IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, December 2024

Physicochemical Properties of Soil Samples Collected from Three Different Areas of Haldwani Region of Uttarakhand, India

Akanksha Papola[1], Pankaj Arya[1], Manoj Karakoti[1] and Prasoon Kumar Joshi[2]
M.B. Government Post Graduate College, Haldwani (Nainital) Uttarakhand, India[1]
SSJDWSSS Government Post Graduate College, Ranikhet (Almora) Uttarakhand, India[2]
Corresponding Author: Dr. Prasoon Kumar Joshi
prasoonjoshi2012@gmail.com

Abstract: *The physicochemical properties of soil are essential in determining its suitability for agricultural, environmental, and engineering applications. This study presents a comprehensive physicochemical analysis of soil samples from diverse locations to evaluate key parameters such as texture, pH, electrical conductivity, organic matter content, cation exchange capacity (CEC), and nutrient levels (nitrogen, phosphorus, potassium). In the present study, three soil samples in triplicate are collected from different areas of Nainital district of Uttarakhand State and texture of soil, its pH value. Organic carbon %, Available N, P_2O_5, K_2O, electrical conductivity, CEC and WHC properties were analysed. The results indicate significant variations in soil composition, which influence fertility and overall soil health. Correlations between soil properties and land use patterns were observed, offering insights into sustainable land management practices. The study highlights the importance of regular soil analysis to guide effective soil conservation, crop management, and environmental monitoring efforts.*

Keywords: Soil analysis, physio-chemical properties, Haldwani region

I. INTRODUCTION

Physicochemical analysis of soil is conducted to understand its physical and chemical properties, which are critical for determining soil fertility, its ability to support plant growth, and its overall environmental health. physicochemical analysis of soil is crucial for optimizing agricultural productivity, managing environmental health, and ensuring sustainable land use practices. By understanding the soil's properties, farmers, land managers, and environmental scientists can make informed decisions that improve soil quality and support long-term agricultural and ecological sustainability. The physical and chemical properties of soil play a major role in the ability of plants to extract water and nutrients. High quality soil not only produces fiber but also better food, it also helps establish natural ecosystems and improve air and water quality [1].Physical properties of soil depend on the size, structure, mineral composition, pore space and organic matter content of a soil. Chemical properties are the interaction of various chemical components between soil particles and soil solution. Both physical and chemical properties depend on the soil texture, density, structure, colour, pH, electrical conductivity, cation exchange capacity, organic carbon, organic matter and soil nutrients. Different soils have different physical and chemical properties, so it is important to understand these soil properties to work with any type of soil. Knowledge of physical and chemical properties of any soil helps us in managing those resources while doing agricultural work with any particular soil [2].The physical characteristics of soil, including porosity, moisture, air content, and capillary action, are primarily influenced by the size of its particles.

The pH level, whether acidic or alkaline, significantly impacts plant growth and distribution. Soil fertility is supported by various microorganisms, such as bacteria and fungi. Humus, the dark substance formed from the decay of dead plants, animals, and microorganisms, is essential for the chemical and physical health of plants. It boosts soil fertility by providing essential nutrients, promoting the activity of nitrogen-fixing bacteria, and making dissolved minerals more accessible to plants. Humus also enhances water retention, aeration, and water percolation in the soil [3]. Bell and Dell (2008) [4] demonstrated that nutrient deficiencies have become a significant limitation to soil productivity and stability.

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II. EXPERIMENTAL PROCEDURE

Three samples of soil (about 20 cm depth) in triplicate were collected from Gaulapaar, Kathgharia and Lamachour areas of Haldwani region of Nainital district of Uttarakhand State during the month of June 2022. All the samples were analysed for the physiochemical properties viz. texture of soil, pH value. Organic carbon %, Available N, P_2O_5, K_2O, electrical conductivity, CEC and WHC. Soil samples were collected in plastic bags, with plant debris and stone fragments manually removed. The samples were then air-dried and sifted through a sieve. Total 9 soil samples were then transported to the laboratory for analysis. After air-drying, the soil samples were ground to a fine powder using a pestle and mortar, then sieved through a 2 mm sieve. After sieving the soil samples were stored in an oven at 30°C until ready for further use. A 100 g portion of each soil sample was transferred to a sample bag, with relevant details such as the sampling date, location, and sample number labelled on the bags. These processed soil samples were used to determine pH, electrical conductivity (EC), available nitrogen, available phosphorus, available potassium, organic carbon content using the Walkley Black method, organic matter (OM), soil texture, water holding capacity (WHC), and cation exchange capacity (CEC). All tests were performed in three replicates. Instruments used for the various tests are listed in **table 1**.

TABLE 1: LIST OF INSTRUMENTS USED

Properties	Instruments used
Texture	Potentiometer method using pll (microprocessor based)system 362, SYSTRONICS
pH	Potentiometer method using µpH (microprocessor based)system 362, SYSTRONICS
Organic carbon/ organic matter	Volumetric method using universal auto titrator 354SYSTRONICS
Total Nitrogen	Kjeldahl Method [5]Using PELICAN make A. 1. digitally controlled digestion unit KEL Pius KES 06L.2. KEL Plus Classic DX auto nitrogen distillation unit B. Burerte digital, Brand make, Germany 2. Pipette digital, Brand make, Germany
Available Phosphorus	Olsen method [6]by spectrophotometry Using UV 119, spectrophotometer. SYSTRONICS
Available Potassium	Ammonium acetate extraction method by Flame Photometry using Flame Photometer 128, SYSTRONICS
Micro-nutrients	DTPA extraction method by atomic absorption spectrometry Using Doble bean atomic absorption spectrophotometer SL J76. ELICO

STATISTICAL ANALYSIS

The mean and error of margin is calculated online at significant level 0.05.

III. RESULT AND DISCUSSION

The results of physiochemical properties of all these samples collected from Gaulapaar, Kathgharia and Lamachour areas of Haldwani regions of Nainital district, Uttarakhand were presented in **table 2**. The results revealed that the average sand present in soil samples is ranging from 59.33 to 68.33, average slit present ranging from 31.33 to 37.33 while average clay present ranging from 5.33 to 7.33. The average pH value of Gaulapaar sample is 7.36, pH value of Kathgharia sample is 7.16 while of Lamachour sample is found 6.9. Average total caron percentage of Gaulapaar, Kathgharia and Lamachour samples we found 1.37, 2.16 and 1.35 respectively. Average nitrogen in the three samples collected from Gaulapaar, Kathgharia and Lamachour is found 206.5, 212.43 and 209.06 respectively. Average phosphorous present in these samples is 0.002, 0.003 and 0.0017, Average potassium is found 0.012, 0.112 and 0.0048 respectively. Electrical conductivity is found 0.112, 0.158 and 0.078, CEC is found 41.87, 44.00 and 52.67 while WHC is found 35.67, 34.33 and 33.00 in these three samples collected from Gaulapaar, Kathgharia and Lamachour area.Previous reports on the soil collected from Bajpur, Khatima and Nainital regions of Uttarakhand was done by Geeta et. al.2015 [7]. Results of present research revealed that soil collected from all three areas are sandy, which typically has good drainage and aeration but may require additional organic matter or amendments for improving its

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ability to hold nutrients and moisture. Soils with high sand content are often fast-draining and may dry out quickly unless properly managed. Silt is obtained 31.33 -37.33 % means the soil is silty loam would typically be considered fertile, especially if it has adequate levels of organic matter. It would likely support a wide range of plants, but it may need additional organic matter (e.g., compost). With 5.33% to 7.33% clay, your soil is predominantly sandy with excellent drainage and aeration properties. It will likely dry out faster and may require more frequent watering, especially for crops that need consistent moisture.

Results also revealed that soil collected from Gaulapaar and Kathgharia area is slightly alkaline while collected from Lamachour is slightly acidic.1.37% to 2.16% organic content in soil samples indicated is relatively low to moderate, indicating that your soil has some beneficial organic matter but may benefit from additional amendments to improve fertility, moisture retention, and microbial health. Available nitrogen is a critical component of soil fertility because it is involved in key processes like protein synthesis and chlorophyll production in plants. With 206.5 to 212.43 mg/kg, your soil has a good supply of nitrogen, which should support healthy plant growth, particularly during the vegetative stage. 0.0017 to 0.002 mg/kg of available phosphorus is extremely low and indicates a phosphorus deficiency in the soil. Electrical conductivity values of 0.0078 to 0.115 dS/m are well within the safe to low salinity range and is generally favourable for plant growth. An electrical conductivity range of 0.0078 to 0.115 dS/m is considered low to moderate, indicating that your soil has low salinity and is generally favourable for plant growth. The soil should be suitable for most crops, though if there are nutrient deficiencies, this may be due to factors like soil fertility or organic matter content, not salinity. water holding capacity for soil is found ranging from 33.00 to 35.67% is considered a moderate to high, this means your soil can retain a significant amount of water, making it suitable for growing a wide variety of plants.In general, soils with a high WHC can hold more water available for plants without becoming waterlogged. This is a key characteristic for maintaining consistent moisture levels, which is essential for plant health and growth. Several studies have analyzed soil properties from both cultivated areas and forested regions [8-11]. According to Muche et al. [12], soils from natural forests exhibited higher values of cation exchange capacity (CEC) and available potassium (31.9 cmol+/kg and 120 mg/kg, respectively) compared to soils from cultivated fields (14.4 cmol+/kg and 10 mg/kg). The higher levels of available potassium in the natural forest soils may be attributed to their greater CEC.

TABLE 2: PHYSICOCHEMICAL PROPERTIES OF SOIL SAMPLES COLLECTED FROM THREE DIFFERENT AREAS OF HALDWANI REGION OF UTTARAKHAND

Physicochemical Properties	Gaulapaar Area of Nainital District		Kathgharia Area of Nainital District		Lamachour Area of Nainital District	
Texture	Mean ± Margin of Error	Standard Deviation	Mean ± Margin of Error	Standard Deviation	Mean ± Margin of Error	Standard Deviation
Sand	59.33 ±1.30	0.94	68.66±7.27	8.21	61.33 ±5.69	4.10
Slit	35.33 ±1.30	0.94	37.33 ±1.30	0.94	31.33 ±3.45	2.49
Clay	5.33 ±1.30	0.94	6.00 ±0.00	0.00	7.33 ±2.61	1.88
pH	7.36 ±0.26	0.25	7.16 ±0.06	0.04	6.90±0.22	0.16
OC (%)	1.37 ±0.57	0.41	2.16 ±1.64	1.18	1.35 ±0.50	0.36
Available N (Kg/hect.)	206.5 ±13.13	9.45	212.43 ±12.86	9.28	209.06 ±21.65	15.62
P_2O_5 (%)	0.002 ±0.0001	9.42	0.003 ±0.001	0.00	0.0017 ±0.0001	9.42
K_2O (%)	0.012 ±0.002	0.00	0.112 ±0.013	0.00	0.0048±0.002	0.00
EC (dS/m)	0.112 ±0.013	0.00	0.158 ±0.060	0.04	0.078 ±0.068	0.04
CEC (meq/ 100g)	41.87±1.70	1.22	44.00 ±1.96	1.41	52.67 ±4.17	3.68
WHC (%)	35.67 ±6.44	4.64	34.33 ±2.61	1.88	33.00 ±2.99	2.16

At Confidence level 0.05

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IV. CONCLUSION

The soils from Gaulapaar, Kathgharia, and Lamachour areas are generally sandy, silty loams with good drainage and aeration, making them suitable for a variety of crops. While the soils exhibit good nitrogen levels, they suffer from low phosphorus, which should be addressed through fertilization. The moderate to high water holding capacity ensures that the soils can retain adequate moisture for plant growth, although additional organic matter would enhance soil fertility and moisture retention. The soils are generally low in salinity and have a high cation exchange capacity, making them favourable for most plants, although care should be taken to amend the phosphorus levels for optimal crop production.

ACKNOWLEDGEMENT

Authors are acknowledged to Soil Testing Laboratory, Uttarakhand Development Tea Board, Almora Road, Bhowali District Nainital for soil sample testing.

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