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PHYSICO-CHEMICAL ANALYSIS OF SOIL IN PERSPECTIVE OF SUSTAINABLE AGRICULTURE FROM SUBDIVISION ROUNDU, DISTRICT SKARDU PAKISTAN

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Abstract
The study conducted in Sub Division Roundu assessed various soil characteristics, including conductivity, pH, organic matter, total dissolved solids (TDS), salinity, and nutrient content, with a focus on their suitability for plant growth. Soil samples were collected from different locations for analysis. The conductivity values of the soil ranged from 22.3 to 78.3, with Bilamik having the highest conductivity and Bagardo showing the least electrical conductivity. The areas with the highest conductivity were Tormik, Bilamik, Harpo, and Gunji. The pH values of the 20 soil samples ranged from 5.1 to 7.4, indicating that the soil pH was suitable for plant growth. Harpo had the highest pH value, while Shout had a lower pH value. Surprisingly, the soil samples from Sub Division Roundu exhibited a medium level of organic matter, ranging from 48% to 76%, which is uncommon for Pakistani soil. Tormik and Gunji had the highest organic matter content, while Bagardo had the lowest. Total dissolved solids (TDS), representing inorganic salts in the soil, ranged from 9.8 to 32 in the samples. Bagardo had the lowest TDS value, whereas Bilamik showed a high TDS value. The salinity levels in the soil were generally low, except for minor salinity in soils from Dassu, Dambodas, Khumrah, and Harbot. However, the study revealed widespread deficiencies in nitrogen and phosphorus content in the soil, with only marginal amounts of potassium present in some regions like Tormik, Harpo, Gunji, and Bilamik. Around 85% of the soil samples lacked sufficient nitrogen and phosphorus, while 15% had marginal concentrations. In contrast, potassium was sufficient in 79.8% of the samples, with 20.2% showing marginal amounts.

Keywords: *Agriculture, Roundu, soil fertility, Gilgit Baltistan, physicochemical*

INTRODUCTION

Gilgit Baltistan spans across 72,496 square kilometers and is inhabited by approximately 2 million people. It shares its borders with China, Afghanistan, India, and Iran(Z. Hussain, 2019). The region boasts one of the most rugged terrains globally, situated at an altitude of over 3000 meters and surrounded by the vast Himalayan, Karakorum, and Hindu Kush mountain ranges(Z. Hussain, 2019). The area comprises several districts, including Gilgit, Ghanche, Skardu, Diamer, Ghizer, Shiger, Kharmang, Roundu, and Astore, which fall under the federally administered territory. Given the high altitude and unique climatic conditions in Pakistan's northern regions(A. Hussain, Hussain, *et al*., 2022), there are notable variations in soil texture, mineralogy, and fertility, as well as other physiochemical qualities in different areas In many developing countries(Tula Dhār et al., 2023), agricultural output plays a crucial role in their economies, making sustainable agricultural resource management, particularly soil management, vital for both environmental preservation and economic progress (A. Hussain, Khan, *et al*., 2022)Soil holds significant importance as a natural resource, acting as the foundational layer for plant life and serving as a vital medium for nutrients and materials essential for plant growth (Hamawandy, 2023)The biological, physical, and chemical properties of soil play a direct or indirect role in influencing plant growth and overall yield(Shahzad *et al.*, 2021). To ensure long-term crop production and food security, soil fertility is of utmost importance. Soil fertility refers to the inherent capability of soil to provide a sufficient quantity of micro and macro nutrients for optimal crop yield(Noor & Khatoon, 2013). The evaluation of soil nutrient content and characteristics heavily relies on assessing its physiochemical properties(Zeitschriftenartikel, 2014).

The physicochemical properties of soil exhibit fluctuations due to different land use patterns in various areas. Soil systems are dynamic and can change over time due to natural processes(Tuladhar *et al*., 2023). These changes can be both directional and cyclic in nature(Qutoshi *et al.*, 2022), occurring on a daily to millennial timescale(Noor & Khatoon, 2013). Industrial effluents, especially when untreated, can significantly impact the physicochemical properties of soil (David Shyam Babu, 2010). Additionally, organic matter plays a crucial role in enhancing soil physicochemical properties by stimulating microbial growth and increasing enzymatic activity(Fitrah & Karmila, 2020). The fertility of soil in natural agro ecosystems relies on microbial processes such as the mineralization of organic nitrogen (N), carbon (C), sulfur (S), and phosphorus (P), organic matter transformation, and N2 fixation by the soil microbial biomass (Joniec, 2018).The availability of nutrients in soil is influenced by soil pH, and alkaline soil (with pH greater than 9) can exhibit phytotoxicity of aluminate (Wallenstein *et al*., 2010). Soil is essential for fulfilling the basic needs of human beings, as it serves as the foundation of farming and contributes to food, clothing, and shelter(Din *et al*., 2023). Therefore, studying the physicochemical properties of soil is crucial as both its physical and chemical characteristics determine soil productivity and fertility status(A. . A. G. . & R. H. Baig, 2022).

Micronutrients play a vital role in maintaining balanced plant nutrition, which stabilizes crop yields in a region (Rattan and Sharma, 2004). The management of nutrients and crop production varies from one soil type to another and depends on their physicochemical behavior (Sharma VK *et al*., 2006). This involves the analysis of parameters and techniques that affect soil performance (SS Kekane et al., 2015).Variations in precipitation, snowfall, and temperature can affect the accumulation and decomposition of soil organic matter (SOM) (Jobbagy EG & Jackson RB, 2000). Consequently, these variations influence the fertility status of soils in the region. Several soil fertility characteristics(Ahmad *et al*., 2020), such as pH, cation exchange capacity (CEC), SOM, available phosphorus, extractable potassium, and nitrogen, have been found to exhibit significant variations across mountainous soils (Ishaq S *et al.,* 2015).To maintain good soil quality and ensure its fertility, it is essential to preserve the physical, chemical, and biological characteristics of the soil unchanged (Santorufo, 2013). The objectives of this study were to evaluate the physicochemical properties of soil in the study area(Begum *et al*., 2019), identify the fertility level/status of the soil, and provide baseline information on soil properties to farmers.

Materials and Methods

Study area;

Roundu, a picturesque village in Skardu, Gilgit-Baltistan, Pakistan, captivates visitors with its breathtaking Karakoram mountain surroundings(Wali Khan *et al*., 2015), lush valleys, and glaciers. A haven for trekkers and mountaineers, it boasts popular destinations like Deasia National Park and Sheosar Lake. The hospitable Balti people and their culture add charm(Khan, 2015). Nearby Skardu city serves as the region's hub with amenities and historical sites from the ancient Silk Route. Despite tourism potential, Roundu remains unspoiled, offering an off-the-beaten-path experience. Accessible by air through Skardu Airport and by road via the Karakoram Highway(Abbas *et al*., 2016), this hidden gem beckons adventurers and nature lovers alike.

Methodology.

Soil sampling and processing

A soil nutrient investigation was conducted, and a total of 20 composite soil samples were collected during the sampling process(Alam *et al*., 2023). Each composite sample was obtained by randomly collecting soil from different locations within the designated sampling area, specifically from a depth of 5-7 cm below the main surface, using an auger(Government of Pakistan and IUCN, 2019). Approximately 500g of soil from each stand sample was carefully placed in individual polyethylene bags and appropriately labeled. These labeled soil samples were then transported to the laboratory for further analysis and testing.

Laboratory analysis;

Subsequently, all the collected soil samples were transported to the laboratory for further processing(Spies, 2017). In the lab, each sample was subjected to air drying at a temperature ranging from 25 to 30 degrees Celsius until they were completely dried(Oktavia *et al.*, 2022). Once the soils had reached the desired dryness, they were crushed to break down any clumps and then transformed into a powdery form for subsequent analysis.

Preparation of soil solution;

A total of 20 beakers were thoroughly washed with distilled water and subsequently labeled with unique numbers for identification(Fitrah & Karmila, 2020). Then, 50 ml of distilled water was measured and added to each beaker. After that, 5 grams of soil was carefully added to each respective beaker. To ensure proper mixing, all the beakers were shaken vigorously for a brief period(A. Hussain, Hussain, *et al*., 2022). Finally, the contents of each beaker were transferred and packed into individual plastic bottles to facilitate further analysis.

Analysis of physical parameters;

The physical parameters, including conductivity, pH, salinity, and total dissolved solids (TDS), were measured using a multi-meter. To evaluate the organic matter content, the (Bremner 1965) method was employed. The procedure began by taking 10 grams of soil from each of the 20 samples. The dry weight of each soil sample was measured first(S. Baig *et al*., 2021). Subsequently, the samples were placed in an oven to determine their wet weight. After obtaining both dry and wet weights, the values of each parameter were recorded. These values were then utilized in a given formula for further analysis(Rashid *et al.*, 2023).

OM in soil sample identified by the formula as given below.

B A C

OM= Weight of wet soil +weight of cubical]-[weight of

A

Oven wet soil]-[cubical weight]

For conversion in percentage%

We putting the given answer in the formula given below.

$$D\ \% = \frac{D * 100}{} = OM\%$$

Table .1 soil Physico-chemical properties of different locations of study area

Location	Conductivity	Salinity	Ph	TDS	O M %	N (%)	P (%)	K (%)
Tormik	74.5	0	7.2	30.5	76	1.1	0.23	0.89
Daso	42	0.009	6.4	18.9	61	0.034	0.024	0.79
Baghcha	46	0	5.9	26	54	0.038	0.028	0.94
Dambudas	36.4	0.004	5.9	22	60	0.036	0.035	1
Harpo	77.4	0	7.4	30	67	0.5	0.4	1.11
Thowar	36.2	0	5.8	24	68	0.034	0.03	0.94
Bgardo	22.3	0	5.43	9.8	48	0.034	0.022	1.23
Sari	41	0	7.1	18.3	57	0.031	0.025	0.99
Tongus	39	0	5.4	15.3	60	0.036	0.02	0.92
Stak	35.4	0	6.2	28	63	0.035	0.026	0.95
Bilamik	76.3	0	7	32	72	0.031	0.19	0.75
Shout	24.4	0	5.1	10.6	55	0.04	0.025	0.96
Koshmal	45.6	0	6.5	22	62	0.034	0.022	0.85
Khumrah	36.2	0.003	5.7	21	67	0.039	0.02	0.84
Ganji	78.3	0	7.3	31.2	76	1.035	0.23	1.01
Mandi	26.9	0	5.2	12.1	56	0.027	0.025	0.98
Sabser	22.4	0	5.7	10.1	60	0.031	0.026	0.76
Talu	22.6	0	6.9	10.6	57	0.033	0.024	0.75
Harbot	47	0.006	5.7	28	64	0.038	0.024	0.94
Yulbu	42	0	6.3	17.6	62	0.035	0.026	0.85

Result and discussion

Conductivity;

Based on the provided information(Alam *et al.*, 2023), the conductivity values of soils in Sub Division Roundu range from 22.3 to 78.3. Among the soil samples collected from different areas: Bilamik: Contains high conductivity value.

Bagardo: Contains the least electrical conductivity. Tormik, Bilamik, Harpo, and Gunji: Have the maximum conductivity values. Here's a rephrased summary of the information: The conductivity values of soils in Sub Division Roundu varied between 22.3 and 78.3. Bilamik soil samples exhibited high conductivity, whereas the Bagardo area had the lowest electrical conductivity. On the other hand, Tormik, Bilamik, Harpo, and Gunji areas showed the highest levels of conductivity

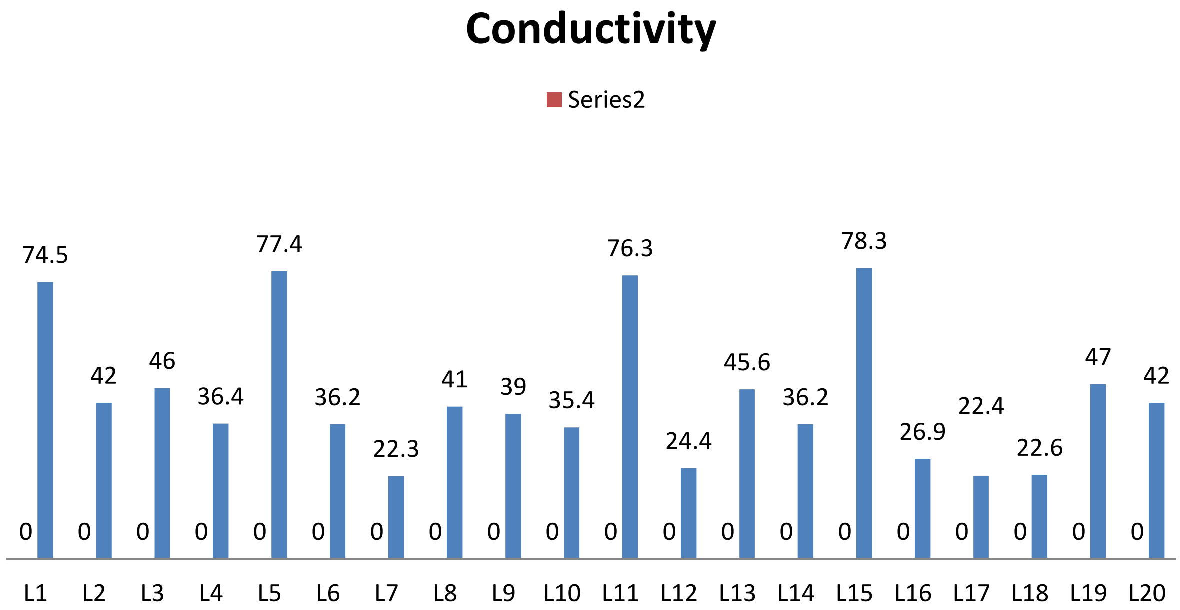

Figure 1. **Soil conductivity of different samples**

PH;

The optimum soil pH range for ideal plant growth varies depending on the crop. Generally, most plants thrive when the soil pH falls between 6.0 and 7.0. Soils with a pH below 7 are considered acidic(Parveen *et al.*, 2022), while those with a pH above 7 are considered alkaline(Qutoshi *et al.*, 2022). In a study area, 20 soil samples were collected and analyzed, and their pH values ranged from 5.1 to 7.4. This indicates that the soil pH in all 20 samples is within the acceptable range. Among the samples, the soil from Harpo exhibited the highest pH value, while the soil from Shout had the lowest pH value.

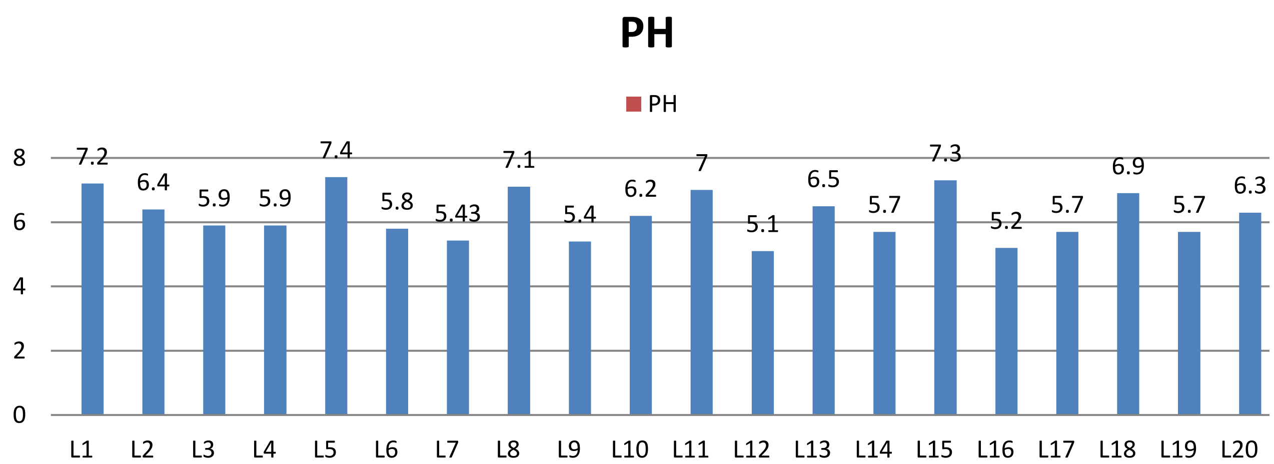

Figure 2: pH graphs of samples

ORGANIC MATTERS;

In general, Pakistani soil is known to have low organic matter content(Z. Hussain, 2019). However, the soil studied in this research shows a medium level of organic matter(Hassan *et al.*, 2022). The soil samples analyzed in the study exhibit organic matter contents ranging from 48% to 76%. Among the samples, Tormik and Gunji have the highest organic matter content, while the sample from Bagardo has the least. Therefore, the order of organic matter content, from highest to lowest, is Tormik & Gunji > ... > Bagardo.

Figure 3: OM graph of samples

TDS;

TDS, which stands for Total Dissolved Solids, refers to the concentration of inorganic salts such as magnesium, calcium, potassium, sodium, bicarbonates, chlorides, and sulfates present in soil(Alam *et al*., 2023). Among the 20 samples analyzed, TDS concentrations ranged from 9.8 to 32. The sample from Bagardo showed the lowest TDS value, while the sample from Bilamik exhibited the highest TDS concentration.

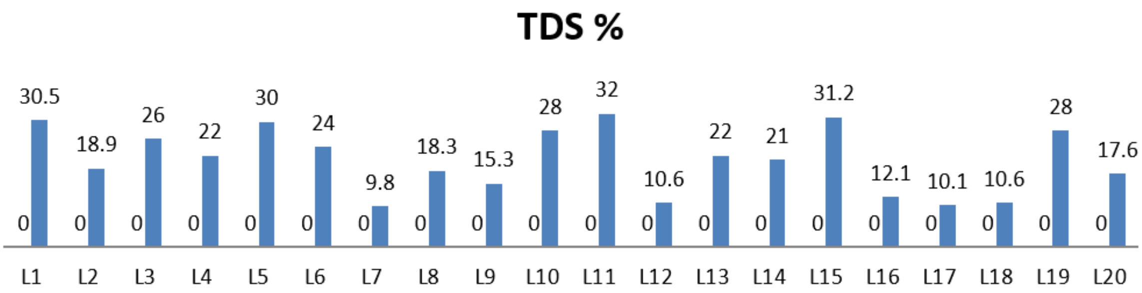

Figure 4 : graph of TDS

SALINITY

Salinity in soil refers to the overall salt content present(Din *et al*., 2023). The analysis indicates that the majority of samples show a salinity level of 0%. However, specific samples from Dassu, Dambodas, Khumrah, and Harbot exhibit low salinity levels of 0.009, 0.004, 0.003, and 0.006, respectively.

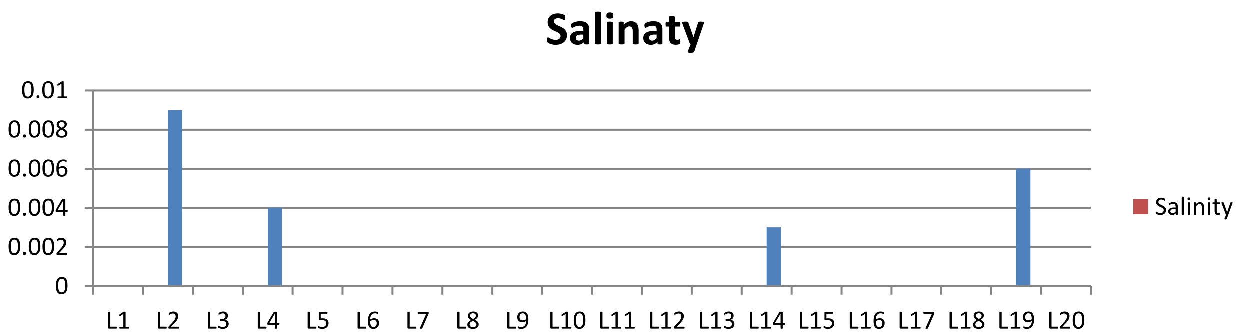

Figure 5 salinity graph of samples

NITROGEN, POTASSIUM AND PHOSPHORUS:

The findings of the current and previous study(Z. Hussain, 2019) show that the soil in the Roundu sub-division is lacking in nitrogen and phosphorus, but certain regions within the study area, namely Tormik, Harpo, Gunji, and Bilamik, contain minor amounts of potassium. Specifically, approximately 85% of the soil samples were found to be deficient in nitrogen and phosphorus, while the remaining 15% exhibited marginal concentrations of these nutrients.

Regarding potassium content, a significant portion, 79.8% of the soil samples, contain sufficient levels of potassium, while a smaller portion, 20.2%, showed only marginal amounts of this nutrient.

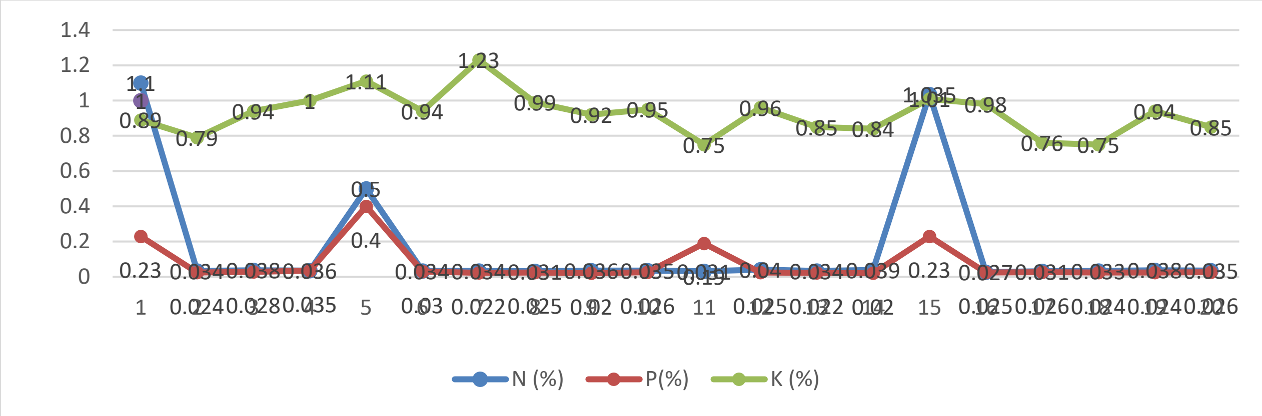

Figure 6 : graphical ratio of NPK among soil samples

Discussion

Soil fertility is critical for plant growth, depending on essential chemical components like nitrogen, Soil physicochemical properties serve as fundamental indicators for estimating the soil nutrient content and characteristics. Studies have shown that the availability of nutrients in the soil is influenced by factors like soil pH (Kinyangi, 2017) conducted research focusing on the physicochemical analysis of soil, which involves various parameters like total organic carbon, nitrogen (N), phosphorus (P2O5), potassium (K2O), pH, and conductivity. This analysis provides insights into the nutrient levels present in the soil. Similarly, (Rajesh P. Ganorkar and P.G. Chinchmalatpure, 2017) conducted research on soils, investigating their physical and chemical properties, as well as the presence of micronutrients. Soil samples were collected from six different locations, specifically (Rajura Bazar, in WTahsil, 2022) Amravati District (Maharashtra, India). The parameters studied included soil moisture, pH, electrical conductivity (EC), carbon content, calcium carbonate, total dissolved solids (TDS), and magnesium.

An analysis was conducted on the fluoride concentration and other physicochemical parameters of 51 surface soils with levels ranging from 1.3 to 2.7 ppm. Both fluoride and pH levels were found to exceed permissible limits. Alkalinity and pH were higher than the permissible limit in all soil and water samples across different seasons. The study (Rehman *et al*., 2023 and Ahmad *et al*., 2020)suggested that leaching of minerals from the soil led to the high fluoride content in water samples, which in turn caused fluorosis in the study area. Another study focused on soil properties, chemical properties, and micronutrients in soils collected from six locations in Amravati District, India(Blundo *et al*., 2021). The soil parameters analyzed included moisture, pH, electrical conductivity (EC), carbon content, calcium carbonate, total dissolved solids (TDS), magnesium, calcium, nitrogen, copper, potassium, and phosphorous. The pH results indicated that all soil samples were alkaline, and moderate amounts of available micronutrients were present(Linger *et al*., 2013). A third study compared impacted and non-impacted soil from two areas in Jaipur district. Physicochemical parameters such as pH, EC, water conserving potential, texture analysis, organic carbon, total hardness, sodium, potassium concentration, sodium adsorption ratio (SAR), and caution exchange capacity (CEC) were analyzed(A. Hussain *et al*., 2019). Significant differences were observed between the parameters of the two soil types, suggesting the impact of industrial effluent on soil quality. The studies also highlighted the influence of cropping sequence, irrigation, land usage, and fertilizer application on electrical conductivity (EC) in soil, which indicates the presence of soluble salts. Organic matter was found to play a crucial role in soil fertility and nutrient retention(Shujuan & Zhaoxia, 2015), affecting soil health and crop productivity(Alam *et al*., 2023). Furthermore, phosphorus and potassium were identified as essential nutrients for crop production, and the infertile nature of the soil could lead to low crop yields if fertilizers are not applied(Sosilawaty, 2020). The addition of organic matter as fertilizer materials can improve soil quality and enhance sustainable crop production. Finally, the studies emphasized the importance of nitrogen in plant growth and highlighted its association with organic matter content in the soil(Hamawandy, 2023). Pakistani soils, being predominantly derived from alluvium and loess material, were reported to be alkaline, calcareous(S. Baig *et al*., 2021), and low in organic matter(Apriliani *et al*., 2021), and deficient in essential plant nutrients, especially phosphorus and potassium. Potassium's role in activating enzymes and providing resistance against pests, diseases, and environmental stress was also noted.

Conclusion & Recommendation

The maintenance and enhancement of soil excellence are crucial criteria for evaluating and ensuring the sustainability of soil ecosystems. In this study, various physicochemical properties of the soil were examined, including pH, Electronic Conductivity, Available Phosphate, Available Nitrogen, Available Potassium, Total Dissolved Solids, Organic Matter Content, and salinity. The results indicated that the soils in the four samples were slightly acidic to slightly alkaline, with minimal salinity issues. Organic matter levels ranged from low to medium, while there was a deficiency of NO3-N, extractable P, and K in the soil samples. Based on this information, farmers can determine the appropriate amount of fertilizers and nutrients required to enhance crop yield. It is concluded that a comprehensive soil survey of the area should be conducted to develop sustainable nutrient management practices for crop production in the study area. Improving and maintaining soil quality is essential for optimal soil function in the present and for future use.

Changes in pH outside the optimum range can lead to soil damage. Two approaches can help balance pH levels: in acidic soil, adding lime or organic matter can increase soil pH, while in alkaline soil, adding sulfur can lower the pH .Soil salinity can be controlled by improving irrigation efficiency and increasing water infiltration into aquifers. Excess salt can be leached below the root zone by applying more water than necessary for crops. Organic matter significantly improves soil structure and protects against erosion and compaction. Adopting practices like no-till or minimum tillage can enhance organic matter content.

N, P, and K are vital nutrients for plant growth and development, influencing leaf growth and seed formation. Nitrogen is also crucial for the functioning of nitrogen cycling in the ecosystem. Soil fertility can be increased by applying animal manure, compost, and practicing crop rotation to boost N, P, and K concentrations in the soil.

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