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Spatio-Temporal Variability Of Physico-Chemical Properties In Agricultural Soils Of Wanoja Village, Maharashtra, India

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Abstract

The present investigation evaluates the spatio-temporal variability of physico-chemical properties of agricultural soils in Wanoja village, Amravati District, Maharashtra, India. Soil samples were collected from fifteen sampling sites (survey no.) at a depth of 0–15 cm and analyzed. Physical parameters such as texture, bulk density, and porosity, along with chemical attributes including pH, electrical conductivity, nitrogen, phosphorus, and potassium, were assessed using standard analytical procedures. The soils were predominantly Vertisols, characterized by high clay content (up to 59.7%) and slightly to moderately alkaline reaction (pH 7.21–8.48). Seasonal variations were statistically significant for soil temperature, nitrogen, and potassium ($P < 0.05$), while pH and electrical conductivity remained stable throughout the year. Electrical conductivity values (0.53–0.69 dS m^{-1}) confirmed the non-saline nature of the soils. Overall, the soils exhibited good fertility status, although increasing bulk density with depth indicates a potential risk of subsoil compaction. The findings emphasize the importance of season-specific nutrient management strategies for sustainable agricultural productivity in Vertisol dominated regions.

Keywords: Soil fertility, Vertisols, Bulk density, Nutrient dynamics, Maharashtra

1. Introduction

Soil is a vital natural resource that underpins agricultural productivity and ecosystem sustainability. Its physical and chemical characteristics regulate water retention, nutrient availability, root penetration, and microbial activity, there by influencing crop growth and yield. In semi-arid tropical regions such as the Deccan Plateau, soils are subject to pronounced seasonal variations in moisture and temperature, which significantly affect nutrient dynamics and soil structure.

Vertisols, which dominate large tracts of central India, are derived primarily from basaltic parent material and are characterized by high clay content, shrink–swell behavior, and deep cracks during dry seasons. While these soils possess high inherent fertility, improper management can lead to compaction, nutrient imbalance, and reduced productivity. Understanding the spatial and temporal variability of soil properties is therefore essential for site-specific nutrient management and sustainable land-use planning.

The present study aims to assess the physico-chemical characteristics of agricultural soils in Wanoja village, Amravati District, with special emphasis on seasonal variability.

2. Material and Method

2.1 Study Area

Wanoja village is situated in Anjangaon Surji Tehsil of Amravati District, Maharashtra, approximately 72 km from Amravati city. The region experiences a hot semi-arid climate, with mean annual rainfall ranging from 800 to 900 mm, received predominantly during the southwest monsoon (June–September). Summer temperatures often exceed 40°C, while winters are mild.

2.2 Soil Sampling and Analysis

Soil samples were collected from fifteen agricultural fields (Survey no.) The abbreviations of farmers names represent samples. Sampling was carried out throughout the year from the surface layer (0–15 cm). Soil temperature was measured in situ, pH and electrical conductivity were analyzed using standard methods, and available nitrogen, phosphorus, and potassium were determined following established laboratory procedures. Statistical analysis was performed using one-way ANOVA at the 5% significance level.

3. Result

The soils exhibited fine-textured characteristics, ranging from clay loam at the surface to heavy clay in deeper horizons. Clay content increased with depth, while bulk density increased and porosity decreased, indicating gradual subsoil compaction.

The seasonal variation in mean soil physico-chemical properties of the study area is presented in Table 2. The results clearly indicate that soil characteristics exhibited distinct seasonal fluctuations influenced by prevailing climatic conditions, crop cover, and soil management practices.

Soil temperature showed variability, with the highest temperature recorded is (33.8 °C) and the lowest is (21.1 °C). The elevated summer temperatures may be attributed to increased solar radiation and reduced soil moisture, while lower winter temperatures reflect reduced atmospheric heat and shorter photoperiods. Such temperature variations are known to significantly influence soil microbial activity and nutrient mineralization processes.

Soil reaction (pH) remained slightly alkaline across all seasons, ranging from 7.52 to 8.48. The highest pH was observed during winter (8.48), while comparatively lower values were recorded during summer (7.52). The marginal increase in pH during winter may be due to reduced leaching and accumulation of basic cations, whereas dilution effects of rainfall during monsoon and increased biological activity during summer might contribute to slight seasonal reductions.

Soil organic carbon (SOC) content exhibited relatively higher values (0.48 %) and lowest value (0.2 %). The higher SOC associated with increased biomass input, reduced decomposition rates under cooler temperatures, and incorporation of crop residues. The decline during summer could be attributed to enhanced oxidation of organic matter under high temperature conditions.

A similar seasonal trend was observed for electrical conductivity (EC), which remained low and within safe limits across all seasons (0.28-0.9 dS m^{-1}), indicating non-saline soil conditions. Slightly higher EC values during winter and monsoon seasons may be due to the dissolution of soluble salts and fertilizer residues, while marginally lower summer values could result from limited salt mobility under drier soil conditions.

Available nitrogen content showed relatively stable seasonal distribution, with slightly higher mean values during summer (247.2 kg ha^{-1}), and winter (230.9 kg ha^{-1}). The increased nitrogen availability during summer may be linked to enhanced mineralization of organic nitrogen under higher temperatures.

Available phosphorus content varied with the highest value observed during winter (19.9 kg ha^{-1}). The relatively higher winter phosphorus levels may be due to reduced fixation and slower crop uptake, while lower in (17.3 kg ha^{-1}) monsoon values could be influenced by leaching losses and fixation under moist soil conditions.

Available potassium showed a declining trend from monsoon (344.44 kg ha^{-1}) to winter (341.92 kg ha^{-1}) and summer (337.31 kg ha^{-1}). Higher monsoon potassium levels may result from weathering of K-bearing minerals and release from soil colloids, while gradual depletion during summer could be attributed to crop uptake and reduced replenishment.

Among secondary nutrients, calcium and magnesium exhibited minimal seasonal variation. Mean calcium content ranged from 21.83 to 22.30 meq 100 g^{-1}, while magnesium ranged from 10.46 to 10.55 meq 100 g^{-1}. Slightly higher concentrations during winter and summer suggest reduced leaching losses and greater retention of exchangeable bases in the soil system.

Available Sulphur content showed moderate seasonal variation, with the highest mean value recorded during monsoon (12.96 mg kg^{-1}), followed by winter (12.39 mg kg^{-1}) and summer (12.27 mg kg^{-1}). The higher Sulphur content during monsoon may be attributed to increased mineralization of organic Sulphur and inputs from rainfall, while lower summer values may result from crop uptake and reduced microbial activity under moisture stress.

4. Discussion

Seasonal variation in soil physico-chemical properties revealed that soil temperature was significantly higher during summer due to increased solar radiation and reduced soil moisture (Hillel, 2004). Lower temperatures during winter are attributed to reduced atmospheric heating and shorter photoperiods (Lal, 2015).

Soil pH remained slightly alkaline across seasons, consistent with Vertisols characteristics and strong buffering capacity (Brady & Weil, 2017). Seasonal variation in organic carbon was marginal, with higher values during monsoon and winter due to greater biomass input and reduced decomposition rates (Walkley & Black, 1934; Stevenson, 1994).

Electrical conductivity values indicated non-saline conditions throughout the year, suggesting minimal accumulation of soluble salts (Richards, 1954). Slight seasonal differences may be linked to fertilizer use and rainfall patterns.

Available nitrogen content showed minor seasonal variation, with relatively higher values during summer, attributed to enhanced mineralization under higher temperatures (Subbiah & Asija, 1956; Havlin et al., 2014). Phosphorus availability was higher during winter due to reduced fixation and slower crop uptake, whereas monsoon reductions may result from leaching and fixation under moist conditions (Olsen et al., 1954).

Potassium content declined from monsoon to summer, likely due to crop uptake and reduced replenishment during dry periods (Tisdale et al., 1993). Secondary nutrients such as calcium and magnesium showed minimal seasonal fluctuation, reflecting strong exchangeable base saturation in Vertisols (Jackson, 1973).

Sulphur availability was highest during monsoon due to mineralization of organic sulphur and atmospheric deposition via rainfall, while lower summer values may result from crop uptake and moisture stress (Tabatabai, 1982).

5. Conclusion

The soils of Wanoja village are fertile, non-saline Vertisols with stable pH and good nutrient status. Seasonal variations in temperature and nutrients underscore the need for season-specific nutrient management strategies to enhance sustainability and productivity.

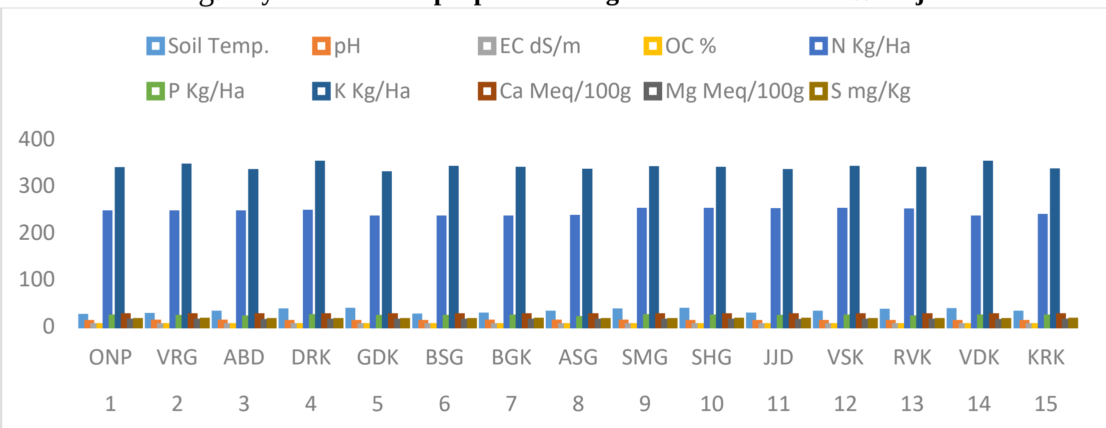
Table 1: Characteristic of Agricultural Soil from Wanoja.

Soil Depth (cm)	Textural Class	Bulk Density (Mg m^{-3})	Particle Density (Mg m^{-3})	Porosity (%)
0–15	Clay loam	1.27	2.64	51.9
0-15	Clay	1.31	2.65	50.6
0-15	Clay	1.36	2.66	48.9
0-15	Clay	1.4	2.67	47.6
0-15	Clay	1.43	2.68	46.6

Table 2: Physico-chemical properties of Agricultural Soil from Wanoja.

Sr, No	Sample Sites Owner Names Abreviations	Soil Temp.	pH	EC dS/m	OC %	N Kg/Ha	P Kg/Ha	K Kg/Ha	Ca Meq/100g	Mg Meq/100g	S mg/Kg
1	ONP	21.1	7.91	0.58	0.48	242	19.3	334	22.1	10.48	12
2	VRG	23.1	8.21	0.48	0.58	241.9	19.1	342	22.27	10.59	12.4
3	ABD	27.7	8.24	0.68	0.58	242.2	17.3	330	22.16	10.22	12.1
4	DRK	32.2	8.11	0.88	0.68	243	20.2	348	22.13	10.48	12
5	GDK	33.7	7.85	0.28	0.88	231	19	325	22.31	10.52	12.3
6	BSG	21.5	7.81	0.38	0.5	230.9	19.1	337.1	22.2	10.56	12.1
7	BGK	23.5	8.43	0.48	0.6	231.2	19.4	335	22.37	10.66	12.6
8	ASG	27.4	8.3	0.5	0.7	232.3	16.3	331.1	22.26	10.33	12.3
9	SMG	32.4	8.48	0.6	0.5	247.1	19.9	336.6	22.23	10.55	12.1
10	SHG	33.8	8.18	0.9	0.2	247	19.2	334.7	22.41	10.61	12.7
11	JJD	23.4	7.76	0.51	0.48	246.9	18.8	330.4	21.9	10.19	12.4
12	VSK	27.6	7.52	0.41	0.58	247.2	19.3	337.2	22.16	10.38	12.2
13	RVK	31.7	7.86	0.31	0.28	246.3	17.5	335.2	22.06	10.49	12.3
14	VDK	33.4	7.83	0.71	0.68	231	19.8	348.2	22.02	10.12	12.1
15	KRK	27.9	7.92	0.81	0.98	234.3	19.4	331.2	22.22	10.38	12.6

Fig. **Physico-chemical properties of Agricultural Soil from Wanoja**



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