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ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES OF SOIL: A CASE STUDY OF DEHRADUN CITY, UTTARAKHAND

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Abstract
Soil quality strongly influences plant growth, agricultural productivity, and environmental sustainability. This study evaluates soil health in Dehradun, Uttarakhand, by analyzing four soil samples collected in early 2025 from distinct zones of the city (residential, agricultural, and open land areas). Eight key physicochemical properties were measured for each sample: pH, Electrical Conductivity (EC), Organic Carbon (OC), and major nutrients including Nitrogen (N), Phosphorus (P), Sulphur (S), Potassium (K), and Iron (Fe). Standard analytical methods (following ICAR protocols) were used for all measurements. Most values at Sites 1, 2, and 4 fell within acceptable or medium ranges of critical limits. Site 3, however, showed notable deviations: available Nitrogen was marginal (291 kg/ha) and EC was elevated (2.8 dS/m), conditions that could adversely affect crop growth. Overall, soil properties varied with land use: agricultural zones tended to have higher nutrient levels, while more urbanized zones showed signs of declining soil quality. These findings highlight the importance of regular soil testing and targeted management to maintain soil fertility. Continued monitoring is recommended to ensure that soil properties remain within optimal ranges.
Keywords: Nutrient status, Physicochemical properties, Sustainable land management, Soil quality.

INTRODUCTION

Soil is a complex mix of water, air, minerals, organic materials, and decomposing life remnants, forms the earth's "skin." This dynamic, living matrix is essential for agricultural production, food security, and sustaining life processes. As a storehouse of microbial biodiversity, soil plays a critical role in soil processes that drive plant productivity [1].The continuous capacity of soil to function as a vital living system, within ecological and land-use constraints, to support biological productivity, enhance the quality of the air and water environments, and maintain plant, animal, and human health [2]. Factors like climate change, environmental variables, and the soil's chemical and physical properties determine crop yield [3]. These factors have to be monitored efficiently and effectively to maxi- mize yield, which is the goal of every farmer. Soil is one of the most important factors to be considered for plant growth because it is the first contact environment for crops, and its quality directly impacts germi- nation [4]. The physical properties of soil largely depend on the size of particles that soil is composed the properties are porosity, soil water, soil air and capillary. Acidity and alkalinity of the soil are more importance for growth and distribution of plants various kinds of bacteria and fungi are present in soil for maintaining fertility dark colour substance that is humus is present in the soil. This is formed by decomposition of dead animals' plants and microorganism. It is more importance to plant, crops both chemically and physically. It increases soil fertility and provide nutrients for growth of plants and other microorganisms including nitrogen fixing bacteria which also increase the availability of minerals in dissolved state to the plants. It can retain high amount of water and also increases the aeration and percolation of water [5].The physicochemical properties of soil, helps in maintaining soil fertility by litter accumulation and decomposition, forms a shield for soil, and prevents soil erosion and improves infiltration rate, water holding capacity, hydraulic conductivity, and aeration [6]. Long-term applications of chemical fertilizers, manure, pesticides, and untreated wastewater in agriculture contaminate soils, altering their physicochemical properties [7].Soil quality status in key production areas and its relationship with soil physicochemical properties. It provides a theoretical basis and practical blueprint for optimizing orchard fertilization strategies and promoting sustainable industry development, offering crucial guidance for the green, efficient, and sustainable growth [8].The deficiency of the nutrients can be mitigated by the use of organic and inorganic fertilizers [9].

Experimental

In early 2025, soil samples were collected from four sites in Dehradun representing different land-use zones: Balawala (Site 1), Maldevta (Site 2), Dharampur (Site 3), and Selaqui (Site 4) along with respective Longitude and Latitude in Table 1.

Table 1: Longitude and Latitude of Sample Sites

S. No.	Site	Latitude	Longitude
1.	Site 1 (Balawala)	30.272529	78.101351
2.	Site 2 (Maldevta)	30.344158	78.127778
3.	Site 3 (Dharampur)	30.301735	78.045163
4.	Site 4 (Selaqui)	30.355241	77.862807

At each site, an area of 10 m × 10 m was selected for sampling. Soil was collected with an auger (6 cm diameter, 12 cm length) from the topsoil layer (0–8 cm depth), sealed in plastic bags, and transported to the laboratory in ice boxes. Samples were air-dried and sieved to pass a 2 mm mesh to remove debris (roots, stones, and macro-fauna) and were air dried to measure the soil physicochemical properties. Fig. 1 shows the sampling locations in the study area.

Site 1: Balawala

Site 2: Maldevta

Site 3: Dharampur

Site 4: Selaqui

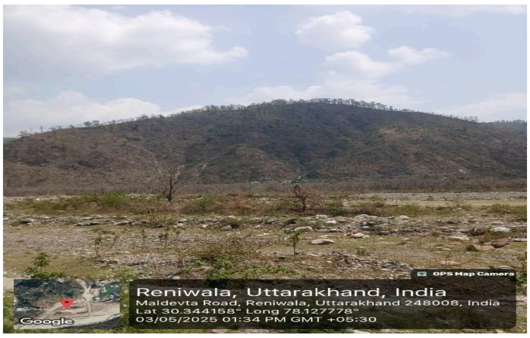


Fig. 1 Site Sampling location

Soil samples were analyzed using different standard laboratory techniques and statistical analysis in the Completely Randomized Design (CRD) [10]. Physicochemical properties such as soil pH and Electrical Conductivity were determined by Digital pH Meter and Digital Conductivity Meter respectively. Soil Organic Carbon was evaluated by Wet Oxidation method [11]. Estimation of Nitrogen was done by Alkaline KMnO4 Method [12]. Assessment of Phosphorus was completed by using Photometric Colorimeter [13] and Potassium by Flame Photometer [10], Iron by EDTA Extraction Method [14]. All analyses were performed according to ICAR (Indian Council of Agricultural Research) guidelines [15].

RESULTS AND DISCUSSION

The growth of plant depends significantly on various environmental factors, including soil quality which is threatened by factors like pollution, urbanization, and exhaustive agricultural practices such as intensive tillage, overuse of pesticides, and chemical fertilizers. Physico-chemical analysis of soil monitors the nutrient level for targeted fertilizer use, crucial for crop needs. The primary function of soil is to provide nutrient to plants. The substances that plants need for growth and development are called nutrients. Plants require 17 essential nutrients out of which six are major nutrients. The major nutrients are sulfur, magnesium, potassium, phosphorus, and nitrogen. Plants require significant amounts of major nutrients. Each nutrient has a unique function in plants. For instance, nitrogen is an essential part of DNA, chlorophyll and protein. The primary variables that directly affect crop yield and quality are soil fertility and nutrient management. Fertility of the soil is one of the key elements influencing crop production. A key factor in the context of sustainable agricultural production is the fertility level of the soils in a certain area or region.

The soil texture and moisture content varied across the sites. Site 1 (Balawala) had a crumbly texture with fine gravel and exhibited the highest moisture content. Site 2 (Maldevta) had a sandy texture (with a relatively high proportion of silt and clay) and retained moderate moisture. Site 3 (Dharampur) had a loose, dark, crumbly texture and the lowest moisture content. Site 4 (Selaqui) was loamy with very little gravel and retained moderate moisture. These differences in texture can influence water retention and aeration at each location.

Table 2: Physico-chemical Properties of Site 1

S. No	Parameters	Value	Critical limit	Result
1.	pH	6.3	Low<6.5 Medium 6.5-8.2 High>8.2	Low
2.	Electrical conductivity (EC) dSm/m	1.1	Low<1 Medium 1-3 High>3	Medium
3.	Organic Carbon (%)	0.32	Low<0.5 Medium 0.5-0.75 High>0.75	Low
4.	Available Phosphorus(kg/ha)	46	Low<28 Medium 28-56 High>56	Medium
5.	Available Potassium (kg/ha)	210	Low<140 Medium 140-280 High>280	Medium
6.	Sulphur(ppm)	15	Low<10 Medium10-20 High>20	Medium
7.	Available Nitrogen (kg/ha)	389	Low<280 Medium 280-560 High>560	Medium
8.	Iron(ppm)	4.2	Low<5 Medium 5-10 High>10	Low

Table 3: Physico-chemical Properties of Site 2

S. No	Parameters	Result	Critical limit	
1.	pH	6.6	Low < 6.5 Medium 6.5-8.2 High > 8.2	medium
2.	Electrical Conductivity (EC) dSm/m	1.4	Low < 1 Medium 1-3 High > 3	medium
3.	Organic Carbon (%)	0.61	Low < 0.5 Medium 0.5 - 0.75 High >0.75	medium
4.	Available Phosphorus(kg/ha)	42	Low < 28 Medium 28-56 High > 56	medium
5.	Available Potassium(kg/ha)	189	Low <140 Medium 140-280 High >280	medium
6.	Sulphur(ppm)	19	Low <10 Medium 10-20 High >20	medium
7.	Available Nitrogen(kg/ha)	410	Low <280 Medium 280-560 High >560	medium
8.	Iron (ppm)	5.6	Low <5 Medium 5-10 High >10	medium

Table 4: Physico-chemical properties of Site 3

S. No	Parameters	Value	Critical limit	Result
1.	pH	6.1	Low<6.5 Medium6.5-8.2 High>8.2	low
2.	Electrical Conductivity (EC) dSm/m	2.8	Low<1 Medium1-3 High>3	medium
3.	Organic Carbon (%)	0.86	Low<0.5 Medium0.5 -0.75 High>0.75	high
4.	Available Phosphorus (kg/ha)	26	Low<28 Medium28-56 High>56	low
5.	Available Potassium(kg/ha)	151	Low<140 Medium140-280 High>280	medium
6.	Sulphur(ppm)	21	Low<10 Medium10-20 High>20	high
7.	Available Nitrogen (kg/ha)	291	Low<280 Medium280-560 High>560	medium
8.	Iron(ppm)	7.8	Low<5 Medium5-10 High>10	medium

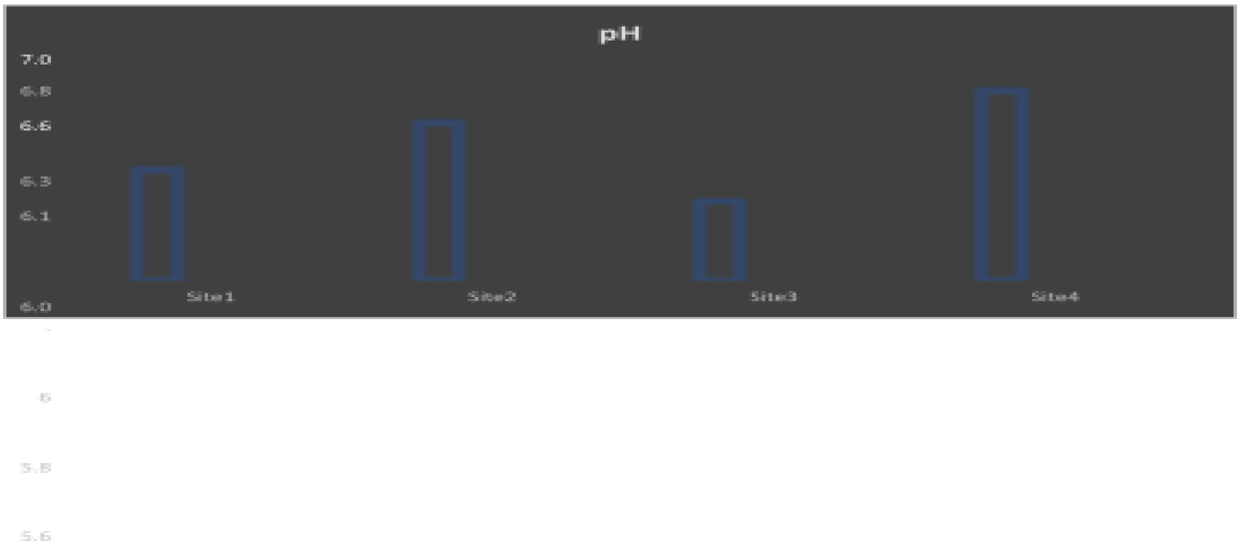
Table 5Physico-chemical Properties of Site 4

S. No	Parameters	Value	Critical limit	Result
1.	pH	6.8	Low<6.5 Medium6.5-8.2 High>8.2	medium
2.	Electrical Conductivity (EC) dS/m	1.2	Low<1 Medium1-3 High>3	medium
3.	Organic Carbon (%)	0.41	Low<0.5 Medium0.5 -0.75 High>0.75	low
4.	Available Phosphorus(kg/ha)	49	Low<28 Medium28-56 High>56	medium
5.	Available Potassium(kg/ha)	196	Low<140 Medium140-280 High>280	medium
6.	Sulphur(ppm)	12	Low<10 Medium10-20 High>20	Medium
7.	Available Nitrogen(kg/ha)	460	Low<280 Medium280-560 High>560	Medium
8.	Iron(ppm)	5.3	Low<5 Medium5-10 High>10	Medium

The table above provides the soil analysis data for four sites, focusing on various soil properties such as pH, EC, Organic Carbon, Phosphorus, Potassium, Sulphur, Nitrogen, and Iron. A detailed discussion of the observed results follows:

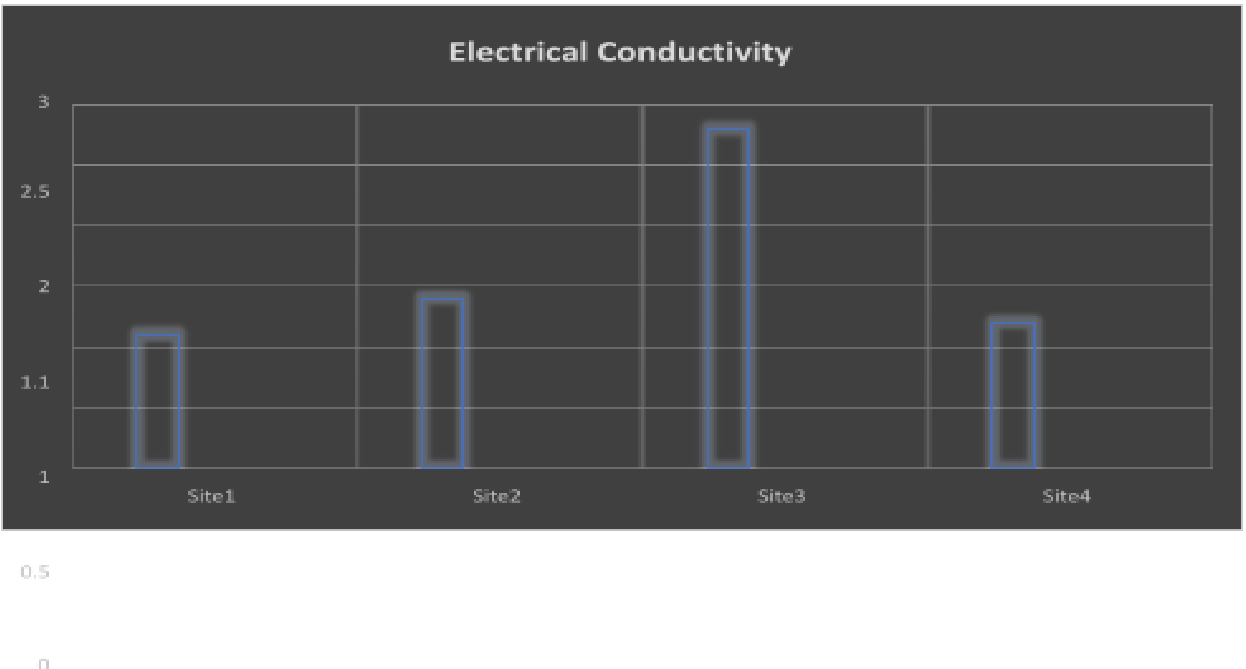
pH

The graph indicates a consistent trend of increasing pH values from Sample 1 through Sample 4, with all four sites falling within the slightly acidic to near-neutral range. Sample 1 records a pH of 6.3, representing the more acidic condition among the set. Sample 2 shows a pH of 6.6, indicating a slightly acidic state, while Sample 3 exhibits the lowest pH at 6.1, though still within an acceptable limit. Sample 4, with a pH of 6.8, remains slightly acidic but closest to neutrality. Such minor variations are commonly attributed to differences in soil organic matter, mineral composition, and localized environmental factors. Extreme deviations in pH can significantly influence nutrient availability and microbial activity. Therefore, regular monitoring of soil pH is essential to maintain optimal nutrient accessibility for plants and to prevent potential imbalances.



Electrical conductivity

Electrical conductivity (EC) is directly influenced by the total concentration of dissolved cations and anions present in the solution. The graph reveals that Sample 1 and Sample 4 exhibit relatively low electrical conductivity values of 1.1 dS/m and 1.2 dS/m, respectively. Sample 2 shows a slightly higher conductivity of 1.4 dS/m, whereas Sample 3 records the highest value at 2.8 dS/m, indicating a comparatively greater salt concentration. Such elevated levels may result from factors such as irrigation with saline water, inadequate drainage, or increased evaporation rates. Overall, electrical conductivity serves as a key indicator of a material's ability to conduct electric current and reflects the ionic composition of the medium.



Organic Carbon

Organic carbon represents a vital determinant of soil health, as it regulates nutrient availability, enhances water-holding capacity, and supports overall soil structure. Among the sites, Site 3 records the highest organic carbon content (0.86%), reflecting comparatively greater organic matter, which contributes positively to soil fertility and productivity. In contrast, Site 1 exhibits the lowest value (0.32%), suggesting relatively reduced organic matter content and lower fertility potential.

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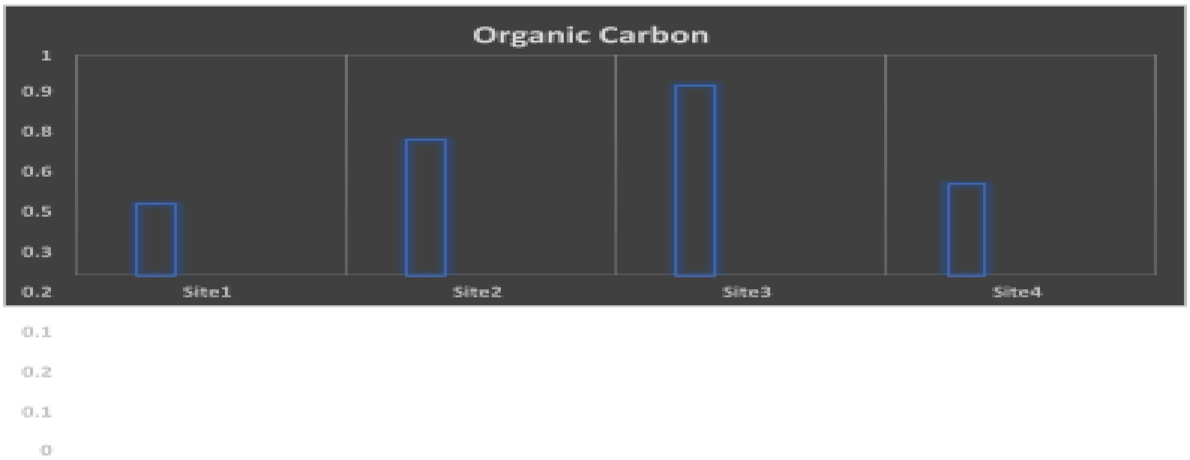
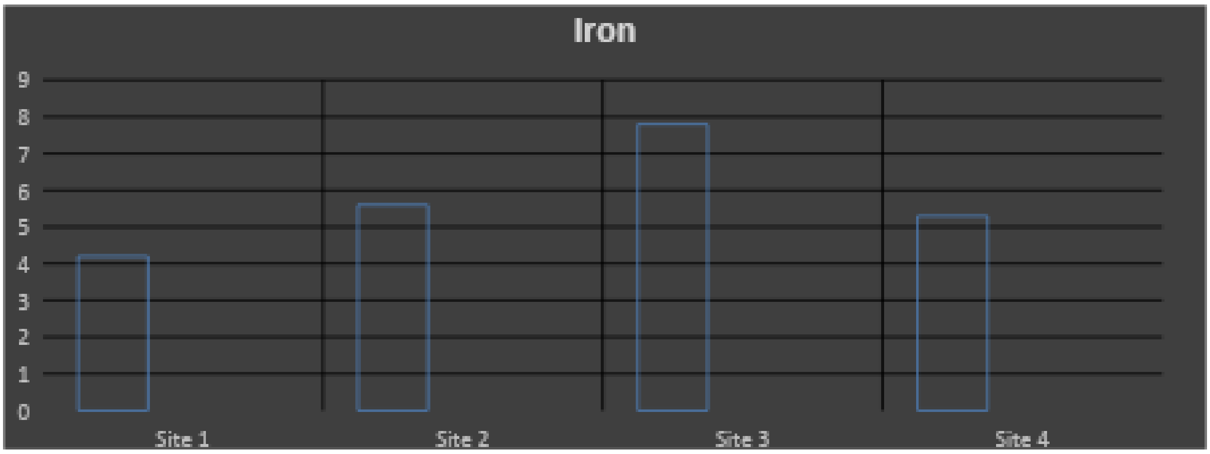


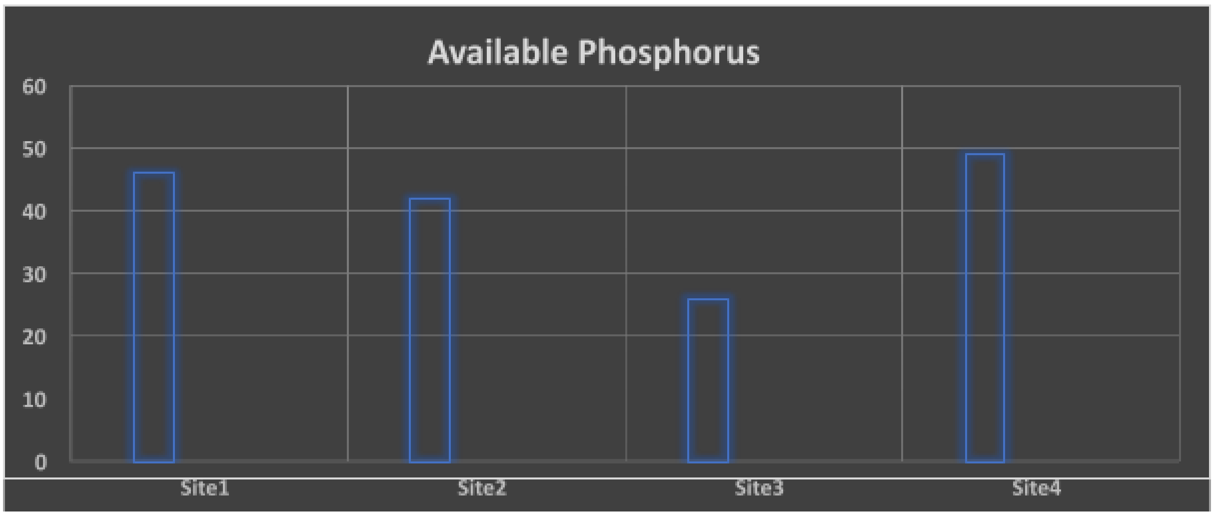
Iron

Iron plays a crucial role in plant metabolism, being indispensable for chlorophyll synthesis, respiration, and electron transfer processes. The critical range of available iron in soils is considered to be 5–10 ppm. Among the sites, Site 3 shows the highest iron concentration (7.8), whereas Site 1 records the lowest (4.2). Insufficient iron availability often leads to chlorosis, characterized by the yellowing of leaves due to impaired chlorophyll formation.



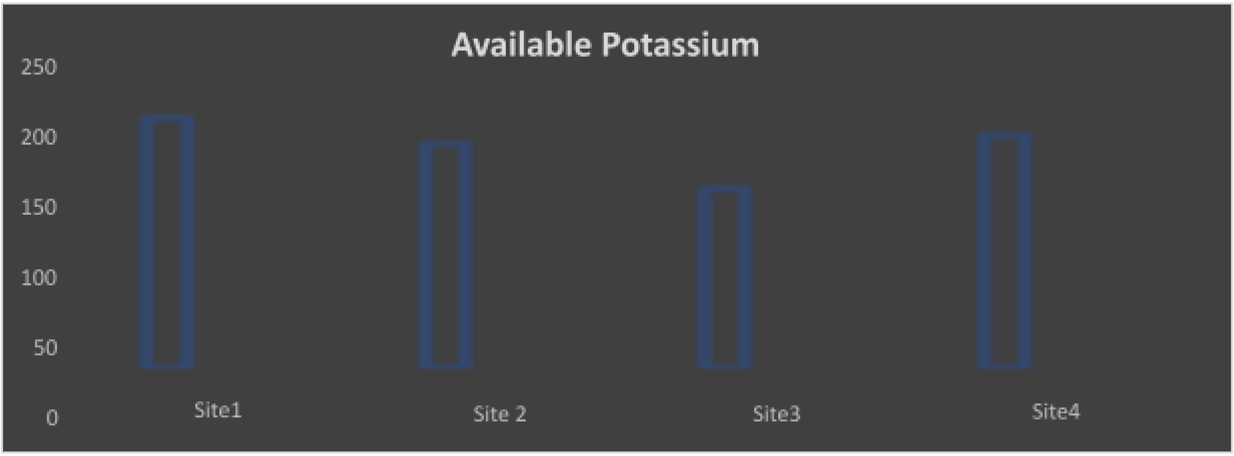
Available Phosphorus

Phosphorus is an essential macronutrient for plant growth, playing a key role in root development, energy transfer, and flowering. The graph illustrates the available phosphorus content across four soil samples, expressed in
kilograms per hectare (kg/ha). Sample 4 contains the highest level at 49 kg/ha, notably exceeding the other sites. Sample 1 records 46 kg/ha, followed by Sample 2 at 42 kg/ha, while Sample 3 shows the lowest value at 26 kg/ha, which may restrict optimal plant growth. The observed variation in phosphorus availability among samples likely reflects differences in soil composition, fertilizer management practices or environmental factors influencing nutrient dynamics.



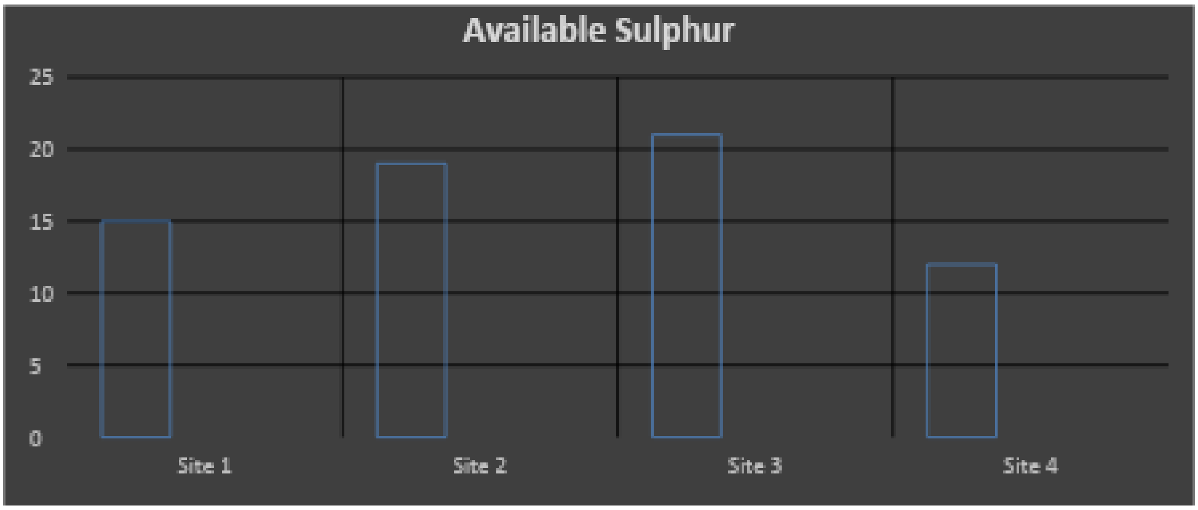
Available Potassium

Potassium is a vital nutrient for plant health, particularly in enhancing stress tolerance and overall physiological performance. Across the soil samples, available potassium levels range from 151–210 kg/ha, which lies within the critical range of 140–280 kg/ha. Site 1 exhibits the highest potassium concentration (210), whereas Site 3 records the lowest (151), possibly due to greater leaching losses. Potassium availability is often reduced in acidic soils and is also influenced by soil moisture conditions. Deficiency in potassium can manifest as leaf scorching or marginal necrosis, weak stems, reduced flowering, and increased vulnerability to pests and diseases.



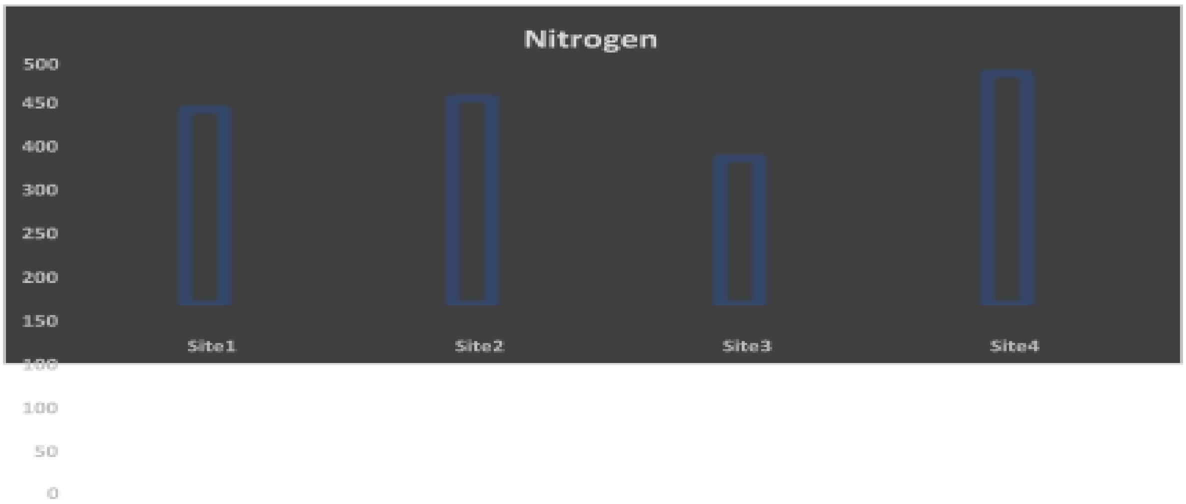
Available Sulphur

Sulphur is an essential nutrient for plants, playing a key role in protein synthesis, enzyme activity, and overall metabolic processes. The available Sulphur across the soil samples ranges from 15–21 ppm, with the critical threshold for sufficiency being 10–20 ppm. In soils, Sulphur occurs in various forms, including organic matter, sulphates (SO_4^{2-}), and elemental Sulphur. Site 4 records a comparatively lower level (12), which may be attributed to limited rainfall, thereby reducing natural Sulphur deposition. The availability of Sulphur is strongly influenced by soil pH and organic matter content. Deficiency is typically expressed through the yellowing of young leaves, stunted growth, and delayed crop maturity.



Nitrogen

The available nitrogen across the soil samples ranges from 291–460 ppm, falling within the critical range of 280–560 ppm. Site 3 records the lowest nitrogen level (291), a variation likely influenced by factors such as fertilization history and crop type. Nitrogen is a fundamental element in plant metabolism, serving as a primary constituent of proteins, enzymes, chlorophyll, and nucleic acids. It is indispensable for vegetative growth, photosynthesis, and overall plant vigor. In soils, nitrogen is present within organic matter, organic nitrogen compounds, and inorganic forms such as ammonium (NH_4^+) and nitrate (NO_3^-). Its availability is governed by multiple factors, including soil pH, temperature, moisture, and microbial activity.



CONCLUSION

Soil quality analysis in Dehradun indicates that Sites 1, 2, and 4 have generally adequate fertility, while Site 3 shows deficiencies in Nitrogen and Phosphorus and elevated salinity (EC). All soils were slightly acidic, which is acceptable for most crops. Potassium and Iron levels were mostly adequate, except for the low Iron at Site 1. These findings suggest that soil amendments (such as N- and P-based fertilizers at Site 3) could improve fertility at the low-performing site. Overall, regular monitoring of soil properties is important for sustainable agriculture in the region. The present study provides a baseline assessment of the physicochemical properties and nutrient status of soils in Dehradun. This information can guide targeted management practices (e.g. site-specific fertilization and organic amendments) to optimize soil health and crop productivity.

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