]Centre for Environment Assessment and Climate Change, GB Pant National Institute of Himalayan Environment Kosi-Katarmal, Almora, Uttrakhand (263 643), India

Open Access

Corresponding prembharti406@gmail.com

0000-0003-1832-8381

ABSTRACT

The current study was conducted at the different villages of the Arajiline block of Varanasi district, Uttar Pradesh, India during November, 2022–June, 2023 to evaluate the variability of soil properties and nutrient indexof soils. The random sampling technique was used to collect 40 soil samples at different locations with the help of GPS at 0–15 cm depth. The collected soil samples were air-dried in shade at room temperature, passed through a 2 mm filter paper, and analyzed for different physico-chemical properties. The result revealed that the TS (range 8.2–81.3%), VFS (range 4.2–35.5%), Silt (range 10.1–54.2%), Clay (range 7.7–38.8%), BD (range 1.08–1.45 g cm^{-3}), PD (range 2.04–2.33), Porosity (range 30.24–51.56%) pH (range 6.4-7.8), EC (range 0.1-0.3 dS m^{-1}), OC (0.2-0.6%), and available N, P, K, S, Ca, and Mg varied from 130.12–260.30 kg ha^{-1}, 14.2-23.2 kg ha^{-1}, 145.0–240.0 kg ha^{-1}, 7.5–17.6 kg ha^{-1}, 3.8–8.2 cmol(P+)/kg, and 2.1-4.1 cmol(P+)/kg, respectively. The findings indicated that the studied soils were slightly acidic to moderately acidic and free from salinity hazards; 70% of the soil samples were low in organic carbon, 30% were medium in organic carbon, and 100% of the soil samples were low in available N and medium in available P, K, and S. 100% of soil samples were found to be sufficient in exchangeable Ca and Mg. The findings of this research could help in crop nutrient management, fertilizer recommendation, and decision-making for increasing agricultural production and farmer profitability.

KEYWORDS: GPS, nutrient index, pysico-chemical properties, soil fertility

***Citation* (VANCOUVER):** Maurya et al., Geospatial Variability of Soil Properties of the Different Villages in Arajiline block of Varanasi district of Uttar Pradesh. *International Journal of Bio-resource and Stress Management,* 2024; 15(1), 01-14. HTTPS://DOI.ORG/10.23910/1.2024.4988a.

Copyright: © 2024 Maurya et al. This is an open access article that permits unrestricted use, distribution and reproduction in any medium after the author(s) and source are credited.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 01st November 2023 RECEIVED in revised form on 20th December 2023 ACCEPTED in final form on 05th January 2024 PUBLISHED on 18th January 2024

1. INTRODUCTION

Soil is a vital, natural, and dynamic body that sustains all living things on Earth (Jones, 2012). It is a complex mixture comprising minerals, organic materials, countless microorganisms, and variable proportions of air and water, all crucial for sustaining life (Wilding and Lin, 2006). Fertile and productive soils proliferate life, whereas unfertile and unproductive soils bring hunger and famine (Khadka et al., 2019). By weathering and soil-forming processes, organic matter, fertilizer, and parent material give macro and micronutrients to the soil (Haby et al., 1991). Among the nutrients, macronutrients are nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca) and magnesium (Mg) (Thaker et al., 2023). These are essential for plant growth, which is important to preserve ecosystems and high crop yields (Qiu et al., 2005). In soil science, the term "soil fertility" is frequently employed to describe the role played by various soil properties such as nutrients, moisture, minerals, and organic matter in supporting plant growth (Desbiez et al., 2004). Soil fertility refers to the interactions of the physical, chemical and biological properties of soil and is directly related to agricultural production (Rakesh et al., 2012). Various regions exhibit distinct limiting factors affecting soil fertility; for instance, tropical areas face challenges like moisture stress, elevated phosphorus fixation, and increased acidity (Cardoso and Kuyper, 2006). Consequently, soil fertility proves to be a multifaceted concept, not directly quantifiable but assessable through other soil properties as indicated by (Bautista-Cruz et al., 2007). The soil fertility evaluation is the most basic decision-making tool in order to make an efficient plan for a particular land use system (Havlin et al., 2010). It is an important factor that determines the growth of plants. It has identified levels of macronutrient and micronutrient concentrations in the soil that are sufficient for field crop production without further additions. There are several techniques for the evaluation of soil fertility status; soil testing is the most important method. Soil testing provides information regarding nutrient availability in soils, which forms the basis for fertilizer recommendations for the economic production of crops (Panda, 2010). The advent of GIS technology and its great potential in the field of soil have unleashed innovative opportunities for enhancing the soil statistics system, as GIS permits augmented, repetitive, spatial, and temporal synoptic evaluation. The GIS is an effective tool for supervising large amounts of data and has the capacity to support spatial statistical investigation; therefore, there is a significant opportunity to enhance the precision of soil surveys through the application of the GIS. The primary objective of this investigation is to conduct a non-traditional soil survey in a newly established region. This research will use GIS and remote sensing to represent and clarify the geo-referenced laboratory analysis results of the soil analysis through thematic soil maps of various soil physico-chemical properties of the study area (Yadav et al., 2022). Many researchers have used soil testing to figure out how fertile the soil is. Bharteey et al. (2023) looked at how the physical and chemical properties of soils in the Moridhal watershed in the Dhemaji district of Assam changed depending on where they were. Also, evaluate the spatial variability of soil properties using geo-spatial techniques in Subhumid Southern Plain of Rajasthan (Yadav et al., 2022). Prajapat et al. (2023) conducted one experiment to assess the soil fertility status of different villages in the Depalpur Block of Indore District, Madhya Pradesh, India. Soil testing is perhaps the most regularly used method for determining soil fertility (Havlin et al., 2010) and increasing agricultural production through fertility management (Goovaerts, 1998). This paper reports on the soil fertility status of different villages in Varanasi district, Uttar Pradesh during 2022–23. It can be useful in recommending optimum soil management practices, crops, and cropping systems for ensuring sustained yields in the region.

2. MATERIALS AND METHODS

2.1. Site description

The current investigations were to assess the soil fertility status of Eight villages (Kendriya, Harsos, SuiChak, Gajari, Mehandiganj, Darekhu, Mechkanpur, and Kachnar) in the Arajiline block of Varanasi district of Uttar Pradesh during November, 2022–June, 2023. The coordinates of the location are 25'12'' N to 82'49'' E and the elevation is 82 m (Figure 1). Most of the land in these villages is cultivable. The soils of these villages are mostly sandy loam or lightly textured. The farmers in this village are progressive and creative. Farmers become aware of their soil's health.

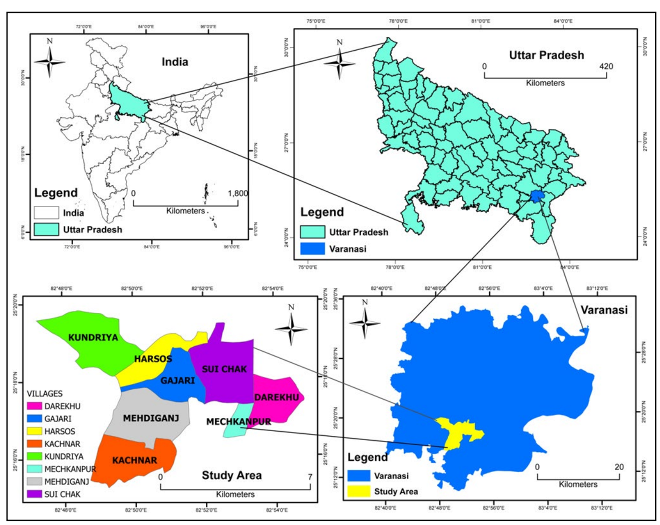

Figure 1: Study area

2.2. Climate

The climate of the Varanasi district is congenial to successful cultivation of cereals, oilseeds, pulses, horticultural crops, fisheries, and poultry farming. The temperature rises up to 47°C or more during the summer and drops to 4°C during December and January. The average rainfall is 225 to 350 mm, of which 90% is received by the south-west monsoon. The normal period of onset of the monsoon in the region is the first week of July, which lasts up to the end of September. About 90% of the annual rainfall is received during the monsoon season, but it is highly erratic and unpredictable, at times causing drought spells of varying degree and duration.

2.3. Soil sampling and analysis

A total of 40 surface soil samples were collected from the undisturbed land of the Arajiline block of Varanasi district, Uttar Pradesh, in 2023 (Figure 2). A sample was randomly collected from a depth of 0–15 cm (plough layer) in a 'V' shape with the help of a spade. The soil samples were mixed systematically, and about 500 g of composite samples were collected in polythene bags from the farmer's field for analysis. The collected soil samples were air dried in shade at room temperature, crushed, powdered, and grinded with a wooden roller before sieving with a 2.0 mm sieve and being transported to the laboratory. Finally, a 500 g soil sample was preserved in a labeled polythene bag for further laboratory analysis.

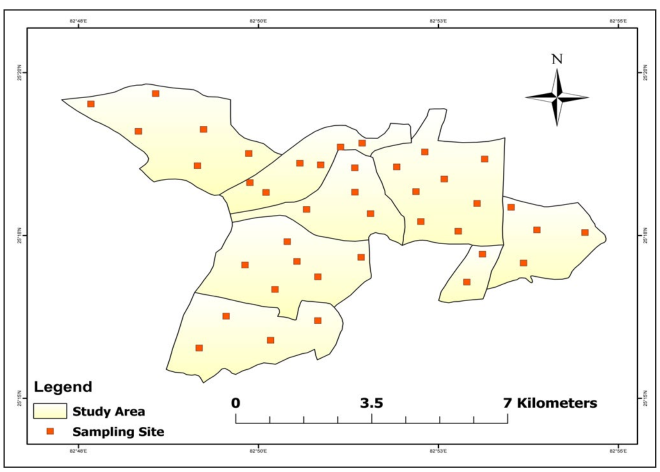

Figure 2: Sampling site map

Particle size analysis was conducted following the International pipette method recommended by (Piper, 1966). Bulk density and particle density were determined using a pycnometer, as suggested by (Black, 1965). pH measurement employed a pH meter with a 1:2.5 soil-water suspension, while electrical conductivity was gauged using an EC bridge, following method given by (Jackson, 1973). Organic carbon content was assessed through the Walkley and Black method proposed by (Walkley and Black, 1934). Available nitrogen was quantified using the alkaline potassium permanganate method by (Subbiah and Asija, 1956), employing a Kjeldahl apparatus. Olsen's method, utilizing a spectrophotometer, was employed for estimating available phosphorus, as described by (Olsen et al., 1954). Available potassium was determined by flame photometer, with neutral normal ammonium acetate method, suggestedby (Hanway and Heidal, 1952). Exchangeable calcium and magnesium were assessed through the EDTA method introduced by (Cheng and Bray, 1951). Available sulphur was estimated using the Calcium chloride method with a spectrophotometer, following the procedure outlined by (Chesnin and Yien, 1950).

2.4. Nutrient index evaluation

The characterization of the soils of the individual blocks as a whole into the three fertility classes was done according to the nutrient index values calculated from the soil test summaries giving their percentage distribution into low, medium and high categories. The nutrient index was given by Parker et al. (1951)

Nutrient index=(% in high category×3+% in medium category×2+% in low category×1)/Total no of samples

In this percent assessment a nutrient index less than 1.5 denotes low category and that falls between 1.5 and 2.5 represents the medium fertility class. A value of 2.5 and above (maxi 3.00) signifies a high fertility class with respect to the particular nutrient (Ghosh and Hasan, 1976).

2.4. Statistical analysis

Snedecor and Cochran's (1967) technique for doing simple statistical analysis was used. These analyses included maximum, minimum, mean, coefficient of variation and correlation. The Coefficient Variation was determined by using formula:

C.V.=(Standard deviation/Mean)×100

The relationship between relevant soil properties and available cationic macronutrient of soils were calculated by using standard statistical methods. The correlation coefficient was determined by using the formula:

$$r=\sqrt{\frac{SP(xy)}{SS(x), SS(y)}}$$

Where:

r=Correlation coefficient

SP (xy)=Sum product of x, y variables

SS (x)=Sum of square of x variable

SS (y)=Sum of square of y variable.

3. RESULTS AND DISCUSSION

3.1. Physical properties

The data on the physical properties such as total sand, very fine sand, silt, clay, BD, PD, Porosity of soil are given in the Table 1.

3.1.1. Particle size distribution

The textural properties of the studied soils varied from loamy sand to clay. The textural classification of soils under different villages in the Arajiline villages of Varanasi district is presented in Table 1. The textural properties of the studied soils as described by parameters like total sand content ranged from 8.2 to 81.3%, with a mean value of 46.8. The very fine sand content was found within the range of 4.2 to 35.5%. The silt content varied from 10.1 to 54.2% and the clay content ranged from 7.7 to 38.8%. The exhibited mean values for very fine sand, silt, and clay were 19.2, 27.5, and 25.7%, respectively. However, the standard deviation (18.77) and standard error (2.97) were highest in total sand. The coefficient of variation (43.93%)

Table 1: Physical properties of different villages of Arajiline block of Varanasi district

Sample No.	TS (%)	VFS (%)	Silt (%)	Clay (%)	Texture	BD g cm^{-3}	PD g cm^{-3}	Porosity (%)
S_1	43.5	18.1	28.2	28.3	Clay loam	1.33	2.12	37.26
S_2	45.6	19.1	28.3	26.1	Loam	1.26	2.14	41.12
S_3	48.5	28.1	19.4	32.2	Sandy clay loam	1.43	2.12	32.55
S_4	39.2	25.2	32.1	28.7	Clay loam	1.44	2.22	35.14
S_5	39.5	28.3	29.7	30.8	Clay loam	1.32	2.16	38.89
S_6	49.3	22.9	21.9	28.8	Sandy clay loam	1.42	2.07	31.40
S_7	39.0	26.0	31.0	30.0	Clay loam	1.43	2.05	30.24
S_8	50.0	35.5	24.0	26.0	Sandy clay loam	1.45	2.25	35.56
S_9	39.3	29.3	32.4	28.3	Clay loam	1.38	2.07	33.33
S_{10}	48.3	28.3	23.3	28.3	Sandy clay loam	1.45	2.22	34.68
S_{11}	47.2	27.0	32.7	20.2	Loam	1.31	2.06	36.41
S_{12}	34.2	23.5	35.4	30.4	Clay loam	1.28	2.05	37.56
S_{13}	40.4	18.5	25.4	34.2	Clay loam	1.22	2.22	45.05
S_{14}	50.2	12.3	20.3	29.5	Clay loam	1.24	2.28	45.61
S_{15}	38.8	22.3	36.2	25.0	Loam	1.16	2.06	43.69
S_{16}	45.3	19.3	22.3	32.3	Sandy clay loam	1.22	2.29	46.72
S_{17}	46.3	23.6	26.0	27.7	Sandy clay loam	1.23	2.28	46.05
S_{18}	40.0	16.3	23.6	36.5	Clay loam	1.34	2.24	40.18
S_{19}	32.2	20.2	31.5	36.3	Clay loam	1.13	2.04	44.61
S_{20}	50.3	15.2	20.1	29.6	Sandy clay loam	1.23	2.32	46.98
S_{21}	27.6	14.3	38.2	34.2	Clay loam	1.22	2.33	47.64
S_{22}	42.1	16.3	23.2	34.7	Clay loam	1.25	2.25	44.44
S_{23}	15.5	9.5	49.0	35.5	Sandy clay loam	1.18	2.12	44.34
S_{24}	75.7	16.3	13.0	11.3	Sandy loam	1.28	2.10	39.05
S_{25}	35.1	20.0	52.3	12.6	Silty loam	1.34	2.21	39.37
S_{26}	71.5	16.3	11.2	17.2	Sandy loam	1.32	2.23	40.81
S_{27}	34.0	26.6	39.1	26.9	Loam	1.28	2.22	42.34
S_{28}	31.2	22.1	30.0	38.8	Clay loam	1.27	2.16	41.20
S_{29}	17.6	4.2	52.0	30.4	Silty clay loam	1.25	2.12	41.04
S_{30}	80.0	18.5	11.0	9.0	Loamy sand	1.23	2.04	39.71
S_{31}	75.5	22.2	10.1	14.4	Sandy loam	1.21	2.14	43.46

Table 1: Continue...

Sample No.	TS (%)	VFS (%)	Silt (%)	Clay (%)	Texture	BD g cm^{-3}	PD g cm^{-3}	Porosity (%)
S_{32}	79.1	17.5	12.0	9.0	Sandy loam	1.08	2.12	49.06
S_{33}	14.6	8.2	47.1	38.3	Silty clay loam	1.09	2.25	51.56
S_{34}	8.2	6.3	54.2	37.6	Silty clay loam	1.32	2.23	40.81
S_{35}	81.3	17.5	11.0	7.7	Loamy sand	1.10	2.05	46.34
S_{36}	77.0	12.0	11.4	11.6	Sandy loam	1.22	2.12	42.45
S_{37}	50.0	16.3	25.0	25.0	Sandy clay loam	1.18	2.14	44.86
S_{38}	77.8	18.5	10.5	11.7	Sandy loam	1.32	2.15	38.60
S_{39}	51.0	11.2	28.0	21.0	Loam	1.15	2.31	50.22
S_{40}	58.3	15.7	28.1	13.5	Sandy loam	1.22	2.32	47.41
Max	12	35.5	54.2	38.8		1.45	2.33	51.56
Min	8.2	4.2	10.1	7.7		1.08	2.04	30.24
Mean	46.8	19.2	27.5	25.7		1.27	2.17	41.44
SD	18.77	6.73	12.08	9.24		0.10	0.09	5.25
SEm±	2.97	1.06	1.91	1.46		0.02	0.01	0.83
CV	40.15	35.00	43.93	35.90		7.85	4.14	12.67

was highest in silt content, and it was lowest for very fine sand (35.00%). There were no increasing trends of washed finer materials from the upper surface to the lower surface because there were flat surfaces (Singh et al., 2019; Reddy et al., 2023). The geographical distributions of total sand, very fine sand, silt, and clay content in the study area are presented in Figure 3, 4, 5 and 6.

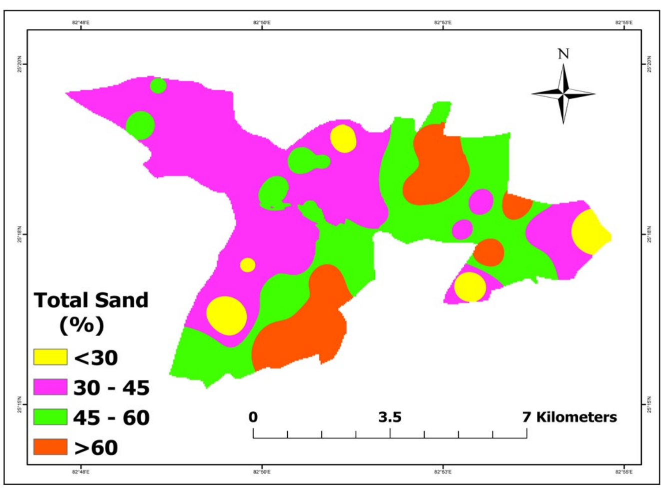

Figure 3: Spatial variability map of total sand

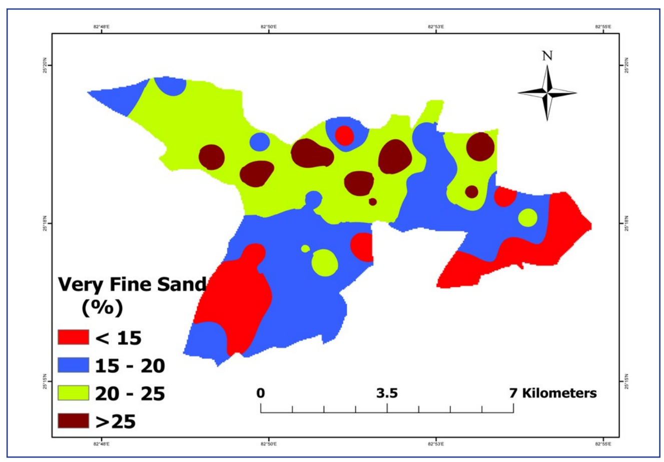

Figure 4: Spatial variability map of very fine sand

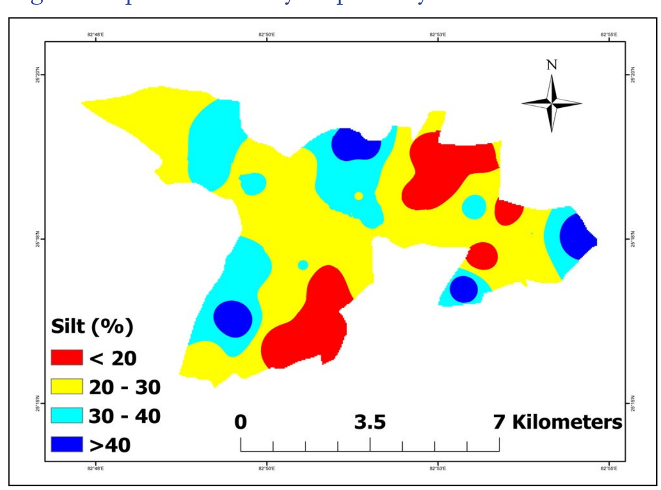

Figure 5: Spatial variability map of Silt

3.1.2. Bulk density, particle density and porosity distribution

The bulk density of the studied soil varied from 1.08 to 1.45 g cm^{-3}, with a mean value of 1.27 g cm^{-3}. The values of the standard deviation and coefficient of variation were 0.10 and 7.85 %, respectively (Table 1). In S_8 and S_{10} of SuiChak and Harsos villages, the highest (BD) was which might be due

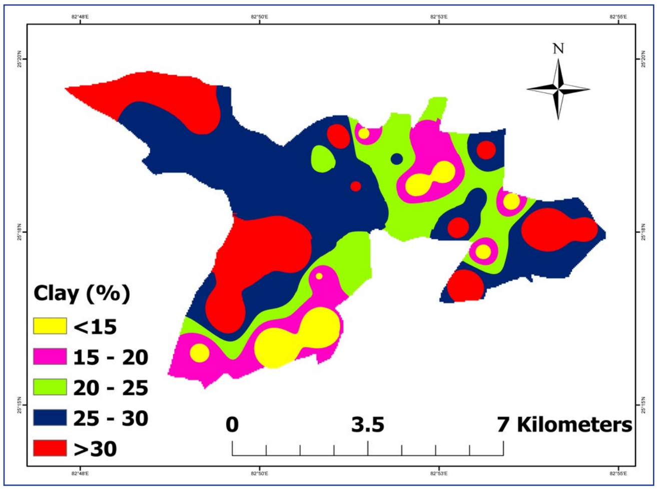

Figure 6: Spatial variability map of Clay

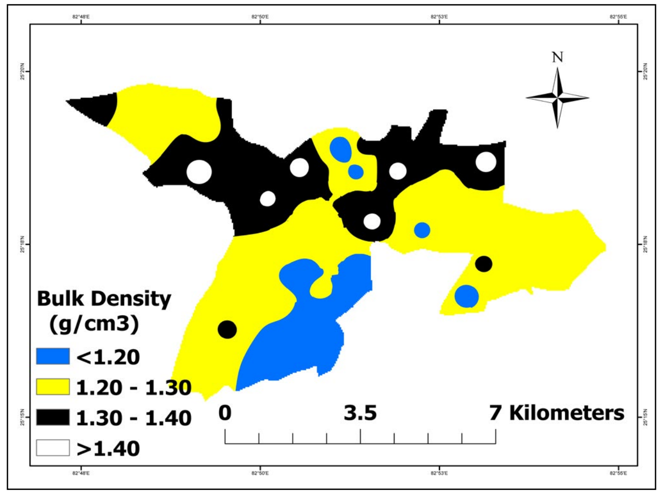

Figure 7: Spatial variability map of Bulk density

to the presence of low organic carbon content and in S_{33} and S_{34} of Harsos and Kachnar villages and thelowbulk density, which might be due to low intensive agricultural practices in the field. Deoli et al. (2020) recorded similar incidents in the Saheshpur block of Dehradun. The particle density of soil samples ranged from 2.04 to 2.33 g cm^{-3}, with an average value of 2.17 g cm^{-3}. The standard deviation of particle density was 0.09 and the coefficient of variation was 4.14% (Table 1). In S_{19} of Mehdiganj, the lowest particle density was updated, and in S_{21} of Mehdiganj highest particle density was updated. Selviet al. (2023) recorded similar results in the Theni district of Tamil Nadu. The porosity percentage of the soil samples ranged from 30.24 to 51.50%, with a mean value of 41.44%. The standard deviation (S.D.) of porosity (%) was reported as 5.25, and the coefficient of variation was 12.67%. The highest value (55.16%) was observed in S_{26} of SuiChak village. The findings showed that as soil particles erode, they fill up the pore spaces, raising the bulk density of the soil and decreasing its porosity. Srinidhi et al. (2020) recorded similar observations in the Chittoor district of Andhra Pradesh. The overall distribution of bulk density, particle density, and porosity is presented in Figure 7, 8, and 9.

3.2. *Chemical properties*

The data on the chemical properties such as pH, EC, OC, N, P, K, S, Ca and Mg of soil are given in Table 2.

3.2.1. *Status of pH, EC, and organic carbon in soil*

The pH of the studied soils was varied from 6.4 to 7.8, with a mean value of 7.0. In S_{21} of Mehdiganj village had the lowest pHand the highest in S_{27} of SuiChak village. S.D. and CV values were 0.35 and 4.82%, respectively (Table 2). Out of 40 soil samples 12.5% and 47.5% belonged to the neutral category and 40% belonged to the moderately saline category. The soils of study area were saline in reaction due to the inherent heterogeneity of soils, fertilizer

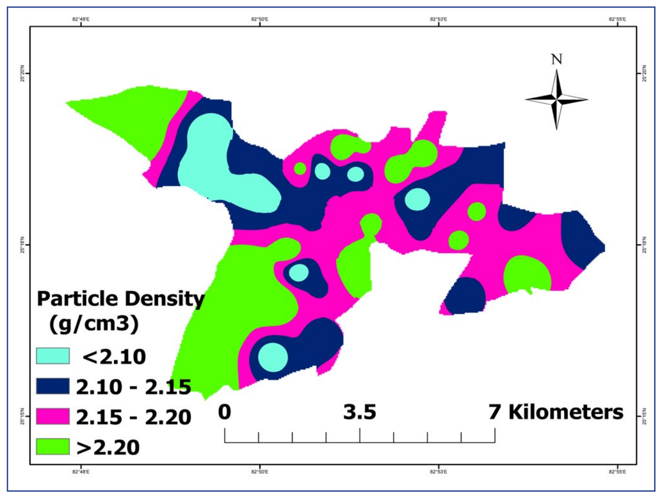

Figure 8: Spatial variability map of Particle density

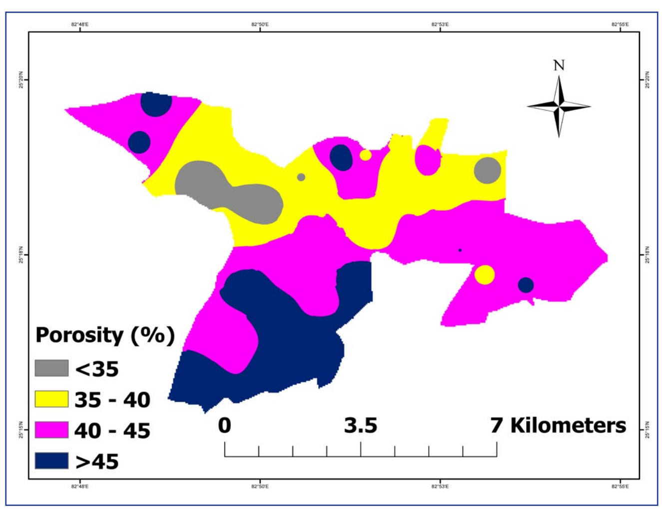

Figure 9: Spatial variability map of Porosity

management practices, and to some extent, the influence of resource region-specific cultural differences (Khan et al., 2021). Electrical conductivity was a measure of the

Table 2: Chemical properties of different villages of Arajiline block of Varanasi district

Sample No.	pH	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Ca (cmol (P+)kg^{-1})	Mg (cmol (P+)kg^{-1})
S_1	7.1	0.28	0.37	134.23	16.90	182.10	15.00	6.70	3.56
S_2	7.4	0.23	0.44	141.12	16.50	230.20	16.20	7.30	4.12
S_3	7.5	0.13	0.17	132.21	23.20	200.20	15.20	6.20	3.54
S_4	7.1	0.24	0.26	130.12	20.30	199.23	14.50	5.30	2.65
S_5	7.3	0.09	0.29	155.23	15.32	210.12	12.00	5.55	2.78
S_6	7.6	0.11	0.30	145.00	16.32	205.50	13.50	6.20	3.10
S_7	7.5	0.08	0.26	155.23	20.10	215.32	14.30	4.56	2.33
S_8	7.4	0.07	0.24	145.12	17.21	190.23	14.00	3.80	2.23
S_9	7.3	0.07	0.35	150.12	19.00	182.23	14.50	4.00	2.23
S_{10}	7.3	0.11	0.31	142.12	18.32	188.23	12.30	5.10	2.55
S_{11}	7.4	0.08	0.45	148.12	19.32	200.23	17.20	6.20	3.10
S_{12}	7.2	0.11	0.40	146.12	20.21	162.32	14.30	5.20	2.60
S_{13}	6.6	0.18	0.60	132.12	17.00	155.23	12.00	4.00	2.12
S_{14}	7.3	0.09	0.47	142.23	16.55	210.23	15.00	5.20	2.60
S_{15}	7.3	0.07	0.45	200.12	18.12	172.23	15.30	6.30	3.15
S_{16}	7.1	0.07	0.41	210.12	17.32	166.23	17.30	5.30	2.65
S_{17}	7.3	0.21	0.43	220.12	18.23	171.23	12.00	6.20	3.10
S_{18}	7.5	0.11	0.45	210.12	19.21	172.23	10.30	6.20	3.10
S_{19}	7.1	0.11	0.53	198.23	18.71	173.45	10.50	5.20	2.60
S_{20}	7.5	0.11	0.40	182.25	16.21	240.00	15.00	4.50	2.25
S_{21}	6.4	0.14	0.54	166.23	17.23	238.20	15.60	6.10	3.05
S_{22}	6.5	0.23	0.45	159.56	16.25	185.23	12.00	5.10	2.55
S_{23}	6.8	0.15	0.60	179.23	17.21	210.23	13.20	5.20	2.60
S_{24}	6.5	0.24	0.45	215.23	18.21	205.12	16.20	4.60	2.30
S_{25}	7.6	0.22	0.43	220.12	21.12	210.23	14.50	5.50	2.75
S_{26}	7.3	0.18	0.54	210.12	20.10	180.23	10.50	6.20	3.10
S_{27}	7.8	0.10	0.53	200.12	16.32	204.12	17.60	6.10	3.05
S_{28}	6.9	0.18	0.27	220.23	15.21	185.23	10.50	5.20	2.60
S_{29}	7.7	0.21	0.48	160.23	16.32	195.00	8.00	4.80	2.40
S_{30}	7.2	0.28	0.56	210.12	15.23	175.00	7.50	5.70	2.85
S_{31}	7.6	0.13	0.60	220.15	16.23	165.00	13.20	6.66	3.33
S_{32}	6.5	0.23	0.53	230.12	14.23	156.00	14.00	5.55	2.78
S_{33}	6.8	0.25	0.44	250.45	16.32	200.23	14.50	4.56	2.28
S_{34}	6.9	0.27	0.47	260.28	17.23	156.21	12.30	5.24	2.62
S_{35}	7.6	0.15	0.53	260.12	18.21	166.23	12.03	5.32	2.66
S_{36}	7.5	0.20	0.30	240.12	16.32	165.00	13.50	5.65	2.83
S_{37}	7.3	0.27	0.56	182.23	17.12	154.00	14.00	7.65	3.83
S_{38}	7.6	0.25	0.23	190.30	16.23	165.00	15.00	8.21	3.56
S_{39}	7.2	0.20	0.47	195.23	17.12	145.00	15.20	4.56	2.28

Table 2: Continue...

Sample No.	pH	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Ca (cmol (P+)kg^{-1})	Mg (cmol (P+)kg^{-1})
S_{40}	7.1	0.20	0.50	200.12	16.21	210.23	13.50	5.65	2.83
Max	7.8	0.3	0.6	260.3	23.2	240.0	17.6	8.2	4.1
Min	6.4	0.1	0.2	130.12	14.2	145.0	7.5	3.8	2.1
Mean	7.2	0.2	0.4	195.21	17.6	187.5	13.6	5.6	2.8
SD	0.35	0.07	0.11	46.63	1.83	23.91	2.30	0.95	0.47
SEm±	0.06	0.01	0.02	7.37	0.29	3.78	0.36	0.15	0.07
CV	4.82	41.76	26.66	25.74	10.43	12.76	16.90	17.15	16.57

soluble salt concentration present in the soil. The EC range of the studied soils in the Arajiline block varied from 0.1 to 0.3 dS/m, with a mean value of 0.2 dS/m. The lowest value of EC was observed in S_{27} of SuiChak village, while the highest was 0.28 dS/m from S_1, S_{28} of Kundriya and Darekhu villages, with S.D. and C.V. values of 0.07 and 41.76%, respectively, as shown in Table 2. A similar result was observed by Pandey et al. (2020) in the Mirzapur district of eastern Uttar Pradesh. The data showed that the organic carbon content of the studied soils ranged from 0.2 to 0.6%, with a mean value of 0.4%. The lowest value (0.17%) of organic carbon was observed in S_3 of SuiChak village, and the highest value (0.6%) was observed in S_{13}, $S_{23,}$ and S_{31} of SuiChak, Mechkanpur, and Mehdiganj villages, with S.D. and C.V. values of 0.11 and 26.66%, respectively. Out of the total 40 soil samples collected from Arajiline Block, 70% had low organic carbon levels and 30% were in the medium category, which is represented in Table 2. This occurred due to the sub-tropical climate with high temperatures prevailing in that area, causing rapid decomposition of the organic carbon. The spatial variability map of pH, EC, and organic carbon is presented in Figure 10, 11, and 12.

3.2.2. Status of available nitrogen, phosphorous and potassium in soils

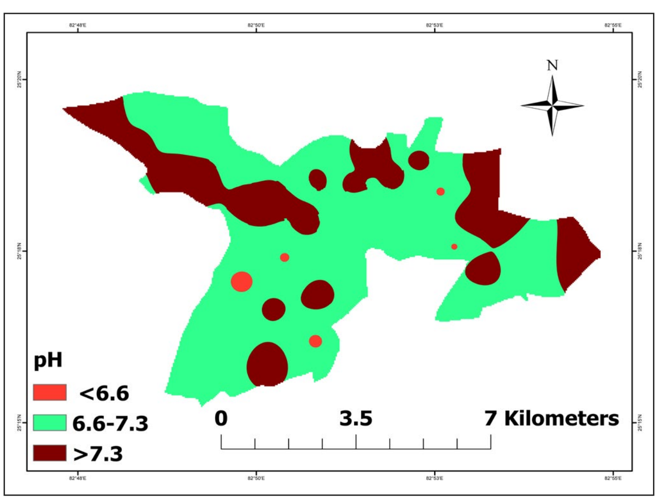

Figure 10: Spatial variability map of pH

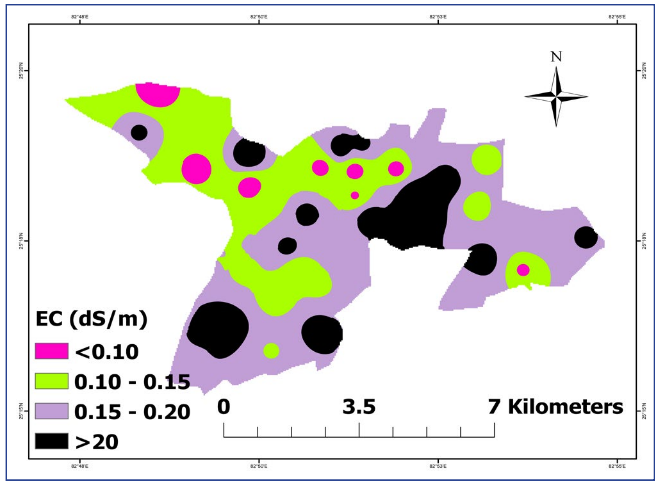

Figure 11: Spatial variability map of EC

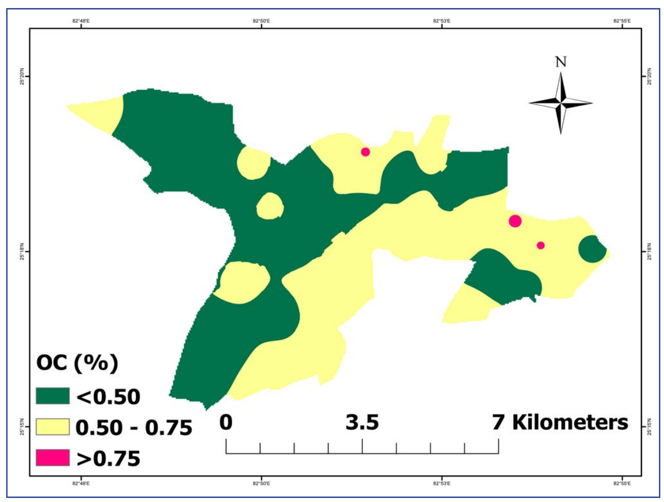

Figure 12: Spatial variability map of Organic carbon

The available nitrogen content of the soil samples from Arajiline Block ranged from 130.12 to 260.3 kg ha^{-1}, with a mean value of 195.21 kg ha^{-1}. The S.D. and C.V. values for available N in the soil were 46.63 and 25.74%, respectively (Table 2). S_4 had the lowest nitrogen content in the soil, whereas the highest available nitrogen content was mainly observed in the soils of S_{35} of Kachnar village. Out of 40 soil samples collected from Arajiline Block, 100% of the soil samples were in the low category for available N. The studied soil was low in available N due to the high pH, which declined the OC status through faster degradation, which reflected low available N (Ammannawar et al., 2017; Rajendiran et al., 2018). The close relationship observed between available nitrogen and organic carbon might be due to the close association between ammonia and the humus complex in the soil. A similar result was observed by Bharteey et al. (2023) in the Dhemaji district of Assam. The available P in the studied soils varied from 14.2 to 23.2 kg ha^{-1}, with a mean value of 17.6 kg ha^{-1}. The S.D. and C.V. values were 1.83 and 10.43%, respectively. 100% of the total soil samples were in the medium category. Low P availability in these soils might be attributed to their low P status, fixation with sesquioxides (Fe and Aloxides and hydroxides), and formation of calcium phosphate in calcareous soils (Meena et al., 2006; Bhattacharyya et al., 2007). The range of available potassium content in the soil was varied from 145.0 to 240.0 kg ha^{-1}, with a mean value of 187.5 kg ha^{-1}. S_{39} of Mehdiganj had the lowest value of potassium, and the highest value was observed in S_{40} of Kachnar village, with S.D. and C.V. values of 23.91 and 12.76%, respectively. Out of 40 soil samples, 100% of the studied area had medium levels of available K, according to limits (108–280 kg ha^{-1}) defined by Muhr et al. (1965).The area distributions of available N, P and K are presented in Figure 13, 14 and 15.

3.2.3. Status of available calcium, magnesium and sulphur in soils

The available calcium in the study area varied from 3.8 to 8.2 Cmol (P+)/kg, with a mean value of 5.6 Cmol (P+)/kg (data represented in Table 2). The S.D. and C.V. values were 0.95 and 17.15%, respectively. The soils of Sample No. 8 of SuiChak village were noted to have a minimum content of available calcium, whereas the maximum content

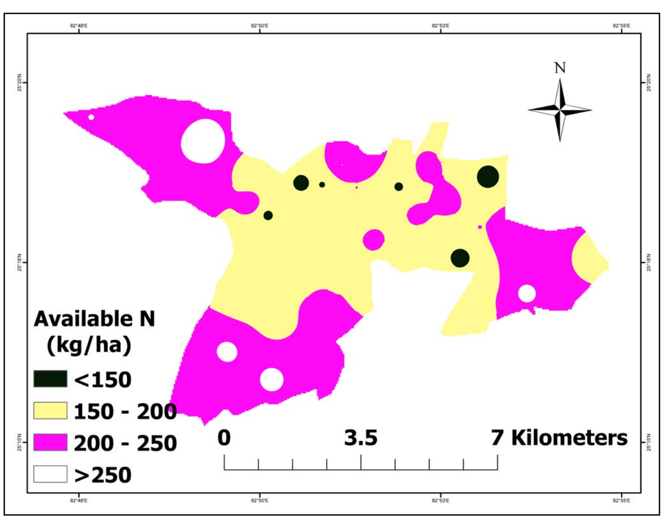

Figure 13: Spatial variability map of Available N

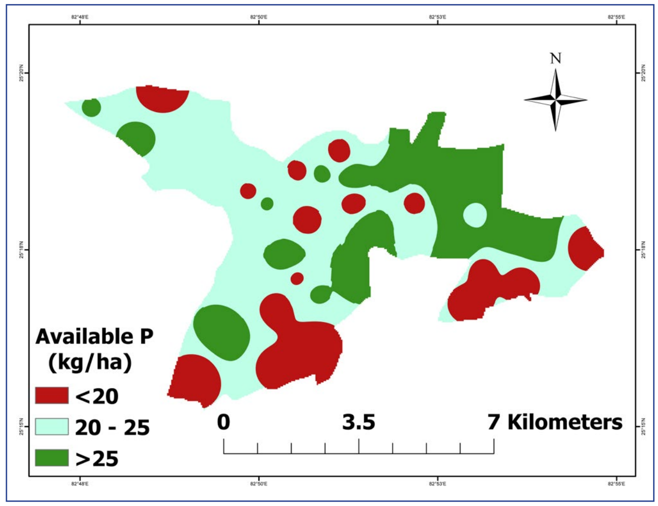

Figure 14: Spatial variability map of Available P

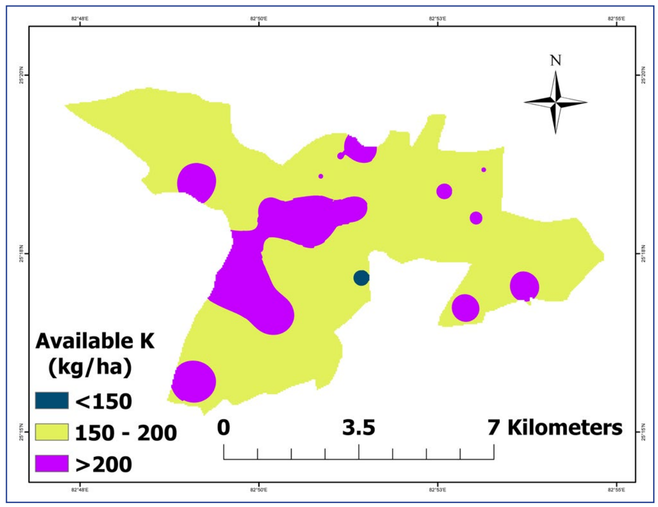

Figure 15: Spatial variability map of Available K

of exchangeable calcium was observed in the soil of Sample No. 38 of Mechkanpur village. Total samples were found to be in the sufficient category for available calcium. As limes were used in the soils of Arajiline Block, or might be due to the application of Ca-rich fertilizers in the soil. Similar results were also obtained by Sharma et al. (2013) in the vegetable growing soil of Varanasi district, with a mean value of 1764 ppm of available calcium. The exchangeable Mg content in the soils of the Arajiline block varied from 2.1 to 4.1, with a mean value of 2.8 Cmol (P+) kg^{-1}. The lowest Mg content was found to be present in Sample No. 13 of SuiChak village. On the other hand, the highest content of exchangeable Mg was detected in Sample No. 2 of Gajari village, with a value of 6.70 cmol (P+) kg^{-1}. S.D. and C.V. values for exchangeable Mg content were found to be 0.47 and 16.57%, respectively. The total sample was found to be in the sufficient category for exchangeable Ca. Similar results were also obtained by Sharma et al. (2013) in the vegetable growing soil of Varanasi district, with a mean value of 496 ppm of available magnesium. The sufficient Mg^{2+} might be attributed to low rainfall, which favours the least leaching of Mg^{2+}. The range of sulphur content in soils of Arajiline block varied from 7.5 to 17.6 $kgha^{-1}$, with a mean value of 13.6 kg ha^{-1}. Sample No. 30 of SuiChak village had the lowest content of available sulphur while the highest content of available sulphur was found in another edge of Sample No. 27 of Suichak village. The S.D. and C.V. value for available S in soils of the Arajiline block region were 2.30 and 16.90%, respectively. 100% of the collected soil samples were found to be in medium range of available Sulphur. Similar results were also found by Rai et al. (2018) on the black soil of Varanasi district in eastern Uttar Pradesh. The Ex. Ca, Mg, and available S distributions are shown in Figure 16, 17, and 18.

3.3. Nutrient index value of soils of different village in Arajiline block of Varanasi district, Uttar Pradesh

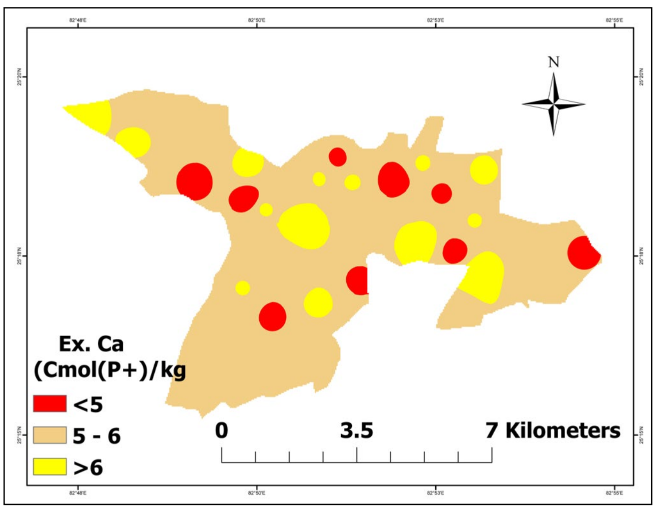

Figure 16: Spatial variability map of Ex Ca^{++}

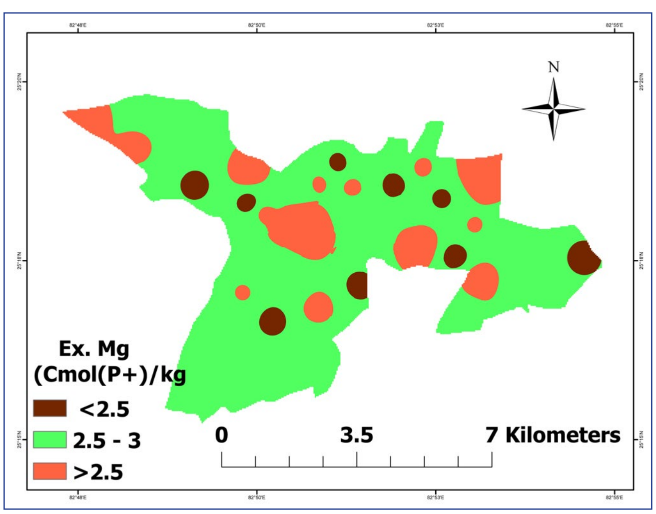

Figure 17: Spatial variability map of Ex. Mg

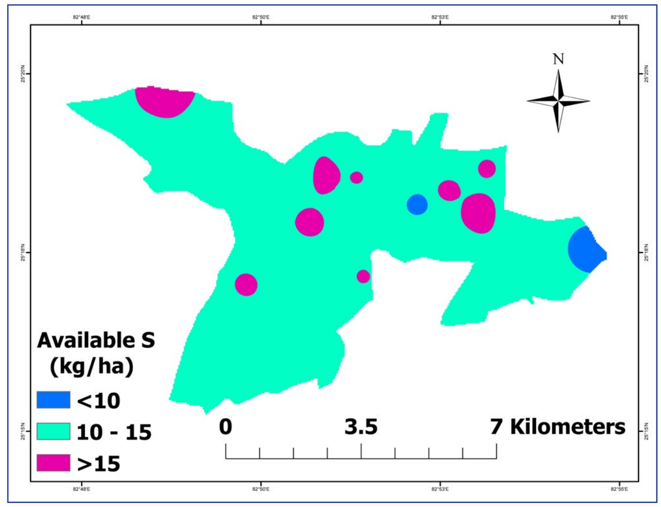

Figure 18: Spatial variability map of Available S

The Nutrient index value (NIV) for available primary nutrients i.e. N. P. K and S of Arajiline block of Varanasi district were given below in figure 19 and Table 3. The nutrient index value for the soils of Arajiline block was low for the available nitrogen, Phosphorus, potassium and Sulphur. It was analyzed that NIV for N, P, K and S were 1.20, 0.8, 0.8 and 0.8 respectively, against the nutrient index value less than 1.5 for low, 1.5 to 2.5 for medium and greater than 2.5 for high (Thombe et al., 2020).

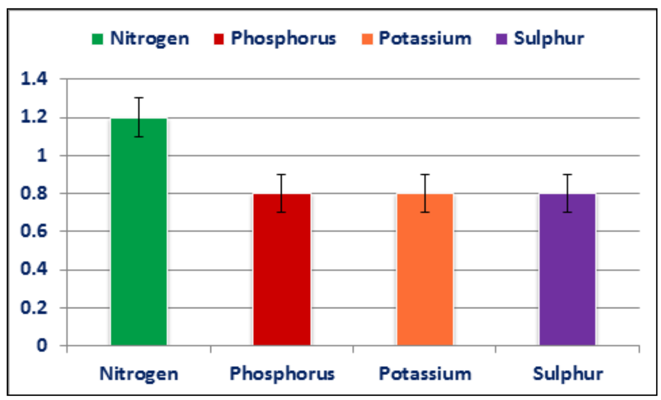

Figure 19: Nutrient index of Arajiline block of Varanasi district

TS in soil was in Negative correlation but statistically significant with silt and clay (r=-0.911, -0.841), TS was negatively non-significant with BD, PD, OC, K and S (r=-0.101, -0.181, -0.101, -0.260 and -0.005). TS was in Positive correlation but statistically non-significant with VFS, Porosity, pH, EC, N, P, Ca and Mg (r =0.157, 0.011, 0.160, 0.123, 0.043, 0.046, 0.272 and 0.223).

VFS in soil was in positive correlation but significant with BD (r=0.574) and statistically not significant with pH, P, K, S and Mg (r=0.287, 0.034, 0.089, 0.228 and 0.093). VFS was in negative correlation but significant with Porosity, EC, OC and N (r=-0.606, -0.523, -0.406 and -0.337) and

Table 3: Correlation between physico chemical properties of different villages of Arajiline block of Varanasi district, Uttar Pradesh

Parameters	TS	VFS	SILT	Clay	BD	PD	Porosity	pH
TS	1							
VFS	0.157	1						
Silt	-0.911**	-0.224	1					
Clay	-0.841**	-0.025	0.542**	1				
BD	-0.101	0.574**	0.028	0.169	1			
PD	-0.181	-0.233	0.101	0.235	-0.029	1		
Porosity	0.011	-0.606**	0.018	-0.047	-0.891**	0.478**	1	
pH	0.160	0.287	-0.077	-0.224	0.328*	-0.208	-0.381*	1
EC	0.128	-0.523**	0.002	-0.264	-0.234	0.067	0.242	-0.321*
OC	-0.101	-0.406**	0.203	-0.060	-0.444**	-0.001	0.393*	-0.147
N	0.043	-0.337*	0.049	-0.150	-0.313*	-0.077	0.240	0.030
P	0.046	0.034	-0.102	0.041	0.195	0.064	-0.138	-0.180
K	-0.260	0.089	0.256	0.193	0.285	0.178	-0.180	0.045
S	-0.005	0.228	0.048	-0.053	0.066	0.152	0.000	0.001
Ca	0.272	-0.004	-0.228	-0.254	-0.035	-0.146	-0.030	0.289
Mg	0.223	0.093	-0.206	-0.183	0.040	-0.170	-0.107	0.296

Table 3: Continue...

Parameters	EC	OC	N	P	K	S	Ca	Mg
EC	1							
OC	0.274	1						
N	0.114	0.299	1					
P	0.074	0.295	-0.092	1				
K	-0.221	-0.202	-0.307	-0.270	1			
S	-0.230	-0.134	-0.101	0.039	0.268	1		
Ca	0.268	0.014	-0.097	-0.112	-0.075	0.140	1	
Mg	0.224	-0.004	-0.192	-0.069	0.001	0.183	0.949**	1

statistically not significant with silt, clay, PD and Ca (r=-0.224, -0.225, -0.223 and -0.004).

Silt in soil was in positive correlation but statistically significant with clay (r=0.542) and not significant with BD, PD, Porosity, EC, OC, N, K and S (r=0.028, 0.101, 0.018, 0.002, 0.203, 0.049, 0.256 and 0.048). Silt was negatively non-significant with pH, P, Ca and Mg (r=-0.077, -0.102, -0.228 and -0.206). Clay in soil was negatively non-significant in correlation with Porosity, pH, EC, OC, N, S, Ca and Mg (r=-0.047, -0.224, -0.264, -0.060, -0.150, -0.053, -0.254 and -0.183) and Positively non-significant with BD, PD, P and K (r=0.169, 0.235, 0.041 and 0.193). BD in soil was negatively significant in correlation with Porosity, OC and N (r=-0.891, -0.444 and -0.313) and statistically non-significant with PD, EC and Ca (r=-0.029, -0.234 and -0.035). BD was positively significant in correlation with pH (r=0.328) and statistically non-significant with P, K, S and Mg (r=0.195, 0.285, 0.066 and 0.040).

PD in soil was in positive correlation but statistically significant with Porosity (r=0.478) and non-significant with EC, P, K and S (r=0.067, 0.064, 0.178, 0.152). PD was negatively non-significant in correlation with pH, OC, N, Ca and Mg (r=-0.208, -0.001, -0.077, -0.146 and -0.170). Porosity in soil was negatively significant in correlation with pH (r=-0.381) and statistically non-significant with P, K, Ca and Mg (r=-0.138, -0.180, -0.030 and -0.107). Porosity was in positive correlation but significant with OC (r=0.393) and statistically non-significant with EC and N (r=0.242 and 0.240).

pH in soil was negatively significant in correlation with EC (r=-0.321) and non-significant in correlation with OC and P (r=-0.147 and -0.180). pH was Positively non-significant in correlation with N, K, S, Ca and Mg (r=0.030, 0.045, 0.001, 0.289 and 0.296).

EC in soil was positively not significant in correlation with OC, N, P, Ca and Mg (r=0.274, 0.114, 0.074, 0.268 and 0.224). EC was in negative correlation but statistically non-significant with K and S (r=-0.221 and -0.230). OC in soil was positively non-significant in correlation with N, P and Ca (r=0.299, 0.295 and 0.014) and negatively non-significant in correlation with K, S and Mg (r=-0.202, -0.134 and -0.004). N in soil was negatively non-significant in correlation with P, K, S, Ca and Mg (r=-0.092, -0.307, -0.101, -0.097 and -0.192). P in soil was negative in correlation but statistically non-significant with K, Ca and Mg (r=-0.270, -0.112 and -0.069) and positively non-significant in correlation with S (r= 0.039). K in soil was Positively non-significant in correlation with S and Mg (r=0.268 and 0.001) and negatively non-significant in correlation with Ca (r=-0.075). S in soil was positively not significant in correlation with Ca and Mg (r=0.140 and 0.183) and Ca was in positive correlation but statistically significant with Mg (r=0.949).

4. CONCLUSION

The study area, ranging from loamy sand to clay, exhibited a textural distribution with slightly acidic to moderately saline soil. Soil in the area had low OC, and N levels were low, while P, K and S were in the medium range. Exchangeable Ca and Mg were considered sufficient. Examining the chemical and physical properties of soil was advantageous for enhancing optimized soil fertility. The collection of valuable soil data established a connection between soil composition and plant growth, assisting farmers in the implementation of sustainable agricultural practices.

5. REFERENCES

Ammannawar, P.B., Kondvilkar, N.B., Annapurna, M.V.V.I., Palwe, C.R., 2017. Soil macro and secondary nutrients status of Pathardi Tehsil of Ahmednagar District. International Journal of Communication System 5(5), 2354–2358.

Bacchewar, G.K., Gajbhiye, B.R., 2011. Correlation studies on secondary nutrients and soil properties in soils of Latur district of Maharashtra. Research Journal of Agriculture Science 2(1), 91–94.

Bautista-Cruz, A., Carrillo-González, R., Arnaud-Vinas, M. R., Robles, C., De León-González, F., 2007. Soil fertility properties on Agave angustifolia Haw plantations. Soil and Tillage Research 96(1-2), 342–349.

Bharteey, P.K., Deka, B., Dutta, M., Goswami, J., Saikia, R., 2023. Geospatial variability of soil physico-chemical properties of Moridhal watershed in Dhemaji district of Assam, India using Remote sensing and GIS. Annals of Plant and Soil Research 25(1), 99–109.

Bhattacharyya, T., Pal, D.K., Easter, M., Batjes, N.H., Milne, E., Gajbhiye, K.S., Powlson, D.S., 2007. Modelled soil organic carbon stocks and changes in the Indo-Gangetic Plains, India from 1980 to 2030. Agriculture, Ecosystems and Environment 122(1), 84–94.

Black, C.A., 1965. Methods of soil analyses. Black CA ed. Madison Wisconsin, USA 1-2, 1572.

Cardoso, M., Kuyper, T., 2006. Mycorrhizas and tropical soil fertility Agriculture. Ecosystems and Environment 116(1), 72–84.

Cheng, K.L., Bray, R.H., 1951. Determination of calcium and magnesium in soil and plant material. Soil Science 72(6), 449–458.

Chesnin, L., Yien, C.H., 1950. Turbidimetric determination of available sulfur. Proceeding of Soil Science America, 149.

Deoli, V., Kumar, D., 2020. Analysis of groundwater fluctuation using GRACE satellite data. Indian Journal of Ecology 47(2), 299–302.

Desbiez, A., Matthews, R., Tripathi, B., Ellis-Jones, J., 2004. Perceptions and assessment of soil fertility by farmers in the mid-hills of Nepal. Agriculture, Ecosystems & Environment 103(1), 191–206.

Ghosh, A.B., Hasan, R., 1976. Available potassium status of Indian soils. In: Potassium in soils, crops and fertilizers. Bulletin No.10, 1976, Indian Society of Soil Science, New Delhi.

Goovaerts, P., 1998. Geostatistical tools for characterizing the spatial variability of microbiological and physico-chemical soil properties. Biology and Fertility of Soils 27, 315–334.

Haby, V.A., Davis, J.V., Leonard, A.T., Patten, K.D., 1991. Rabbiteye blueberry plant response to nitrogen and phosphorus. Journal of Plant Nutrition 14(10), 1081–1090.

Hanway, J., Heidal, 1952. Soil analysis methods as used in lowa State College. Agriculture Bulletin 57, 1–13.

Havlin, H.L., Beaton, J.D., Tisdale, S.L., Nelson, W.L., 2010. Soil fertility and fertilizers- an introduction to nutrient management (7th edition). PHI Learning Private Limited, New Delhi.

Jackson, M.L., 1973. Soil Chemical analysis, (2nd Indian Print) Prentice-Hall of India Pvt. Ltd. New Delhi 38, 336.

Jones Jr, J.B., 2012. Plant nutrition and soil fertility manual. CRC press.

Kalita, B., Bora, S., Sharma, A.K., 2013. Plant essential oils as mosquito repellent-a review. International Journal of Research and Development in Pharmacy and Life Sciences 3(1), 741–747.

Khadka, D., Lamichhane, S., Amgain, R., Joshi, S., Shree, P., Kamal, S.A.H., Ghimire, N.H., 2019. Soil fertility assessment and mapping spatial distribution of Agricultural Research Station, Bijayanagar, Jumla, Nepal. Eurasian Journal of Soil Science 8(3), 237–248.

Khan, M.Z., Islam, M.R., Salam, A.B.A., Ray, T., 2021. Spatial variability and geostatistical analysis of soil properties in the diversified cropping regions of Bangladesh using geographic information system techniques. Applied and Environmental Soil Science 2021, 1–19.

Kim, H.J., Sudduth, K.A., Hummel, J.W., 2009. Soil macronutrient sensing for precision agriculture. Journal of Environmental Monitoring 11(10), 1810–1824.

Meena, H.B., Sharma, R.P., Rawat, U.S., 2006. Status ofmacro and micronutrients in some soils of Tonkdistrictof Rajasthan. Journal of the Indian Society of Soil Science 54, 508–512.

Muhr, G.R., Datta, N.P., Shankara Subraney, N., Dever, F., Lecy, V.K., Donahue, R.R., 1965. Soil testing in India, USAID Mission to India.

Olsen, S.R., Cole, C.V., Watanabe, P.S., Dean, L.A., 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture Circular No. 939.

Panda, A.K., Mishra, B.G., Mishra, D.K., Singh, R.K., 2010. Effect of sulphuric acid treatment on the physico-chemical characteristics of kaolin clay. Colloids and Surfaces A: Physicochemical and Engineering Aspects 363(1-3), 98–104.

Pandey, L., Amit, P., Singh, S., Singh, S., 2020. An assessment of soil available nutrients status of Chunar area in Mirzapur District of eastern Uttar Pradesh. Journal of the Indian Society of Soil Science 68(3), 237–243.

Parker, F.W., Nelson, W.L., Winters, E., Miles, I.E., 1951. The broad interpretation and application of soil test information. Agronomy Journal 43(3), 105–112.

Piper, C.S., 1966. Soil and plant analysis, Hans Publishers: Bombay, India.

Prajapat, V., Singh, V.Y., Bharteey, K.P., Sarvajeet, K., Singh, K., Sharma, S., Saraswat, A., 2023. Assessment of soil fertility status of different villages of Depalpur Block of Indore District, Madhya Pradesh, India, Environment and Ecology 41, 191–196.

Qiu, X., Zhu, T., Yao, B., Hu, J., Hu, S., 2005. Contribution of dicofol to the current DDT pollution in China. Environmental Science and Technology 39(12), 4385–4390.

Rai, A., Singh, S., 2018. Available nutrients status in black soils of Varanasi district of eastern part of Uttar Pradesh. Journal of Applied and Natural Science 10(4), 1238–1242.

Rajendiran, D., Packirisamy, S., Gunasekaran, K., 2018. A review on role of antioxidants in diabetes. Asian Journal of Pharmaceutical and Clinical Research 11(2), 48–53.

Rakesh, K., Singh, Y.V., Surendra, S., Latare, A.M., Mishra, P.K., 2012. Effect of phosphorus and sulphur nutrition on yield attributes, yield of mungbean (*Vigna radiata* L. Wilczek). Journal of Chemical and Pharmaceutical Research 4(5), 2571–2573.

Reddy, G.R., Thomas, T., Swaroop, N., Singh, A.K., Naga, I.R., 2023. Assessment of physico-chemical properties of soil from different Blocks of Adilabad District, Telangana, India. International Journal of Plant & Soil Science 35(15), 121–130.

Selvi, P.K., Thomas, T., Swaroop, N., Singh, A.K., 2023. Assessment of physico-chemical properties of soil from different Blocks of Theni District, Tamil Nadu, India. International Journal of Plant & Soil Science 35(15), 392–406.

Sharma, R.P., Yadava, R.B., Lama, T.D., Bahadur, A., Singh, K.P., 2013. Status of secondary nutrients vis-à-vis soil site-characteristics of vegetable growing soils of Varanasi. Vegetable Science 40(1), 65–68.

Singh, V., Singh, R.P., Chandel, S.K.S., Patel, S.K., 2019. Physico-chemical properties and available N, P, K and S in soils of Harahua block of Varanasi district, Uttar Pradesh. Agropedology 29(01), 72–75.

Snedecor, G.W., Cochran, W.R., 1967. Statistical methods, 6th ed., Iowa State University Press, Ames, Iowa, p. 274.

Srinidhi, P., Singh, Y.V., Sharma, P.K., Singh, R.K., Latare, A.M., Srinath, I., Yogesh, Y.C., 2020. Physico-chemical analysis of soils in Madanapalle block, Chittor district of Andhra Pradesh. International Journal of Communication Systems 8(3), 154–158.

Subbiah, B.V., Asija, G.L., 1956. A rapid procedure for the estimation of available nitrogen in soils. Current Science 25, 259–60.

Thaker, P.N., Nayana, Brahmbhatt, N., Karishma, D.S., 2023. Assessment of physico-chemical properties of soil in selected areas of Khambhat taluka, Gujarat. Annalsof Plant and Soil Research 1, 187–192.

Thombe, S.V., Badole, W.P., Sarnaik, K.B., Karwade, S., 2020. Assessment of soil fertility status in selected villages under Jalyukt Shivar in Nagpur district. Journal of Soil and Crops 6(6), 81–85.

Yadav, K.K., Mali, N.L., Kumar, S., Surya, J.N., Moharana, P.C., Nogiya, M., Meena, R.L., 2022. Assessment of soil quality and spatial variability of soil properties using geo-spatial techniques in sub-humid southern plain of Rajasthan, India. Journal of the Indian Society of Soil Science 70(1), 69–85.

Walkley, A., Black, I.A., 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science 37, 29–38.

Wilding, L.P., Lin, H., 2006. Advancing the frontiers of soil science towards a geoscience, Geoderma 131, 257–274.

Yadav, R., Bhat, M.I., Faisul-Ur-Rasool, P.K., Ahmad, R., Bisati, I.A., Bhat, K.A., Singh, R., 2022. Spatial distribution of soil physico-chemical properties of North Western Himalayan Region of Jammu and Kashmir, (India) using inverse distance weighted (IDW) interpolation technique in GIS environment. Agricultural Machenization in Asia 53(05), 8113–8124.