Soil properties as influenced by different land use systems under subtropical region of Jammu

Abstract

The purpose of this work was to investigate the impact of various land use systems on physical and chemical changes in soil. Soil samples were taken from five different land use systems: agriculture, horticulture, forest, agroforestry, and grasslands. Soil bulk density, mean weight diameter, maximum water holding capacity, pH, nitrogen, phosphorus and potassium levels were measured. Forest land use had the lowest bulk density and pH in surface and sub-surface soil layers when compared to all other land uses, but it had the highest mean weight diameter, maximum water holding capacity, nitrogen, and potassium in surface and sub-surface soil layers when compared to all other land uses. Agriculture land use had the highest available phosphorous. The forest land use is best for soil bulk density, mean weight diameter, water holding capacity, pH, nitrogen, phosphorous over all other land uses.

Keywords: bulk density, land uses, water holding capacity

INTRODUCTION

Locally implemented ecologically incompatible human land-use and management practises such as deforestation and soil fertility depletion have resulted in a change in the global biogeochemical cycles. Changes in land use have an impact on many natural resources and ecological processes, such as surface runoff and erosion, as well as soil resilience to environmental impacts (Fu et al 2000, Hacisalihoglu 2007). Changes in soil physical and chemical properties may cause erosion and soil compaction as land use intensifies (Celik 2005). Soil quality index (SQI) is a tool that combines various types of collected data to produce a single number that can be used to compare one soil to another in order to better understand and evaluate the process that improves or degrades soils. It is a comprehensive method for determining a region's environmental quality, agronomic sustainability, and socioeconomic viability (Bhardwaj et al., 2011). This tool can help determine whether soil quality is improving, stable, or declining under various land use systems (Masto et al., 2008).

Material and Methods

Soil samples were collected from different land uses of subtropical region of Jammu and analysis was done in the Division of Soil Science and Agriculture Chemistry, Faculty of Agriculture, SKUAST, JAMMU. A total of 180-200 soil samples were collected from five different land use systems such as agriculture, horticulture, forest, agroforestry and grasslands. each location samples were taken from two depths i.e 0-15 and 15-30cm.

The core method (Blake and Hartge 1986) was used for determination of soil bulk density. Fresh undisturbed soil cores of 5 cm diameter and 5 cm length were collected in triplicate from each replicated plot from 0-15 and 15-30 cm soil depths. These samples were oven-dried at 105^{0}C, weighed and the dry weights were divided by the core volume to obtain the soil BD for the respective layer. Maximum water holding capacity, it was determined by Keen Roezkowski box method (Chopra and Kanwar, 1991) The mean weight diameter (MWD) of aggregates were calculated as (Kemper and Rosenau, 1986):

$$MWD\ (mm) = \frac{\sum_{i=1}^{n} x_i w_i}{\sum_{i=1}^{n} w_i}$$

Where, Wi is the aggregates retained over the sieve (g) and Xi the mean diameter of the size class (mm). A soil suspension was prepared with distilled water keeping 1:2 soil to water ratio and the concentration of hydrogen ions in soil (pH) of suspension was measured by potentiometric method

(Jackson 1973). The pH of the solution being directly proportional to the potential developed on the glass membrane was measured in conjunction with saturated calomel electrode as reference electrode. Available nitrogen was determined by alkaline $KMnO_4$ method (Subbaiah and Asija, 1956), which is based on the extraction of inorganic and readily oxidizable N from organic compounds. The N was extracted with 0.32 % $KMnO_4$ and distilled by 2.5% NaOH. The distillation process was carried out by nitrogen analyzer and manual titration was done. The liberated ammonia was absorbed in 2 % boric acid, containing bromocresol green and methyl red mixed indicator. The amount of ammonia absorbed was determined titrimetrically using standard H_2SO_4 (0.02 N) till the colour flashed from green to pink. Available phosphorous was determined by Olsen's method as described by Watanabe and Olsen using 0.5 M sodium bicarbonate pH (8.5) as an extractant. Darco-G-60 was used to absorb the dispersed organic matter and make the filtrate colorless for further colorimetric analysis (Nelson and Sommer 1982). Available potassium and CEC were determined by the flame photometer using neutral N ammonium acetate (pH 7.0) as an extractant as described by Piper (1996).

Statistical analysis

The data were analyzed by using analysis of variance by single factor ANOVA, least significant difference (LSD) was used to compare the treatment effects.

Results and Discussion

Forest land use had the lowest bulk density in surface and subsurface soil layers (1.39 and 1.44 Mgm^{-3}), followed by grassland, horticulture, agroforestry, and agriculture. The addition of fallen litters, which loosened the soil, may have contributed to this result (Chandel et al (2017). These findings are consistent with those of Sharma et al. According to a 2014 study, agriculture had the highest mean bulk density, followed by degraded land in all three soil depths. Soils from forests and horticulture had lower bulk density than soils from other land uses. Soil bulk density increased with soil depth in all land use systems. Chandel et al. (2017) also reported that forest, horticulture, and grasses have lower bulk density than agriculture and bare land uses. Forest land use had the highest MWHC (38.74 and 37.19 per cent) in both soil depths, followed by horticulture, agroforestry, grassland, and agriculture land use had the lowest (Table 1). Chandel et al. (2017) reported similar findings: the highest WHC was found in the land use forest, which was significantly higher than horticulture, followed by grasses and cultivated land use, and the lowest WHC was found in bare land use. According to Saha et al. (2014), the bulk density values in eroded soils are higher in both the surface and sub-surface soil than in other land-uses. The same trend was observed in Goyal's (2009) study, where maximum water holding capacity was found in forest, grasslands, and agricultural land use. The highest values of maximum water holding capacity in forest soil could be attributed to the soil's high organic matter and finer clay content. The decreasing trend of WHC with depth could be attributed to soils with lower organic carbon and clay content under various land use systems. Table 1 shows that the MWD in surface (0-15 cm) and subsurface (15-30 cm) soil layers was highest in forest land (3.18 and 2.64 mm), followed by grassland, agroforestry, horticulture, and least in agriculture (Table.1). Lower MWD agriculture land use could be attributed to lower organic matter inputs from vegetation and loss of SOC by water erosion. On the contrary, the higher fibrous root biomass in forest soils, followed by grassland agroforestry and horticulture soils, could have contributed to a higher SOC and leads to a higher MWD in these soils; these findings are consistent with Kukal et al. (2007), who found that the stability of soil aggregates was higher in grasslands than in other land use systems. Sushil et al. (2002) discovered that forest soils had higher MWD than cultivated land. The higher the MWD of a soil sample, the more stable the soil is to break down due to erosion agents and degradation. Lower MWD in agricultural land use may be caused by a lack of vegetative cover, the impact of raindrops, and low SOC content in degraded soils. Mechanical disturbance, according to Franzluebbers et al. (1999), reduced soil structural stability in various soil types. These low mean-weight diameter (MWD) values could result in rapid soil dispersion during any rainfall event, resulting in severe rill or inter-rill erosion. Hadda et al. (2020) discovered that the mean weight diameter of pear, grasses, and fallow was greater than that of rice-wheat. Forest land had the lowest soil pH (6.6 and 6.7 in surface and subsurface soil layers, respectively), followed by Agriculture (6.8 and 6.9), Horticulture (6.9 and 7.0), Agroforestry (6.9 and 7.0), and Grassland (6.9 and 7.0). (7.0 and 7.1). The soils under investigation ranged in pH from slightly acidic to slightly alkaline. Sharma et al. (2009), discovered comparable results in kandi soils of Jammu.Forest soils had lower pH values than degraded lands, which could be attributed to their higher organic carbon content. The pH increased with depth in all land use systems, which is consistent with Gupta's findings (1994). The increase in pH with depth could be due to calcium carbonate and exchangeable bases leaching. Soil pH variability is usually attributed to organic materials in the soil that decompose and produce organic acids, including carbonic acid, which eventually lowers the soil pH. According to Sarkar et al. (2001), the low pH value in surface soil is primarily caused by base leaching and the accumulation of basic cations from higher topography due to rainfall. Forest land use had the highest available N content (326.07 and 317.12 kgha-1) in surface and sub-surface soil layers (326.07 and 317.12 kgha-1) followed by horticulture, grassland, agroforestry, and agriculture had the lowest (326.07 and 317.12 kgha-1). Mandal et al. (2018) investigated the impact of three agricultural land-uses on soil quality and fertility status: cropland, horticultural land, and uncultivated land. Available nitrogen content followed a trend of horticulture > cropland > uncultivated land, and Panwar et al. 2013 investigated the impact of land use on soil fertility and found that the highest N content was found under forest followed by grassland, horticulture and agriculture and least in wasteland. Chandel et al. (2017) discovered that soil quality degradation is a major issue in submontane Punjab, and that available N was lower across all land uses. The available N was highest in the forest land use, followed by cultivated grasses, which was significantly higher than horticulture and bare. The available nitrogen was higher in land use forest, as expected, because a large amount of nitrogen was made available through organic matter addition. In the long run, conversion of forest to cropland reduced soil nitrogen (Runquan et al. 2002). The available P ranged from 19.45 to 21.49 kg ha^{-1} in surface soil depths and from 17.87 to 19.94 kg ha^{-1} in subsurface soil depths across all land uses. Agriculture had the highest available P content in the surface and subsurface soil layers, followed by grassland, forest, agroforestry, and horticulture, which had the lowest. Cultivated land had 40% more available P than bare land, which was significantly higher than grasses, followed by forest, horticulture, and bare land (Chandel et al. 2017). Mandal et al. (2018) investigated the effect of three agricultural land-uses, cropland, horticultural land, and uncultivated land, on soil quality and fertility status, and discovered that in the case of phosphorus (P), cropland > horticultural land > uncultivated land. Forest land use had the highest available K content (273.39 and 259.37 kg ha^{-1}) in the surface and subsurface soil depths, followed by horticulture, grassland, and agroforestry.and lowest in agriculture. According to S.Pal.et al. (2013), the highest N and K content was found in forests, followed by grassland, horticulture, and agriculture, and the lowest in wasteland. Nitrogen content decreased significantly as soil depth increased. According to Singh et al. (2013), available K was highest in natural forest, followed by grassland, plantation, and lowest in cultivated. According to R. Singh et al. (2017), available K was higher in forests than in all other land uses.

Table 1: Effect of different land use systems on physical properties of soil

Land use	**B.D (Mgm^{-3})**		**Maximum WHC (%)**		**MWD (MM)**	
Depths→	**0-15 cm**	**15-30cm**	**0-15 cm**	**15-30cm**	**0-15 cm**	**15-30cm**
Agriculture	1.47	1.51	32.53	31.16	2.09	1.94
Horticulture	1.45	1.47	36.72	35.28	2.27	2.14
Forest	1.39	1.44	38.74	37.19	3.18	2.64

Agroforestry	1.46	1.48	35.66	34.01	2.88	2.56
Grassland	1.44	1.47	36.65	35.00	3.05	2.58
LSD@5%	0.046	0.043	1.55	1.56	0.17	0.17

Table 2: Effect of different land use systems on chemical properties of soil

Land use	**Soil pH**		**Available N kg/ha**		**Available P kg/ha**		**Available K kg/ha**	
Depths→	**0-15 cm**	**15-30cm**	**0-15 cm**	**15-30cm**	**0-15 cm**	**15-30cm**	**0-15 cm**	**15-30cm**
Agriculture	6.8	6.9	266.27	246.15	21.49	19.94	230.50	213.32
Horticulture	6.9	7.0	321.92	290.04	19.45	17.87	264.70	250.16
Forest	6.6	6.7	326.07	317.12	20.41	19.06	273.39	259.37
Agroforestry	6.9	7.0	293.78	276.64	19.90	18.62	246.35	240.21
Grassland	7.0	7.1	300.02	282.26	21.16	19.41	262.60	241.69
LSD@5%	0.38	0.39	41.87	46.83	1.08	1.05	31.87	33.84

Conclusion

The results showed that the forest land resulted in reduced surface and sub-surface compaction, increased the water holding capacity and saturated hydraulic conductivity and improved aggregates stability in surface and sub-surface soil depths, was registered in grassland followed by forest, agroforestry, horticulture and lowest in agriculture. Available N and K were highest in both the soil depths of forest and lowest in agriculture land use but available P was highest under agriculture land use and lowest under horticulture land use.

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