COMPARATIVE ANALYSIS OF SOIL CHARACTERISTICS UNDER PINE TREE PLANTATION OF DISTRICT PESHAWAR AND MANSEHRA

Muhammad Ilyas[1*], Sanam Zarif Satti[2], Bashir Ullah[3] and Salim Saif Ullah[4]

ABSTRACT

The present research was conducted to study and compare the soil's characteristics under pine trees of district Peshawar and Mansehra of Khyber Pakhtunkhwa, Pakistan in the year 2022. Eight soil samples from each site i.e. Hazara University Mansehra and Botanical Garden, Pakistan Forest Institute, Peshawar were collected at a depth of 0-30 cm and brought to the Forest Chemistry Lab, Pakistan Forest Institute, Peshawar in polyethylene bags for soil analysis. Various soil parameters, including soil $pH_{(1:5)}$, electrical conductivity $(EC)_{(1:5)}$, soil organic matter (%), moisture content (%), and bulk density, were analysed. The statistical analysis was done through STATISTIX 8.1 software by using a Two-sample T-Test, and means were compared at a 95% Confidence Interval (C.I.). The results of the analysis indicated that the soil organic matter and moisture content were found higher in the Mansehra district, with respective values of 4.28% and 18.38%, compared to district Peshawar with 1.45% organic matter and 9.74% moisture content. The soil pH and bulk density were higher in district Peshawar with values of 6.43 and 1.10 gcm^{-3} respectively, compared to district Mansehra, where the soil pH was 5.64 and the bulk density was 0.88 g/cm^3. The electrical conductivity was found to be statistically similar in both districts. The findings of this study reveals that the observed variation among the properties may be attributed to factors such as higher altitude and more annual rainfall in Mansehra, which increase the organic matter content, resulting in reduced soil pH and bulk density as well as increased moisture-holding capacity of the soil.

Keywords: Soil Charateristics, Peshawar, Mansehra.

INTRODUCTION

Soil is a major source of nutrients needed by plants for growth. Soil also provides support in terms of moisture, nutrients, and anchorage for vegetation to flourish successfully. Vegetation is one of the important factors, in safeguarding soil cover, checking soil erosion, and assisting in maintaining soil fertility by accumulation of soil organic matter (Eni *et al*., 2012). Soil organic matter serves as a source of nutrients for plant growth and development and also improves and maintains the physical health of soils (Iiorkar and Toley 2001). The soil chemical

[1] Research Officer (Soil), Pakistan Forest Institute, Peshawar
[2] Director Biological Sciences Research Division, Pakistan Forest Institute, Peshawar
[3] Soil Chemist, Pakistan Forest Institute, Peshawar
[4] Assistant Forest Chemist, Pakistan Forest Institute, Peshawar
* Correspondence author's email: ilyasswabi@gmail.com

environment is dynamic and reactions that maintain dilute solutions of nutrient elements are indispensable for continual plant growth. The nutrient transformation and its availability in soils depend on pH, clay minerals, cation, and anion exchange capacity (Reddy and Reddy, 2010). Changes in the soil chemical properties in the form of P mineralization-immobilization of organic P are strongly influenced by variations in temperature, moisture, plant growth, root activity, and by organic matter accumulation from litter fall (Perrot *et al*., 1990).

Forest plantations can generally affect soil's physical and chemical characteristics. The long-term impact of conifers on soil frequently involves nutrient loss and soil acidification through litter and root inputs. These impacts are the result of slower decomposition and litter buildup on the forest floor (Berg and McClaugherty 2003; Stendahl *et al*., 2010), differing concentrations of nutrients and chemical compounds within litter, and lower soil pH from litter and ectomycorrhizal leachates (Hizal *et al*., 2013; Berg and McClaugherty 2003; Yin *et al*., 2014). Release of strong aliphatic acids: oxalic, malic, citric, and formic acid during litter decomposition (Pohlman and McColl 1988) and ectomycorrhizal leachates (Landeweert *et al*., 2001) lower the soil pH and increase the soil acidity.

Altitude also is one of the major factors affecting the properties of the soil ecosystem. Soils are complex systems where soil organisms and mineral particles interact to produce species richness and complexity (Havlicek and Mitchell, 2014). As the altitude increases, the temperature falls and rate of decrease in temperature is 6.5ºC for each 1000 m altitude change. The physicochemical properties and the biodiversity of soil ecosystems are highly influenced by altitude (Kumar *et al*., 2019). There is a diverse variation of physicochemical properties among different regions of the world. As the increase in altitude, pH, base saturation, bulk density, exchangeable sodium percent, and fine silt-sized particles decrease significantly, while the organic matter, soil aggregate stability, water repellency, and coarse sand-sized particles increase significantly (Badia *et al*., 2016). The key nutrients C, N, P, and K of soils at higher altitudes differ significantly from those that are present on plains. There is a steady increase in soil organic carbon and the microbial biomass N also increases (Jeyakumar *et al*., 2020).

This study has explored and analyzed various soil parameters of the samples collected from two districts (Peshawar and Mansehra) of the Khyber Pakhtunkhwa (KP) province. The status of the soils of the selected areas is documented that can be used as a source for the effective management of the soil resources of the study areas.

MATERIALS AND METHODS

Methodology

The present research was conducted to study and compare the soil's charateristics under pine trees of district Peshawar and Mansehra of Khyber Pakhtunkhwa, Pakistan in the year 2022. Eight soil samples from each site i.e. Hazara University Mansehra and Botanical Garden, Pakistan Forest Institute, Peshawar, were collected with the help of augur at a depth of 0-15 cm. the smples were properly labelled with sample number and location, and brought to the Forest Chemistry Lab, Pakistan Forest Institute, Peshawar in polyethylene bags for various parameter analysis.

Parameters recorded and statistical analysis

The soil samples were analyzed for the following soil parameters

Soil Moisture Content

The soil moisture content was determined by weighing a 50g soil sample, which was then placed in an oven at 105°C overnight. The following day, it was cooled in a desiccator for at least 30 minutes and then re-weighted (Gee and Bauder, 1986). The moisture content was calculated using the provided formula.

Moisture content

$$(\%) = \frac{wet\ weight\ of\ sample\ (g) - Oven\ dry\ weight\ of\ sample\ (g)}{Oven\ dry\ weight\ of\ sample\ (g)} X100$$

Soil Bulk Density

Soil bulk density was determined by core method by using the following formula (Black and Hartage, 1986).

$$Bulk\ Density\ = \frac{Mass\ of\ Soil}{Total\ Volme\ of\ Soil}$$

Soil pH

A 10 gram soil was weighed and added 50 ml of distilled water to make the ratio of 1:5. The mixture was vigorously shaken for 15 minutes using a mechanical shaker. Once the suspension was ready, the soil pH was measured by inserting a pH meter (Mettler-Toledo GmbH 8603), following the method described by McLean in 1982.

Soil EC (dSm^{-1})

The same procedure was applied to measure the soil electrical conductivity (EC) as was done for soil pH. A 10 grams of soil were carefully weighed and 50 ml of water was added. The resulting suspension was vigorously shaken for 15 minutes and the electrical conductivity was measured using an EC meter (Mettler-Toledo GmbH 8603), following the method outlined by Richard in 1954.

Soil Organic matter (%)

In a conical flask, 1 gram of air-dried soil was combined with 10 mL of 0.5 N potassium dichromate ($K_2Cr_2O_7$) and 20 mL of concentrated sulfuric acid (H_2SO_4). The mixture was cooled, and then 200 mL of distilled water was added to the flask. The resulting suspension was filtered, and 2-3 drops of Orthophenolpthalein indicator were added to the filtrate. The filtrate was titrated against 0.5 N $Fe_2SO_4.7H_2O$ until the color turned dark brown, indicating the end point, as described by Walkley and Black in 1934. The organic matter content was determined using the following formula

$$\%\,OM = \frac{[(mL\ of\ K_2Cr_2O_7\ x\ N)\text{-}(mL\ of\ FeSO_4.7H_2O\ x\ N)]}{Weight\ of\ soil} \times 0.69$$

Statistical Analysis

The statistical analysis was carried out through STATISTIX-8.1 using Two- sample T-Test and means were compared at 95 % Confidence Interval (C.I.) (Steel *et al.,* 1997).

RESULTS

Bulk Density ($g\ cm^{-3}$)

Soil bulk density as influenced by spatial variations under pine tree plantation is presented in table 1. According to the statistical tool, Two-Sample T-Test analysis, the data revealed a significant difference at $p \leq 0.05$. The average maximum soil bulk density was recorded in Peshawar district (1.10 $g\ cm^{-3}$), compared to Mansehra district (0.88 $g\ cm^{-3}$).

Table 1. Comparative analysis of soil bulk density under Pine tree plantation of district Mansehra and Peshawar

Sample No.	Bulk density (Peshawar)	Bulk density (Mansehra)
1	1.25	0.84
2	1.22	0.76
3	1.13	0.97
4	1.06	1.06
5	0.97	0.89
6	1.23	0.79
7	0.89	0.91
8	1.05	0.81
Means	1.10	0.88
P at 95% C.I.	0.0020	

Moisture Content (%)

Soil moisture content as influenced by spatial variations under pine tree plantation is presented in table 2. According to the statistical tool, Two-Sample T-Test analysis, the data revealed a significant difference at $p \leq 0.05$. The mean maximum moisture content (18.38 %) was found in the soils of the Mansehra district, while that of the Peshawar district is 9.74 %.

Table 2. Comparative analysis of soil moisture content under Pine tree plantation of district Mansehra and Peshawar

Sample No.	Soil Moisture (Peshawar)	Soil Moisture (Mansehra)
1	7.71	19.25
2	8.43	23.48
3	10.58	18.09
4	9.80	22.15
5	9.21	13.51
6	9.70	11.60
7	12.05	16.69
8	10.45	22.24
Means	9.74	18.38
P at 95% C.I.	0.0001	

Soil pH

Soil pH as influenced by spatial variations under pine tree plantation is presented in Table 3. According to the statistical tool, Two-Sample T-Test analysis, the data revealed a significant difference at $p \leq 0.05$. Laboratory analysis of the soil pH stated that the average pH of eight samples from the Peshawar district is about 6.43, while the pH of the Mansehra district was comparatively low, which was 5.64 under pine trees.

Table 3. Comparative analysis of soil pH under Pine tree plantation of district Mansehra and Peshawar

Sample No.	Soil pH (Peshawar)	Soil pH (Mansehra)
1	6.41	5.84
2	6.29	4.59
3	5.91	4.89
4	6.73	5.10
5	5.58	5.67
6	6.70	6.25
7	6.80	6.30
8	7.00	6.50
Means	6.43	5.64
P at 95% C.I.	0.0218	

Electrical conductivity (dSm^{-1})

Soil electrical conductivity (EC) as influenced by spatial variations under pine tree plantations is presented in Table 4. According to the statistical tool, Two-Sample T-Test analysis, the data revealed a non-significant difference at $p \leq 0.05$. Laboratory analysis of the data shows that the average EC of the Peshawar district is 0.78 dSm^{-1} and that of the Mansehra district is 0.77 dSm^{-1}. The EC of soils varies depending on the amount of moisture held by soil particles and also strongly correlates with soil particle size and texture.

Table 4. Comparative analysis of soil EC (dSm^{-1}) under Pine tree plantation of district Mansehra and Peshawar

Sample No.	Soil EC (Peshawar)	Soil EC (Mansehra)
1	0.75	0.73
2	0.73	0.64
3	0.84	0.72
4	0.73	0.87
5	0.88	0.67
6	0.86	0.85
7	0.72	0.83
8	0.72	0.85
Means	0.78	0.77
P at 95% C.I.	0.8308	

Soil Organic Matter (%)

Soil organic matters as influenced by spatial variations under pine tree plantations are presented in Table 5. According to the statistical tool, Two-Sample T-Test analysis, the data revealed a significant difference at $p \leq 0.05$.

The mean analysis of eight soil samples shows that the soil of the Mansehra district has the highest organic matter (4.28 %) in comparison to the district Peshawar (1.45%).

Table 5. Comparative analysis of soil organic matter (%) under Pine tree plantation of district Mansehra and Peshawar

Sample No.	Soil OM (Peshawar)	Soil OM (Mansehra)
1	1.39	4.98
2	1.29	6.23
3	1.32	4.37
4	1.61	4.03
5	1.45	3.17
6	1.26	5.56
7	1.61	3.60
8	1.69	2.30
Means	1.45	4.28
P at 95% C.I.	0.0001	

DISCUSSIONS

The current study was arranged to compare the soil characteristics of two districts i.e. district Peshawar and Mansehra. After statistical analysis, the soil properties i.e. districts soil pH, organic matter, and moisture content of both were significantly different from each other, while the electrical conductivity was statistically similar in both districts. According to Kumar *et al*., 2019, the greater the organic matter at the highest altitude may be attributed to the slow rate of decomposition caused by the low temperature. Since low temperatures reduce microbial and enzymatic activity which ultimately reduces the decomposition rate. The reduction in pH can be attributed due to the accumulation and subsequent slow decomposition of organic matter, which releases acids i.e. humic acid, and fulvic acid (Brady & Weil, 2002). The EC of the soils of low and high altitudes does not have any significant variation proving that there is a cumulative accumulation of salts along the altitude (Charan *et al*., 2013). The spatial variability of soil moisture (specifically, the total quantity of water contained inside a particular soil mass or volume) may be influenced by many conflicting variables including soil characteristics and organic matter (Nyberg, 1996), water table depth, vegetation (Hawley *et al*., 1983; Francis *et al*., 1986), and climatic indices, such as precipitation and solar radiation (Famigletti *et al*., 1998).

CONCLUSION

Characteristics of soils vary with space and time due to variations in topography, climate, physical weathering processes, microbial activities, and several other biotic and abiotic factors. Regarding the current study soil properties i.e. soil pH, organic matter, and moisture content of districts Peshawar and Mansehra were significantly different from each other, while the electrical conductivity was statistically similar in both districts. The variation among the properties may be due to high altitude and more annual rainfall, which increase the organic matter content, consequently reducing the soil pH and bulk density and increasing the moisture-holding capacity.

REFERENCES

Badia, D., Ruiz, A. and A. Girona. 2016. The influence of elevation on soil properties and forest litter in the Siliceous Moncayo Massif, SW Europe. Journal of Mountain Science. 13: 2155-2169.

Berg, B., and C. McClaugherty. 2003. Plant litter. Decomposition, humus formation, carbon sequestration. Berlin, DE.© Springer-Verlag Berlin Heidelberg.

Blake, G. R. and K. H. Hartage. 1984. Bulk Density. In: Campbell, G.S., R. D. Jackson,

Mart, M. M., Nilson, D. R. and A. Klute. Eds., Methods of Soil Analysis, Part 1, American Society of Agronomy, Inc., Madison, W. I: 364-366.

Brady, N., and R. Weil. 2002. The Nature and Properites of Soils. 13th ed.

Charan, G., Bharti, V. K., Yadhav, S. E., Kumar, S., Acharya, S., Kumar. P., Gogoi, D. and R. B. Srivastava. 2013. Altitudinal variations in soil physicochemical properties at cold desert high altitude. Journal of Soil Science and Plant Nutrition.13 (2): 267-277.

Eni, D. D., Iwara, A. I., R. A. Offiong. 2012. Analysis of Soil-Vegetation Interrelationships in a South-Southern Secondary Forest of Nigeria. Int J For Res 2012: 469326.

Famigletti J. S., Rudnicki, J. W., M. Rodell. 1998. Variability in surface moisture content along a hillslope transect: Rattlesnake Hill, Texas. Journal of Hydrology 210: 259–281.

Francis CF, Thornes JB, Diaz Romero A, Lopez Bermuda F. and G. C. Fisher. 1986. Topographic control of soil moisture, vegetation cover and land degradation in a moisture stressed Mediterranean environment. Catena 13: 211–225.

Gee, G. W. and J. W. Bauder. 1986. Particle-size analysis. Methods of soil analysis: Part 1-Physical and mineralogical methods, (methods of soil an1) pp. 383-411.

Hawley, M. E., McCuen, R. H. and T. J. Jackson. 1983. Volume–accuracy relationships in soil moisture sampling. Journal of the Irrigation and Drainage Division Processes, American Society of Civil Engineering 108: 1–11.

Ilorkar, V. M. and N. G. Totey. 2001. Floristic diversity and soil studies in Navegaon National Park (Maharashtra). Indian J For 24: 442-447.

Jeyakumar, S.P., Dash, B., Singh, A.K., Suyal, D.C. and Soni, R. 2020. Nutrient cycling at higher altitudes. Microbiological Advancements for Higher Altitude Agroecosystem and Sustainability. 293-305.

Kumar, S., Suyal, D.C., Yadav, A., Shouche, Y. and R. Goel. 2019. Microbial diversity and soil physicochemical characteristic of higher altitude. PLoS One.14(3): 1-15.

Landeweert, R., Hoffland, E., Finlay, R. D., Kuyper, T. W., and van Breemen, N. 2001. Linking plants to rocks: ectomycorrhizal fungi mobilize nutrients from minerals. Trends in Ecology & Evolution, 16(5), 248-254.

Mclean, E. O. 1982. Soil pH and lime requirement. In A.L. Page, R.H. Milelr and D.R. Keeney (eds). Method of Soil Analysis. Part 2. 2nd ed. Agronomy. 9: 209-223.

Nyberg, L. 1996. Spatial variability of water content in the covered catchment at Gardsjon, Sweden. Hydrological Processes 10: 89–103.

Perrot, K.W., Sarathchandra, S.U., and J. E. Waller. 1990. Seasonal storage and release of phosphorous and potassium by organic matter and microbial biomass in a high-producing pastoral soil. Austr. J. Soil Res. 28: 593-608.

Pohlman, A. A., and J. G. McColl, 1988. Soluble organics from forest litter and their role in metal dissolution. Soil Science Society of America Journal, 52(1), 265-271.

Reddy, T. Y., and G. H. S. Reddy. 2010. Principles of Agronomy. Kalyani Publishers, New Delhi. 527.

Richard, L. A. 1954. Diagnosis and improvement of saline and alkali soils. Agri. Hand book-60. Pp: 101-129.

Stendahl, J., Johansson, M. B., Eriksson, E., Nilsson, Å., and O. Langvall, 2010. Soil organic carbon in Swedish spruce and Pinus forests–differences in stock levels and regional patterns. Silva Fennica, 44(1), 5-21.

Steel, R. G. D., J. H. Torrie and D. A. Dicke. 1997. Principles and Procedure of Statistics. A Biomaterial Approach 3rd .Ed. The McGraw- Hill, Companies, Inc. NY. USA. to San Joaquin Valley vineyards. California Agriculture. 59(3): 188-191.

Walkley, A., and I. A. Black, 1934. An Examination of degtjarefe method for determining soil organic matter and a proposed modification of chromic acid titration method. Soil Sci., 37: 28-35.

Yin, H., Wheeler, E., and R. P. Phillips. 2014. Root-induced changes in nutrient cycling in forests depend on exudation rates. Soil Biology and Biochemistry, 78, 213-221.