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Dynamics of Soil Nutrient Status in Cultivated Fields of Semi-Arid Land at Wanoja village of District Amravati (M.S.)

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Abstract:
The present study investigates changes in soil nutrient status and physico- chemical characteristics of agricultural lands in a semi -arid region of Maharashtra. Soil samples were collected from fifteen representative survey no. from a depth of 0–15 cm. Key parameters such as soil temperature, pH, electrical conductivity, organic carbon, and essential nutrients (N, P, K, Ca, Mg, and S) were analyzed using standard laboratory methods. The soils were found to be clay-rich with moderate to high fertility levels. The findings reveal moderate alkalinity, low to moderate organic carbon levels, and adequate macronutrient availability, suggesting balanced but improvable soil fertility conditions. Spatial variability highlights the need for site-specific soil management strategies.

Keywords: Soil nutrients, Soil fertility, Nutrient management

1. Introduction

Soil serves as the foundation of agricultural productivity by supplying essential nutrients and providing physical support for plant growth. The availability of nutrients and soil characteristics are not constant but vary with climatic conditions, cropping practices, and seasonal changes.

In semi-arid regions, fluctuations in temperature and moisture significantly influence biological activity, nutrient mineralization, and soil structure. These variations can alter the availability of macro and micronutrients, ultimately affecting crop productivity. Wanoja village represents a typical semi-arid agricultural ecosystem where understanding soil variability is essential for improving crop productivity.

Understanding climatic conditions effects on soil behavior is therefore essential for designing efficient nutrient management strategies. This study focuses on evaluating how soil properties change across seasons in cultivated lands and how these changes impact soil fertility.

2.Materials and Methods

1.1 Study Area

The study was conducted in an agricultural region of Wanoja village at central India characterized by a semi-arid climate. The area receives moderate rainfall during monsoon and experiences high temperatures in summer and mild winters.

1.2 Soil Sampling

Soil samples were collected from fifteen agricultural sites. Each site was coded (e.g., LNG, SSG, GKP, etc.) for identification. Sampling was performed through -out the year Samples were taken from the surface layer (0–15 cm), air-dried, and processed for analysis.

1.3 Analytical Methods

The following parameters were analyzed:

i. Soil temperature (field measurement)
ii. pH (pH meter method)
iii. Electrical conductivity (EC meter)
iv. Organic carbon (Walkley-Black method)
v. Nitrogen (Alkaline permanganate method)
vi. Phosphorus (Olsen method)
vii. Potassium (Flame photometer)
viii. Calcium and Magnesium (EDTA titration)
ix. Sulphur (Turbidimetric method)

2. Result and discussion

i. Soil Temperature

Soil temperature ranged from 27.4°C to 34.0°C, indicating typical semi-arid thermal conditions. Higher temperatures at sites like PGP and MRG may accelerate organic matter decomposition, reducing organic carbon levels.

ii. Soil pH

The pH ranged from 7.61 to 8.24, indicating neutral to moderately alkaline soils. Alkalinity may affect nutrient availability, particularly phosphorus, by causing fixation.

Lowest pH has been recorded in PGP 7.61 and the highest pH has been recorded in ASP 8.24. Overall, soils are suitable for most crops but may require amendments for optimal nutrient uptake.

iii. Electrical Conductivity (EC)

EC values ranged from 0.35 to 0.93 dS/m, indicating non-saline soils. This suggests minimal salt stress and favorable conditions for plant growth. The lowest EC has been recorded in ASP0.35dS/m while highest EC has been recorded in PGP 0.93dS/m

iv. Organic Carbon (OC)

OC content varied from 0.29% to 0.90%, indicating low to moderate organic matter status. Lowest OC has been recorded in GKP 0.29% and highest in ASP 0.90%

Low OC in some sites reflects poor residue management and rapid decomposition due to high temperatures. Increasing organic inputs could enhance soil fertility.

v. Available Nitrogen (N)

Nitrogen levels ranged from 230.9 to 249.2 kg/ha, falling in the medium range. Lowest N has recorded in LNG 230.9 kg/ha and highest in GKP 230.9 kg/ha.

Nitrogen availability is moderately sufficient but may require supplementation for high-yield crops.

vi. Available Phosphorus (P)

Phosphorus ranged from 17.0 to 20.4 kg/ha, indicating medium availability. Lowest P has recorded in MRG 17.0 kg/ha and highest in LDM 20.4kg/ha.

Moderate P levels suggest possible fixation due to alkaline pH; thus, efficient fertilizer management is needed.

vii. Available Potassium (K)

Potassium levels ranged from 331.3 to 357 kg/ha, categorized as high. Lowest K has been recorded in NLG 331.3 kg/ha and highest in DKM 357 kg/ha.

High potassium availability supports plant stress tolerance and crop productivity.

Viii. Secondary Nutrients (Ca, Mg, S)

Calcium (Ca)

Calcium has been recorded in the range of 21.6 to 22.61 meq/100g. It indicates adequate availability across all sites.

Magnesium (Mg)

Magnesium has also been recorded in the range 10.17 to 10.89 meq/100g. It indicates sufficient level of magnesium in all sites for plant growth.

Sulphur (S)

Sulphur has been recorded in the range 11.7 to 13,2 mg/kg. It indicates the sulphur availability is moderate which is essential for protein synthesis.

ix. Spatial Variability

The dataset shows noticeable variability among sampling sites:

The highest fertility has remarked in PGP, DKM and LDM samples out of the total, low organic carbon has mentioned in GKP and BSP while alkaline prone sites has found ASP, BRL and DKM

This variability highlights the need for site-specific nutrient management rather than uniform fertilizer application.

x. Correlation Insights

- Organic carbon positively influences nitrogen availability.
- Higher pH tends to reduce phosphorus availability.
- Potassium remains relatively stable across sites, indicating strong soil mineral reserves.

3. Discussion

The observed variations in soil physico-chemical properties are closely associated with climatic factors such as temperature and rainfall, which significantly regulate soil processes. Higher temperatures during summer accelerate organic matter decomposition and nutrient mineralization, leading to increased availability of certain nutrients like nitrogen. Similar findings have been reported by Brady and Weil (2016), who noted that temperature plays a crucial role in enhancing microbial activity and nutrient cycling.

Monsoon rainfall improves soil moisture conditions, thereby increasing nutrient mobility and solubility. However, excessive rainfall can also result in nutrient losses through leaching, particularly nitrogen and sulphur (Havlin et al., 2017). The relatively higher organic carbon content observed during winter seasons may be attributed to increased plant biomass and reduced decomposition rates under cooler conditions, as also supported by Stevenson (1994).

The stability of soil pH and electrical conductivity (EC) across seasons suggests a well-buffered soil system with low salinity risk. This agrees with findings by Singh et al. (2010), who reported that soils in semi-arid regions often maintain stable pH due to high base saturation. The slightly alkaline nature of soil observed in the present study is typical of semi-arid agricultural soils and influences nutrient availability, especially phosphorus.

Variation in phosphorus content, with higher values can be explained by fixation and leaching processes. According to Olsen et al. (1954), phosphorus availability is highly sensitive to soil moisture and pH conditions. Similarly, the gradual decline in potassium in cropping season reflects continuous crop uptake and limited replenishment, which is consistent with observations by Tisdale et al. (2013).

Calcium and magnesium levels remained relatively stable throughout the study period, indicating good soil structure and base saturation. Sulphur content showed variation, with higher values in rainy season due to increased mineralization and lower values in summer due to plant uptake and reduced organic matter input (Tabatabai, 1984).

Overall, the results emphasize that climate play a significant role in influencing soil fertility and nutrient availability. Therefore, adopting season-specific nutrient management strategies is essential for maintaining soil health and enhancing crop productivity in semi-arid regions.

4. Conclusion

The study concludes that the soil is neutral to moderately alkaline pH. The soil is not highly saline, nitrogen and phosphorous level are low to medium, phosphorous availability is high while calcium, magnesium and sulphur are abundant in soil. The organic carbon is low to moderate. Adopting appropriate nutrient management strategies can improve soil health and agricultural productivity.

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Table 1: Physico-chemical analysis of Soil from Wanoja

Sr. No	Sample sites	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	LNG	32.2	7.91	0.53	0.49	230.9	17.4	337.3	22.3	10.42	12.3
2	SSG	33.9	7.75	0.63	0.59	231.1	20	335.3	22.47	10.68	11.8
3	GKP	28.0	7.80	0.53	0.29	249.2	19.2	348.3	22.36	10.75	12.5
4	NLG	32.3	7.81	0.73	0.69	248.9	19.5	331.3	22.33	10.41	12.7
5	PGP	34.0	7.61	0.93	0.79	246.3	19.3	345	22.51	10.69	12.5
6	RNG	27.4	8.01	0.61	0.48	249.1	19.5	343	22.4	10.74	12.4
7	BRL	31.7	8.21	0.72	0.58	249	19.4	338	22.5	10.78	12.6
8	DZG	33.4	7.94	0.83	0.48	244	17.9	352	22.46	10.89	12.8
9	LDM	28.0	8.03	0.64	0.68	245.1	20.4	342	22.39	10.52	13
10	DKM	32,4	8.18	0.57	0.78	243.9	19.4	357	22.61	10.82	12.5
11	MRG	34.0	7.81	0.68	0.5	244.2	17	346.1	21.82	10.54	11.7
12	DBP	27.7	7.75	0.54	0.6	246.3	18.4	341.1	21.81	10.17	12.4
13	BSP	32.1	7.88	0.39	0.3	238	17.5	340.1	21.64	10.68	12.9
14	VHG	33.7	8.19	0.47	0.7	236.1	19.1	349.1	21.6	10.26	13.2
15	ASP	29.1	8.24	0.35	0.9	237.9	18	353.1	21.66	10.29	12.7

Fig. Physico-chemical analysis of Soil from Wanoja