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Macronutrient Analysis of Soil Samples from the Akbarpur Area of Kanpur District, Uttar Pradesh, India

Sarika Bajpai

Associate Professor in Chemistry, PSIT, Kanpur, U.P., India

E-mail: dr.sarikabajpai@gmail.com

ABSTRACT

The Akbarpur block is positioned in the Kanpur district. A detailed analysis of the soils in this area was performed to evaluate specific macronutrients. The macronutrients assessed included Organic Carbon, Total Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium. This investigation, conducted during the 2023-24 timeframe (from June to March), focused on an extensive chemical examination of soil samples gathered from diverse locations within the district during different seasons. Soil samples were analyzed at three-month intervals (June, September, December, and March) to capture seasonal changes. The pH measurements indicated a highly alkaline soil composition, with values ranging from 8.1 to 12.6. The results generally suggested that the Organic Carbon levels were elevated in nearly all seasons. Conversely, the Akbarpur soil displayed a deficiency in Total Nitrogen, while Phosphorus and Potassium were present in adequate amounts, and an excess of Calcium and Magnesium was observed consistently across all seasons.

Keywords: - Soils, Macroelementts, Soil Fertility, pH, Organic Carbon, Total Nitrogen

1. Introduction

The three most crucial elements for our survival are air, water, and soil, all of which are essential for life. Any disruption in the equilibrium of these elements can lead to significant environmental problems [1]. Soil is a fundamental resource that sustains life by providing necessary materials. In Hindu mythology, soil is associated with the 'Tridev,' symbolizing 'Brahma' as the creator, 'Vishnu' as the preserver, and 'Maheshwar' as the destroyer. It is the core of all living entities [2]. The essence of life within the soil is demonstrated through its ability to produce crops, which is a critical measure of soil productivity. Soil fertility specifically refers to the soil's capacity to provide essential nutrients to plants [3]. Soil testing is recognized as one of the most financially viable nutrient management strategies for growers and agricultural consultants. It provides essential guidance for fertilization practices tailored to individual fields and evaluates the potential for soil to respond positively to fertilization [4]. The capacity of soils to supply nutrients to crops varies considerably. Nutrients are categorized into two primary groups: macronutrients and micronutrients. Within the macronutrient category, there are further distinctions between primary and secondary nutrients. Primary nutrients, which are consumed in large quantities by plants, include nitrogen, phosphorus, and potassium, while secondary nutrients consist of calcium, magnesium, and sulfur. This investigation was conducted to assess the status of available macro and micronutrients, thereby aiding farmers in determining the precise fertilizer amounts necessary for the successful cultivation of their crops.

Methodology

The research was performed in diverse locations throughout the Akbarpur block of Kanpur district, across different seasons. Soil samples were obtained from 20 sampling sites of block Akbarpur in regular interval of 3 months during June 2023 to March 2024. Samples are taken from cultivated area of 20 sampling sites (Ambarpur, Baraula, Bigahi, Dastampur, Gaholiya, Hasanapur, Jagdishpur, Kamalpur,Kishunpur, Kumbhi, Madwai, Mandauli, Muridpur, Naurangabad, Patari, Sahabapur,Saraiyan, Sumerpur, Swarooppur & Tigain). The samples were delivered to the laboratory in polythene bags for analysis and were laid out on thick brown paper. Coarse materials, including concretions, stones, and fragments of roots, leaves, and other undecomposed organic residues, were systematically removed. Large moist soil clumps were broken apart by hand. The soil samples were air-dried for 24 hours, after which they were gently crushed in a pestle and mortar and passed through a 2 mm sieve. This size has been recognized as an international standard, as the soil that passes through this mesh contains nearly all the essential nutritional fractions. The pH of the soil samples was assessed using a pH meter. The higher pH levels in the soils are primarily due to a significant concentration of alkaline salts, particularly calcium carbonates and bicarbonates. Estimation of nutrients carried out by given methods:

1. Organic carbon (Walkley & Black Method) [5]
2. Total Nitrogen (Kjeldahl method) [5]
3. Phosphorous (Olsen method) [6]
4. Potassium (Flame photometric method) [5]
5. Calcium (EDTA Titration method) [5]
6. Magnesium (EDTA Titration method) [5]

Study Area

The district lies between 250 25’ & 250 54’ latitudes and 790 34’ and 800 34’ longitudes. The northern boundary of the district is defined by Kannauj and Hardoi, with Unnao to the east, Fatehpur and Hamirpur to the south, and Kanpur Dehat to the west. The Holy Ganga River serves as a natural boundary with Unnao in the east, while the Pandu River distinguishes it from Kanpur Dehat and Fatehpur to the west and south, respectively. As per the records, the total geographical area of Kanpur Nagar district is 3,155 square kilometers.

Fig 1: Location Map of The Study Area in Kanpur

Result & Discussion

Table 1: Variations In Soil Ph and Macronutrient Content Across Different Seasons

S.No	Parameters	June 2023	Sept. 2023	Dec. 2023	March 2024
1	**pH**	8.9 ± 12.3	8.1 ± 11.3	8.4 ± 12.6	8.2 ± 12.0
2	**Org Carbon**	1.9 ± 25.3	1.8 ± 16.9	2.4 ± 20.6	2.6 ± 19.8
3	**Total Nitrogen**	1.2 ± 2.3	1.9 ± 3.9	1.4 ± 3.6	1.6 ± 2.9
4	**Phosphorous**	3.2 ± 6.8	2.9 ± 4.3	1.4 ± 3.7	1.6 ± 4.5
5	**Calcium**	2.4 ± 7.3	2.8 ± 8.8	1.2 ± 6.8	2.7 ± 8.9
6	**Magnesium**	2.2 ± 7.0	3.9 ± 9.3	1.4 ± 8.6	3.9 ± 7.8
7	**Potassium**	2.9 ± 5.9	2.3 ± 6.8	2.8 ± 7.9	2.2 ± 5.8

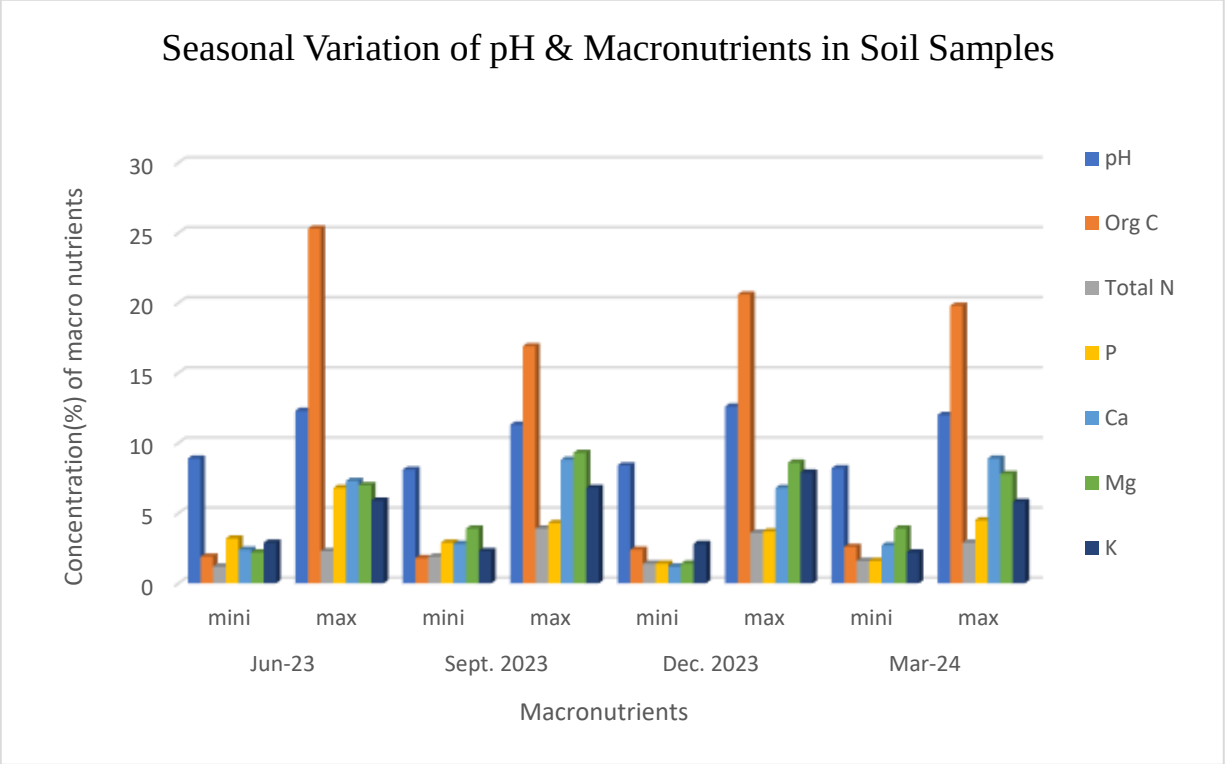

Fig 2: Variations in Soil pH and Macronutrient Content Across Different Seasons

The variation in the concentration of macronutrients is illustrated through a bar diagram in Figure 02. The study revealed that pH values fall within the alkaline range, specifically between 8.1 and 12.6. Organic carbon content exhibited significant fluctuations, peaking at 25.3% in June and reaching a low of 1.8% in September. Total nitrogen was found to be deficient across nearly all seasons, with values ranging from 1.2% to 3.9%. Phosphorus levels varied from 1.4% to 6.8%, indicating an excess in most seasons. Potassium also demonstrated excess levels throughout all seasons, with a range of 2.3% to 7.9%. Additionally, an excess of calcium and magnesium was noted in every season. The standard and ideal concentrations of macronutrients in healthy soils are as follows: organic carbon (0.2 to 10%), total nitrogen (2 to 5%), phosphorus (0.01 to 0.2%), potassium (0.02 to 2%), calcium (0.1 to 2%), and magnesium (0.05 to 3%) [5].

Soil may accumulate an excess of organic carbon when the influx of organic matter surpasses its decomposition rate [7]. Several factors influence this phenomenon, including the texture of the soil. Fine-textured soils, such as clay and silt, possess smaller pores and reduced oxygen levels compared to coarser soils, thereby hindering decomposition processes. Additionally, the chemical bonds formed between organic matter and clay or silt particles offer protection against decomposition. In agricultural systems with similar characteristics, increased rainfall promotes greater plant growth, subsequently elevating the organic matter content in the soil. Furthermore, organic matter tends to decompose at a slower rate in cooler temperatures. The application of soil amendments, particularly organic substrates, can enhance soil organic carbon levels [8].

The enhancement of nitrogen (N) concentration in soils can be achieved through the incorporation of urea and nitrates from sodium, potassium, and calcium. The phosphorus content was found to range between 0.2% and 1.7%, with 50% of the soils classified as having low phosphorus levels and 48% as medium. Approximately 48% of the soils exhibited low to medium availability of potassium (K), with a rapid increase in deficiency attributed to intensive cropping practices and unbalanced fertilizer usage [9]. The concentration of phosphorus increases with rising pH levels, while potassium concentrations are elevated due to the fixation of soluble potassium salts at higher temperatures. Alkaline soils generally present low levels of available nitrogen and medium levels of potassium. In salt-affected soils, both available nitrogen and phosphorus are low, while potassium is at a medium level [10]. The potassium levels in our investigation ranged from 2.3% to 7.9%, calcium levels from 1.2% to 8.9%, and magnesium levels from 1.4% to 9.3%. An excess of calcium and magnesium was reported throughout all seasons.

Conclusion

This study reveals that the soil in Akbarpur, Kanpur district, is predominantly alkaline in nature. A consistently high concentration of organic carbon has been recorded throughout the year. It is noteworthy that organic carbon exhibits a negative correlation with total nitrogen [11]. The presence of excess carbon, resulting from the stabilization of mineral carbon in the soil and intensive cropping practices, plays a significant role in the fixation of carbon as organic matter [12]. Moreover, the levels of phosphorus are observed to increase in conjunction with rising pH values [13]. The concentration of potassium is elevated in December because of the fixation of soluble potassium salts at lower temperatures. Throughout the year, there is a notable excess of calcium and magnesium, attributed to the deposition of industrial waste. The surplus of macronutrients can be detrimental to various plants and humans; therefore, it is recommended to mitigate these toxic effects by utilizing microbial or bio-fertilizers instead of chemical fertilizers [14]. To enhance crop production, it is essential to ensure adequate nutrient levels and maintain an appropriate moisture regime [15]. Furthermore, to achieve a proper balance of micro and macronutrients, the application of suitable salts in the correct ratios is necessary to reduce the leaching of macronutrients into groundwater.

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