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PHYSICOCHEMICAL PROPERTIES OF SOILS FROM THREE DIFFERENT REGIONS OF KUMAON HILLS OF UTTARAKHAND, INDIA

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ABSTRACT

Present investigation was undertaken to study the physicochemical characteristics of three distinct soil samples namely red, white and yellow gathered from various locations within the Kumaon Hills region of Uttarakhand, India during year 2021. The examination of the physicochemical properties of these diverse soil samples includes a comparative evaluation of aspects such as soil texture, soil structure and the elemental makeup of the soil, as well as assessments of pH, EC, CEC, OC, nitrogen, phosphorus, potassium, sulphur, Fe, Mn, Cu and Zn. The ranges of properties for red, white and yellow soils were pH (5.3-7.98), EC (0.11-0.31 dSm^{-1}), CEC (16.8-23.0 Meq 100 g^{-1}), OC (0.15-1.61%), nitrogen (0-219.52 kg ha^{-1}), phosphorus (0.0018-0.008%), potassium (0.0087-1.72%), sulphur (8.96-10.07 ppm), Fe (0.0-0.866 ppm), Mn (0.058-3.98 ppm), Cu (0.093-0.344 ppm) and Zn (0.547-0.957 ppm). On the basis of observed values of properties, these soils were not found suitable for agricultural purposes. The findings hold potential significance for practices related to soil management in agriculture, fostering sustainable forest development and implementing strategies for pollution control.

(Key words: Red, white, yellow, physiochemical properties, composition of soil)

INTRODUCTION

Soil is a coarse covering of fine rock particles which is a major component of earth's ecosystem (Banwart, 2011). The soil serves as a vital interface within the earth's crust, offering a natural medium conducive to plant growth. It functions as a habitat for various soil organisms, regulating water quality, recycling nutrients and organic waste, and modifying atmospheric composition (Addis and Alemayehu *et al.,* 2015; Manimegalai and Sukuya, 2014; Lewis, 1984; Sumithra *et al*., 2013). Soil is a natural entity formed from particles of fragmented rocks that undergo chemical and mechanical transformations due to weathering and erosion phenomena (Subha and Rose, 2016). Soil creates a natural dynamic system for various chemical, physical and biological processes in soil environment (Watanabe *et al*., 2015; Rudd, 2006). It influences the existence of all living organisms and their environment both directly and indirectly (Adhikari and Hartemink, 2016). As per soil management principle, soil fertility control is possible with the practice of soil testing (Vogel *et al*., 2018). It is significant to study physicochemical properties of land soil for better agricultural production, sustainable forest development and soil management (Mingxin Guo, 2021).The physicochemical study of a territory is helpful to know about soil characteristics, as its physical and chemical qualities determine the soil quality (Raj *et al*.,2013; Mahajan and Billore, 2014). Differences in soil characteristics are connected to the kind of land use and soil management techniques (Rejik and Kundu, 2023). It presents both challenges and opportunities for forest and agricultural scientists to actively engage in the evaluation and promotion of sustainable forest management and agricultural production (Amundson *et al*., 2015; Karlen *et al*., 1997). Understanding the soil and crop dynamics is crucial for sustainable agricultural practices as it directly influences crop productivity, resource management and environmental conservation (Bhartendu *et al*., 2023). Furthermore, it can contribute to the conceptualization of soil attributes as a key indicator of durability. This research focuses on the physicochemical analysis of soil to examine different aspects such as pH, texture, moisture content, electrical conductivity, organic matter and the presence of essential inorganic elements like nitrogen, phosphorus and potassium (Kekane, 2015).

MATERIALS AND METHODS

Sample collection

The study area of present investigation is Kumaon Hills of Uttarakhand, India ranges in middle Himalaya region. The three soil samples namely red, white and yellow were collected from three sites namely: Berinag (29.7750° N, 80.0563° E) and Gangolihat (29.6570° N, 80.0393° E), District-Pithoragharh and Bhujiyaghat (29.3159° N, 79.5245° E), District-Nainital, respectively in month of May-June, 2021. The standard protocol for the soil sample collection was followed in which the top soil samples were

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measured from a depth of 0–25 cm (Lawrence *et al.*, 2020). The collected soil samples were stored in airtight plastic bags for subsequent analysis.

Preparation of samples

The gathered soil samples were filtered to remove impurities such as stones and grass. The cleaned soil was air dried for a week in laboratory at room temperature (Ganorkar *et al*., 2013). The desiccated soil was ground and sieved through a sieve with mesh size 2 mm to get desired size soil particles. The powdered soil samples were stored in sealed borosilicate bottles for subsequent analysis.

Soil analysis

Assessment of physicochemical parameters of soil

The clean, dried, and sieved soil samples were examined for their physicochemical properties, including: soil pH, pH, EC, CEC, OC, nitrogen, phosphorus, potassium, sulphur, Fe, Mn, Cu and Zn using standard methods using standard protocols.

pH value

The soil pH (red, white and yellow soils) was assessed using a digital pH metre.

Electrical conductivity

The electrical conductivity of soil was measured in units of milliSiemens meter^{-1} (mSm^{-1}) or deciSiemens meter (dSm^{-1}), where one dS/m was comparable to the reading in mSm^{-1} divided by 100 (Shivanna and Nagendrappa, 2014).

Cation exchange capacity (CEC)

The extraction with ammonium acetate method has been used for determination of the CEC of experimental soils (Foth , 2006).

Organic matter

The available carbon content in the soil sample was assessed using the standard 'Walkley and Black Method' in the laboratory (Gurdeep and Sharma, 2005; Jackson, 1958).

Macro and micro elements of soils

The analyses of Fe, Mn, Cu and Zn was done by Atomic Adsorption Spectroscopy (Kalambe, 2021). The sulphur was estimated by Spectrophotometer (Rashmy *et al*., 2020), P_2O_5 estimated by Digital Colorimeter and K_2O by Flame Photometer (Jackson, 1958).

RESULTS AND DISCUSSION

The texture composition of red soil had 82% sand, 10% silt and 8% clay, the white soil had 72% sand, 18% silt and 10% clay and the yellow soil had 70% sand, 20% silt and 10% clay.

The texture compositions of red, white and yellow soil are outlined in Table 1 as below.

Table 1. Texture of red, white and yellow soils

Composition of soil	Red soil	White soil	Yellow soil
Sand percentage	82%	72%	70%
Silt percentage	10%	18%	20%
Clay percentage	8%	10%	10%

Soil pH serves as a gauge of acidity or alkalinity within soils. It is deemed a pivotal factor in soil composition as it regulates numerous chemical processes occurring within the soil (Ganorkar *et al*., 2013). It significantly influences the availability of plant nutrients by governing the chemical forms of these nutrients (Joel and Amajuoyi, 2009). For most plants, the ideal pH range typically falls between 5.5 and 7.0. The pH of red soil, white soil and yellow soils were measured as 5.3, 7.98 and 7.11 respectively which shows that red soil was acidic in nature while white and yellow soils were alkaline nature. The range of pH in between 5.5-7.5 is favourable for various plant growths (Prabhudev *et al*., 2023). pH in this range provides better nutrients to the soil and allows sufficient microorganisms to break down organic matter (Schoenholtz *et al*., 2000).

Electrical conductivity (EC) is a rapid, straightforward, and cost-effective method for assessing soil health. Soil pollution and composition can be effectively characterised by their electrical conductivity (Seifi *et al*., 2010). Clay-textured soils exhibit high conductivity, whereas sandy soils demonstrate poor conductivity (Grisso *et al*., 2005). The values of EC found highest for red soil (0.31 dSm^{-1}) and lowest for white soil (0.112 dSm^{-1}) and moderate for yellow soil (0.16 dSm^{-1}). The optimal EC for plant growth in soils has been reported 0.8 – 1.8 dSm^{-1}. These soils had shown lower EC than optimal range.

CEC of soil is positively correlated with soil pH (Foth, 2006). It is defined as the quantity of hydrogen ions (H^+) required to saturate the soil cation exchange sites 100 g^{-1} of dry soil. Alternatively, an equivalent quantity of another cation (such as Al^{3+} or Ca^{2+}) can be utilized to determine the CEC. In this current investigation, the CEC values of the red soil, white soil and yellow soil were found as 16.8 meq 100 g^{-1}, 23.0 meq 100 g^{-1} and 20.0 meq 100 g^{-1} respectively. If CEC values of soils are 12.5, 10.0 and 7.6 meq 100 g^{-1}, means CEC values are very good, good and moderate respectively. These investigated soils had possessed very good CEC range.

Organic carbon contributes largely to soil productivity by improving soil health and in alleviating climate change (Cohen Richand, 2007; Pellegrini *et al*., 2022). The available carbon was found 0.67%, 0.15% and 1.61% by weight for red, white and yellow soil respectively. The organic matter content of soil serves as a crucial indicator of soil quality, as it profoundly influences the majority of soil activities (Manrique and Jones, 1991). The existence of organic matter in soil enhances its capacity to adsorb nutrients and water, thereby contributing to the improvement of its structure and stability (Franzluebbers, 2002). Soil organic carbon also plays a significant role in influencing biodiversity and in the mitigation of atmospheric CO_2 concentration (Cassel, 1983). Organic materials in soil enhance the cation exchange capacity (CEC) by augmenting the availability of negative charges. Therefore, the accumulation of organic matter in soil typically enhances soil fertility (Keesstra *et al*., 2016). However, the cation exchange capacity (CEC) of organic matter is significantly affected by soil acidity because acidity is releasing the ions from many organic compounds into the soil solution (Loague, 1992). As the percentage of organic carbon is found maximum in yellow soil and minimum in white soil, therefore yellow soil is said to be the most fertile soil among the investigated soils.

On the basis of nutrient need of the plants, the elements are described as macronutrients and micronutrients (Brandt *et al*., 1993). Macronutrients involves major elements e.g. nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S) and magnesium (Mg) while micronutrients mostly are heavy metals and trace elements such as manganese (Mn), molybdenum (Mo), copper (Cu), cobalt (Co), zinc (Zn), boron (B) and iron (Fe) (Brady *et al*., 2008). The increase in finer fractions, e.g., silt and clay, resulted from the micronutrient's presence (Von Bohlen *et al*., 2003).

The nitrogen plays a critical role in plant growth and development. Deficiency of nitrogen has an adverse effect on these factors. Nitrogen was maximum in yellow soil (219.52 kg ha^{-1}) enriching the fertility of soil, however nitrogen was absent in the red and white soils. Phosphorus stimulates root development and growth in the seedling stage (Patil *et al*., 2014). Phosphorus is a key component in photosynthesis and metabolism of sugars, it was highest in red soil (0.008 %) however white soil (0.0018%) and yellow soil (0.0054%) had low percentage. Potassium is one of the seventeen nutrients that are essential for plant growth. White soil (1.72%) had the highest potassium content comparison to red soil (0.0087%) and yellow soil (0.115%), providing it a property of sugar accumulation. Sulphur a common and essential constituent of all soils as it was found sufficient in red (10.05 ppm), white (10.07 ppm) and yellow soils (8.96 ppm). Shukla *et al.* (2018) reported optimum range of nitrogen (62-120 kg ha^{-1}), phosphorus (3-5%), potassium (14-37%) and sulphur (5-30 ppm). These nutrients were devoid of optimum range, except the nitrogen and sulphur.

The optimum values of micronutrients were found in the range of Fe 100-150 ppm, Mn 25-40 ppm, Cu > 5 ppm and Zn 1.8-3.5 ppm. Soils from study area were showing very small quantity of iron. Red soil (0.866 ppm) had the highest percentage of iron content followed by yellow soil (0.567 ppm) and no iron found in white soil. Manganese (Mn) is an important micronutrient for plant growth particularly in photosynthesis process. It was highest in red soil (3.98 ppm) followed by yellow soil (1.46 ppm) and white soil (0.058 ppm). Copper is essential nutrient naturally present in soils and it was found maximum in yellow soil (0.344 ppm) followed by white soil (0.228 ppm) and red soil (0.093 ppm). Zinc required for the metabolism in plants was present in sufficient quantities in all these three soils i.e. 0.957, 0.649 and 0.547 ppm in red, white and yellow soils respectively.

Table 2. Physicochemical parameters of red, white and yellow soils

Sr. No.	Properties	Red soil	White soil	Yellow soil
1.	pH	5.3	7.98	7.11
2.	EC (dSm^{-1})	0.31	0.112	0.16
3.	CEC (meq100 g^{-1})	16.8	23.0	20.00
4.	Organic carbon (%)	0.67%	0.15%	1.61%
5.	Nitrogen (kg ha^{-1})	Nil	Nil	219.52
6.	P_2O_5(%)	0.008%	0.0018%	0.0054%
7.	K_2O (%)	0.0087%	1.72%	0.115%
8.	Sulphur (ppm)	10.05	10.07	8.96
9.	Iron (ppm)	0.866	Nil	0.567
10.	Manganese (ppm)	3.98	0.058	1.46
11.	Copper (ppm)	0.093	0.228	0.344
12.	Zinc (ppm)	0.957	0.649	0.547

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