Assessment of Soil Acidity under Different Land Use Types and Slope Gradients in West Azernt District, South Ethiopia.

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ABSTRACT

The Study was conducted to assess the level of soil acidity under different land use types and slope gradients of selected kebeles of Azernet District. Three lands use types, namely, natural forest, grazing and cultivated, and three slope gradients i.e. upper, middle and lower in three replications were considered for the present study. A total of 27 composite soil samples were collected from the three land use types and three slope gradients with three replications for laboratory analysis and data was analyzed using SAS software to test the mean differences. Results indicated that highest sand content was recorded in grazing land and highest silt and clay were recorded under forest and cultivated lands. Soils of cultivated lands were strongly acidic (pH =5.2-5.4), whereas natural forest land and lower slope classes were moderately acidic (pH =5.9-6.0). The total porosity, bulk density and pH, Available phosphorus, organic matter, cation exchange capacity and exchangeable bases were significantly ($p \leq 0.001$) affected by land use types and slope gradients. The percent base saturation, total nitrogen and sand, silt and clay contents were significantly ($P \leq 0.05$) affected by land uses and slope classes. The mean values of sand, porosity, pH, OM, TN, exchangeable bases, CEC and PBS were higher in forest land and lower slope classes as compared with grazing, cultivated lands and in upper and middle slope class respectively. The exchangeable acidity and exchangeable Al^{3+} were significantly ($P\leq0.05$) affected by cultivated and grazing lands and upper slope class. The soil acidity problem on cultivated, grazing lands and upper slope classes may be due to removal of crop residues, continuous cultivation without fallow, inappropriate use of inorganic fertilizers and leaching of soil nutrients from upper slope classes and deposited at lower class. In order to reduce soil acidity problem, minimize intensive cultivation, over grazing, and use of liming material, integrated soil acidity management practices and further study on the rest of soil nutrients are recommended for particular study area and other similar agro-ecology.

***Key words**: Soil acidity, land uses, slope gradients*

INTRODUCTION

Soil acidity is one of the major problems limiting the agricultural productivity in many parts of the world. Soil acidity is associated with the content of Aluminum (Al^{3+}) and Hydrogen (H^{+}) and availability of exchangeable bases such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}) and sodium (Na^{+}), which counteract this acidity. Basic cations such as calcium (Ca^{2+}), and magnesium (Mg^{2+})are removed through leaching and crop harvest but at the same time these bases are replaced due to organic matter decomposition and from the weathering of minerals (Ermias et al., 2016), (Lenka et al., 2007). Soil acidity and associated low nutrient availability are key constraints to crop production in acidic soils, mainly Nitisols of Ethiopian highlands (Chimdi, 2022). Soil acidity is one of the chemical soil degradation problems which affect soil productivity in the Ethiopian highlands (Chimdi, 2014 and Bikila, 2019). About 43% of the Ethiopian cultivated land is affected by soil acidity and 28.1% of acid soils of Ethiopia are dominated by strong acid soils (pH 4.1-5.5) (Birhanu et al., 2014); (Behera & Shukla, 2015); (Bikila, 2019), (Mesfin et al., 2020).

The major causes for soils to become acid are acidic parent material, high rainfall, harvest of high yielding crops, leaching and organic matter decay. Balance of soil acidity or alkalinity (measured by pH) of the soil is very necessary to manage optimum availability of soil nutrients and minimizing potential toxicities (Paulos, 2001) (Chimdi et al., 2013). For instance, at a very low pH, aluminum (Al) may become more soluble and can be absorbed by roots and becomes toxic, and soil P and Ca may become deficient. At high pH, iron (Fe) and other micronutrients except Molybdenum (Mo) are become unavailable because they are formed as insoluble hydroxides and carbonates (Chimdi, 2014).

Land use changes from natural ecosystems into managed ecosystems may have deleterious effects on soil physicochemical properties. Land use changes, forest lands to cultivated land are the most widely common activities in Ethiopia. These changes involve intensive agricultural practices for a long period of time and as consequence causes for the loss of basic soil nutrients. As a result, land use change causes a decline in crop production due to the depletion of essential soil nutrients and intensification soil acidity and reduction of soil pH in the highlands of Ethiopia (Eyayu et al., 2010). Now a day, in Ethiopia the problem of soil acidity caused by Al saturation in the high rainfall area has become a national issue. In line with this, several studies (Chimdi, 2014; Eyayu et al., 2010; Lechisa et al., 2015 and Chimdi, 2022) have been made on soil p availability, dynamics and fertility status as well as on the properties, and reclamation procedures of soil acidity in some parts of Ethiopian highlands. However, scientific information regarding status of soil acidity under different land use types and slope gradients in Azernet District was not yet studied in sufficient detail. Therefore, to fill the gap the present study was initiated to assess soil acidity status under different land use types and slope gradients of the present study district. Such scientific information's are very important for better crop production, productivity and to exercise sustainable land management practices.

MATERIALS AND METHODS

Description of the Study Area: The study was conducted in West Azernet Berbere district. The district is located in Silte zone, Southern Nation Nationalities and People's Regional State. Azernet Berbere district is bounded to Southwest by Hadya zone (Mish district) and on the Northwest Gurage zone (Endegagn and Geto) district. The district capital town is Lera, which is located at distance of 85km and 258km from zonal capital town Worabe and Addis Abeba , respectively. The temperature of study area is dominated by (cool, moderately warm, moderately cool, with average minimum and maximum temperatures are 8.5 and 22.1, degree Celsius (Azernet district Agriculture and Natural Resource Develoment Office). The rainfall distribution is high during the three summer months (June to August), which accounts for 85% of the annual rainfall. The location map of the study area is shown below in (Figure1).

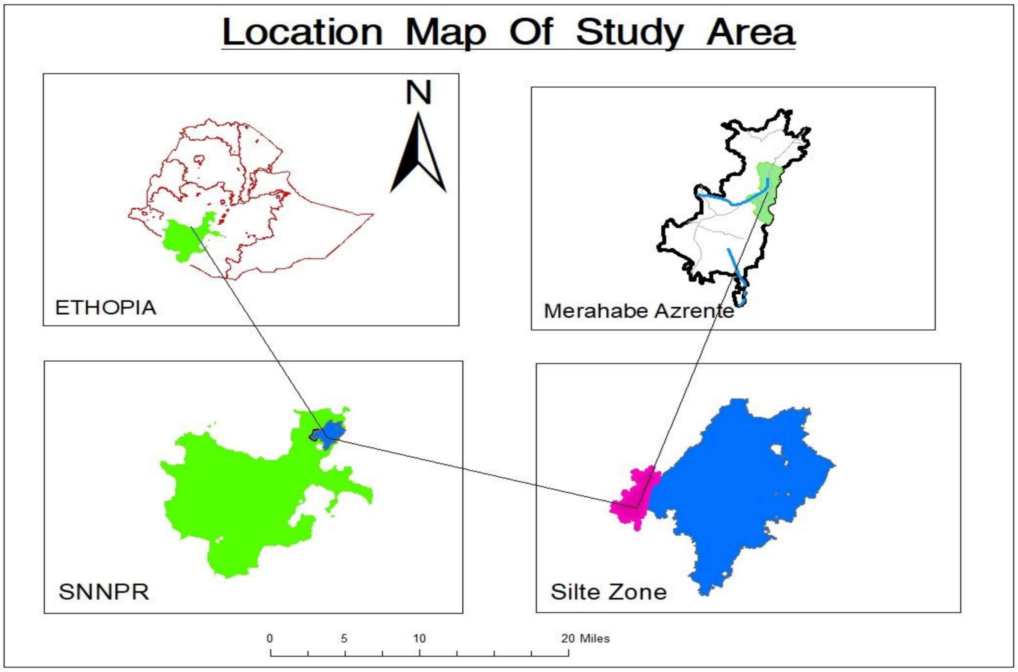

Figure1: Geographical Map of Study Area, SNNPR= Southern Nation Nationalities and People's Region

The topography of the district is generally characterized by flat plain (11%), and moderately sloping (17%) and rugged mountains (18%) and steep slope (37%). The relief of the study Area varies from 2500-3277 m from above sea level. The agro ecology is Moist Dega (69.72%) Moist Weina Dega (30.28%).The major soil types of the district includes Nitosols and Cambisols (FAO,1990). According to information obtained from district agriculture and economic development office, the total population for the year 2012 is estimated to be 95, 158. The total number of male and female population in the district are estimated to be 43, 581and 51, 577, respectively.. The major development challenges of the area include poor crop productivity, due to soil degradation, dependency on rain fed agriculture, and Poor socio- economic services.

Vegetation types and Major Crops: The regional and local geology of study area is generally characterized by geological formation of quaternary (resent sediments) and tertiary basaltic flows consisting of ignimbrite (found inter bedded with the plateau basalt, basalt occupy the lower elevation and trachyte of study area. Some of the major food crops produced in the study area are Enset, Wheat, Barley, Bean, Pea, fruit crops and the major vegetables are Potato, Cabbage, pulses, Garlic, and Onion. The main land use types are cultivated, grazing and natural forest lands as well as man-made forests land.

***Site selection, Soil sample collection and Laboratory analysis*:** Before the start of the study reconnaissance survey was conducted during January, 2020. During surveying, the general geography of the area and subareas were identified and selected using the following criteria: district which has different land use types and its representativeness on the basis of sever yield reduction problems in the district. Then, three land use types (cultivated, grazing land and natural forest) was systematically selected within the sub watershed according to similarity in soil type, slope and altitude. Land use types that bordering each other with in the respective land uses were selected to collect the soil samples. Composite soil samples were collected systematically from each land use types with in upper, middle and lower level of slope gradients along the plot with three replications. During sample collection, soil samples were obtained from a plot with dimension of 10 m x 10 m at constant depth 0-20 cm, following standard lay out design of zigzag line. The 20 sub-samples from each plot were mixed to form one composite sample. (Three replications of three land use types with three slope gradients) by using randomized completely block design (RCBD) method. A total of 27 representative composite samples were collected, labeled and transported to Wolkite soil laboratory research center. Standard laboratory procedure was followed for the analysis of the selected physiochemical properties.

Analysis of soil physical and chemical properties: Soil particle size distribution (texture) was analyzed by the Bouyoucus hydrometer method. Soil bulk density was measured from the core sampling method after drying the soil samples in an oven at $105C^0$ to constant weights (Black, 1965), while the average particle density ($2.65g/cm^3$) was considered for the calculation of total porosity (Brady & Weil, 2016). Soil pH was measured potentiometrically in 1:2.5 soils: H_2O using a combined glass electrode pH meter (Van Reeuwijk, 2002).The cation exchange capacity (CEC) of the soil was determined at pH 7 from the NH^+_4 saturated samples that was subsequently replaced by K from a percolated KCl solution (Chapman, 1965). Organic carbon content of the soil was determined by the wet combustion procedure of described by (Walkley & Black, 1934). Organic matter was determined by multiplying OC by 1.724. Exchangeable Ca and Mg was determined by using atomic absorption spectrophotometry (AAS), while exchangeable Na and K was measured by flame photometer from the same extract (Chapman, 1965). Total exchangeable acidity was determined by saturating the soil samples with 1 M KCl solution as described by Rowell (1994). From the same extract, exchangeable Al in the soil samples was determined. Available P was extracted by the Bray II method (Bray & Kurtz, 1945) using 0.03 M NH_4F and

0.1 M HCl solution. The total N content of the soil was determined by wet-oxidation procedure of the Kjeldahl method.

Method of data analysis: Land uses and slope gradients were taken as main factors. Data were collected and summarized according to land use types and slope gradients. The data obtained from laboratory analysis was subjected to two -way analysis of variance (ANOVA). For statistical and data interpretation of acidity related physical and chemical properties of soil on land use types and slope gradients was carried out using SAS software 9.4(SAS, 2013). Finally, least significant difference (LSD) ($P \leq 0.05$) test was used to separate statistically significant means of soil parameters. In addition simple correlation analysis was carried out by calculating the Pearson's coloration coefficient to determine relationship between soil acidity parameters and acidity related physical and chemical properties.

RESULTS AND DISCUSSION

Effects of Land Use types and Slope Gradient on Soil Physical Properties: The analysis of variance (ANOVA) results indicate that silt, sand and clay particle size distributions were significantly ($P \leq 0.05$) affected by under different land use types and slope gradient. Accordingly the highest clay content (37.22%) and silt (35.11%) were found in soils of the cultivated land and forest land respectively while the highest sand (40. 88 %) content was recorded in soils of grazing land. The lower content of clay fractions in forest land may be due to the process of relatively low weathering rate and continual leaching of clay content from the top soil. Study reported by Wakene and Heluf (2003) revealed that, continual leaching of clay content caused by high rain fall are highly susceptible to soil erosions and may prone to leaching of basic soil nutrients and finally results soil acidity.

Table 1: The main effect of land use type sand slope gradients on particle size distribution

Treatments	Particle size distribution (%)			
Land use Types	Sand	Silt	Clay	Textural Class
Grazing land	40.88[a]	30.90[b]	28.22[b]	Loam
Cultivated land	29.66[b]	33.11[a]	37.22[a]	Silt loam
Natural Forest	40.44[c]	35.11[c]	24.77[c]	Loam
LSD (0.05)	9.22	11.109	13.6	
Slope gradient				
Upper	37.675[a]	33.8[a]	28.66[b]	Clay loam
Middle	37.55[b]	34.05[b]	30.00[b]	Clay loam
Lower	35.86[c]	34.66[c]	33.55[c]	Clay loam
LSD (0.05)	7.22	11.109	13.6	
CV (%)	25.45	29.45	27.25	

Means within a columns followed by the different letter(s) are significantly different from each other at $P \leq 0.001$, LSD = Least significant difference and CV = Coefficient of variation

There was significant difference in percentage of sand, silt and clay content ($p \leq 0.05$) as a result of the main effect of slope gradient. The mean value of sand fraction was higher (37.67%) in upper slope and lower (35.86%) in lower sloping areas. Whereas, the higher silt (33.8%) content in upper slope and lower silt (34.66%) content were recorded in lower sloping areas and higher clay (33.55%) content was recorded in lower slope and lower clay (28.66%) content were recorded in upper sloping areas. The variation of soil textural fractions with in the slope gradients may be due to the removal clay particles by erosion on the upper slope gradient while deposition of these particles occurs on the lower slope gradient.

Bulk density and Total Porosity: Total porosity of the soils of the study area varied significantly ($P \leq 0.05$) among slope gradient (Table 2). Accordingly, higher value (74.39%) of total porosity content was recorded on lower slope areas, whereas lower (68.3%) total porosity content was recorded on upper sloping area (Table 2). This is due to high bulk density, low clay content and low OM content in soils of upper sloping as compared with lower sloping areas. This agreement is lined with (Samuel, 2006) total porosity increases as the bulk density decreases while it decreases as bulk density increases. Total porosity was significantly ($p \leq 0.001$) affected by Land use types (Table 2). Regarding to the mean values of total porosity under different land use types, the mean total porosity of cultivated, forest land and grazing lands were 63.90, 79 and 71.03%, respectively. The highest and lowest total porosity were found under plantation forest (79%) and cultivated land (63.9%) respectively (Table 2). This agreement lined with (Wakene & Heluf, 2003) the lowest and the highest total porosities were observed in the land cultivated for many years and the non-cultivated lands, respectively. This result revealed that the conversion of forest land to crop land followed by intensive cultivation without integrated soil fertility management reduces total porosity of the soil.

Table 2: Main effect of land uses and slope gradients on bulk density, total porosity and pH

Treatments			
	BD (gcm^{-3})	Total porosity (%)	pH (H_2O)
Land uses Types			
Cultivated	0.95^{a}	63.9^{c}	5.2^{c}
Grazing	0.76^{b}	71.03^{b}	5.4^{b}
Natural Forest	0.53^{c}	79.8^{a}	6.0^{a}
LSD (0.05)	0.08	2.9	0.3
Slope gradient			
Upper	0.84^{b}	68.3^{b}	5.3^{b}
Middle	0.73^{b}	72.28^{a}	5.5^{b}
Lower	0.67^{bc}	74.39^{c}	5.9^{ab}
LSD (0.05)	0.08	2.9	0.3
CV (%)	2.86	2.70	0.7

Means within a column followed by the same letter are not significantly different at $P \leq 0.001$; BD= Bulk density; PD = Particle density; TP = Total porosity; CV = Coefficient of variation; LSD = Least significant difference

Soil bulk density was also significantly different ($p \leq 0.001$) affected by land use types (Table 2). Accordingly highest and lowest bulk densities were recorded under cultivated land and forest lands respectively. The highest mean value (0.95) of bulk density was recorded on the cultivated land lowest bulk density (0.53) was recorded under forest land. The higher bulk density found under the cultivated land might be related to the intensive cultivation practices which temporarily loosen the tilled soil layer and in the long-term leads to compaction and this is reason for increment of bulk density. Similarly, availability of smallest organic matter content in the cultivated land soils also prone to the highest bulk density. Increment of bulk density value under both cultivated and grazing was might be compaction of surface soil due to intensive trampling of livestock. This result is in agreement the findings of (Abad et al., 2014) in who indicated that the bulk density of cultivated land was higher than that of grazing lands and forest lands.

Effects of Land Uses and Slope Gradient on Soil Chemical Properties: The soil pH was significantly ($p \leq 0.001$) affected by land use types (Table 3). The highest soil pH (6.0) value was recorded under forest whereas the lowest value of soil pH (5.2) content was recorded under cultivated land as compared to grazing lands .This might be due to the removal of basic cations from crop harvesting, through surface runoff, which created from accelerated water erosions because of depletion of protective vegetation On the other hand, low pH values of these land use types could be application of inorganic fertilizer application and severe base leaching by the high rainfall (Tessema et al., 2008). Additionally, over grazing might be responsible for leaching of basic cations that can lead to acidity of the area in grazing land use types. These results were in agreement with the reports of many research findings (Tessema et al., 2008) . These results were in agreement with the reports of many research findings (Achalu et al., 2012). According to (Jones, 2003) rate of soil pH classification, the soil pH of studied soils under different slope gradients and land use types fall between strongly acidic to moderately acidic soil.

Exchangeable acidity and Exchangeable Aluminum*:* Exchangeable acidity was significantly ($P\leq0.001$) affected by under the different land use types. The highest and lowest exchangeable acidity value obtained from cultivated land (1.305cmol (+)/kg and 0.14cmol (+)/kg) and forest land, respectively. These results show that continuous cultivation and application of in appropriate inorganic fertilizers leads to the exchangeable acidity content under the crop field. This finding was agreed with (Fite et al., 2007) that, the value of exchangeable acidity was significantly different ($p \leq 0.05$) among slope gradients (Table 3).

When compared to forest and grazing lands relatively lower values of exchangeable acidity was recorded for areas from both upper and lower slopping of the cultivated lands. In general the highest exchangeable acidity recorded in cultivated land was mainly due to continuous cultivation and removal of basic cations by crop uptake. This indicated that, there might be excess free Al^{3+} is available in the soil solution of the cultivated lands than the remaining land use types. This is supported by (Chimdi et al., 2013) who considered that Al^{3+} increases in concentration in soil solution below pH value of 5.5. However, soil exchangeable Al was not significantly (P≥0.05) affected by forest and grazing lands as compared to cultivated land.

Table 3: Main effect of land uses and slope gradients on Exchangeable acidity and Aluminum

Treatments	Exchangeable Acidity	Exchangeable Al	pH(H_2O)
Land uses Types			
Cultivated	1.3^a	1.2^a	5.2^c
Grazing	0.49^b	0.49^b	5.4^b
Forest	0.14^b	0.06^c	6.0^a
LSD (0.05)	0.20	0.42	0.03
Slope Gradient			
Upper	0.73^a	1.25^a	5.3^a
Middle	0.71^a	0.44^b	5.5^b
Lower	0.51^b	0.15^b	5.6^c
LSD (0.05)	0.20	0.42	0.03
CV (%)	22.75	25.05	4.2

Means within a column followed by the same letter are not significantly different at P ≤ 0.001; CV = Coefficient of variation; LSD = Least significant difference

Soil organic matter, Total nitrogen and C: N Ratio: The mean soil OM was significantly different (p ≤ 0.001) among gradients (Table 4). The higher OM content (4.4 %) was found in soils of lower slopping areas whereas; the lower OM content (3.41%) was recorded in soils of lower sloping areas (Table 4). This result is in agreement with the work of (Mulugeta & Kibebew, 2016) reported that the variation could be related to the effect of slope gradient on soil moisture storage capacity and biomass production. Soil organic matter (SOM) content was also significantly (P≤0.001) affected by in land use types. Highest (4.4) and lowest (3.31) mean value of soil OM was recorded under forest land and cultivated land respectively. Soil organic matter content has directly related to soil acidity. This due to intensive cultivation and total removal of basic cations had significantly depleted soil OM that led to soil acidity problem. Due to this minimizing continuous cultivation hastens microbial break down of soil organic matter through respiration and improves aeration. This shows that in the study area intensive tillage and removal of crop residues had highly depleted soil OM that led to soil acidity problem. The high concentration of organic matter under the natural forest land could be due to accumulation of organic matter because of soil disturbance little as compared to the cultivated and grazing lands. Both preferential flow along trees roots and accumulation of absorbent humus on the soil surface increases water infiltration, this highly reducing the velocity, volume, erosive and leaching capacity of surface runoff (Jiang et al., 1996). In contrast, distribution of livestock practices in grazing land use types and continuous cultivation without fallow in cultivated land use types was responsible for soil acidity problem. In general, poor integrated soil nutrient management in cultivated land and livestock in grazing land prone to poor organic matter content. This result was in agreement with (Tessema, 2008) and (Achalu et al., 2012) who stated that when amount of biomass return less in the same way content of OM is less in the cultivated and grazing lands.

The C: N ratio was significantly higher ($P \leq 0.05$) affected by all land use types. Higher C: N (11.1) value was recorded in forest land and lowest C: N (9.1) value was recorded in cultivated land. The narrow C: N ratio in cultivated land might be due to low fresh organic materials incorporated into the soil. This result is in agreement with the finding of (Chimdi, 2014)) who reported that the narrow C: N ratio in soil of cultivated land was attributed to higher microbial activity and more CO_2 evolution. It was also agreed with findings of (Yihenew, 2002) found that the higher C: N in natural forest than the adjacent, grazing and cultivated lands. The mean value of total N was significantly ($p \leq 0.05$) affected by slope gradient (Table 4). The higher total N content was recorded under lower slopping area (0.24%) while, lower value was recorded upper slopping area (1.98%) (Table 4).The present finding is concur with (Mulugeta & Kibebew, 2016) revealed that total N an increasing trend from high to lower slope gradients, which might be due to their downward movement with runoff water from higher slope gradient and accumulation there at the lower slope gradients. The total nitrogen (TN) content was significantly ($P \leq 0.05$) affected by all use types. Highest (0.23) and lowest (0.15) mean value of TN were recorded under forest and cultivated land respectively. This might be due to due to low amount of organic matter applied to the soils and complete removal of biomass from the cultivated field. The present findings concur with that of (Yihenew, 2002). Decline in organic matter content is direct relation TN. The low TN value in the grazing land could be over grazing of livestock trampling. The other reason could be continuous cropping without replacement of nutrients. The low carbon input from the agriculture subsistence agricultural system could not compensate for the large mineralization of organic matter on the farm fields and N-losses.

Available phosphorus: The available P contents of the soils were also significantly ($p \leq 0.001$) affected by land use types (Table 4). The highest available phosphorus was recorded (5.64 ppm) under forest land and lower available P was recorded (3.2ppm) under grazing lands. The results the present study are in agreement with that of Ahmed (2002) who observed that the lowest concentration of available P was found under the grazing land while the higher was found under cultivated lands. Higher available phosphorus in the cultivated land might be due to the continuous application of P containing fertilizers.

The result of analysis of variance revealed that available P was significantly ($p \leq 0.01$) affected by slope gradients (Table 4**).** The current study indicates that available P increased with the decreasing slope gradients. The highest value of available P was recorded (4.61 ppm) under lower slope gradients and the lowest value of available P was recorded (3.93ppm) under upper slope gradients. The variation of available P content among the slope gradients is paralleled with that of OM content. However, (Nega & Heluf, 2013) conclude that available P content of tropical soils did not necessarily decrease with decrease OM.

Table 4: Main effect of land uses and Slope gradient on Soil chemical properties

Treatments				
	SOM (%)	C:N	TN (%)	AP
Land uses Types				
Cultivated	3.31^{b}	9.1^{ba}	0.22^{b}	4.2^{b}
Grazing	3.6^{b}	10.1^{c}	0.21^{a}	3.2^{c}
Natural Forest	4.4^{a}	11^{a}	0.23^{c}	5.6^{a}
Slope gradient				
Upper	3.48^{b}	10.42^{b}	0.19^{b}	3.93^{b}
Middle	3.41^{a}	b11.2^{b}	0.18^{ab}	4.5^{ab}
Lower	4.4^{c}	12.1^{a}	0.22^{a}	4.61^{b}
LSD (0.05)	0.36	0.2	0.06	0.508
CV (0.05%)	9.5	9.1	18.32	11.66

Means within a column followed by the same letter are not significantly different at $P \leq 0.001$.AP= Available phosphorus; TN = Total nitrogen; OM = Organic matter**.**

Soil acidity and related soil properties under different land uses**:** There is a strong relationship between soil acidity and other soil properties from soils of different land uses. The correlation analysis indicates that soil pH is strongly significant ($p<0.001$) and positively correlated with total CEC(r=0.49**) and percent base saturation(r=0.41**) but negatively correlated with exchangeable acidity (r=-0.59***).This result was in agreement with the finding of (Yihenew, 2002), who observed that pH is highly significant ($p<0.001$) and positively correlated with exchangeable bases whereas high significant and negatively correlated with exchangeable acidity. Correspondingly, available P was highly significant ($p<0.001$) and negatively correlated with level of exchangeable acidity (r=-0.83***) and it is strongly ($p<0.01$) and positively (r=0.78***) correlated with soil pH. Because, the availability of P is strongly influenced by soil pH(Chimdi, 2014). In general the result of the correlation analysis showed that exchangeable acidity have strong correlation with pH, CEC, and AP, but there was weak correlation with TN and OM contents of the soils in the study areas. Exchangeable Mg^{2+} was significantly ($p<0.001$) affected by land use types. Highest (7.7 cmol (+)/kg) and lowest (5.2 cmol (+)/kg) mean value of exchangeable Mg^{2+} was observed in forest and cultivated, respectively. The exchangeable Mg $^{2+}$ was strongly and positively correlated with pH (0.61***) and negatively (-0.66***) correlated with exchangeable acidity. Calcium (Ca) was significantly ($P\leq0.001$) affected by all land use types. Highest (14.9 mg kg^{-1}) and lowest (12.29 mg kg^{-1}) were recorded in forest and cultivated land respectively. It was significantly ($p\leq0.001$) affected by all land use types. The result revealed that exchangeable Na^{+} had direct relation with pH of the soil in the study area. The highest exchangeable K^{+} was recorded from the surface top soil of the forest land as compared to the cultivated and the grazing lands in exchangeable K^{+} was high as compared to adjacent land use types. This finding is in agreement with the reports of Yihenew et al. (2008).

The decreasing trend of exchangeable K^{+}, Ca^{2+} and Mg^{2+} concentration in the cultivated and grazing land use types could be due to the leaching effect. Moreover, soil erosion, overgrazing and crop harvest removal for the past decades contributed for the depletion of K^{+}, Ca^{2+} and Mg^{2+} in the cultivated and grazing lands. This is in agreement with the findings of different researchers who showed continuous cultivation and use of acid forming inorganic fertilizers depleted exchangeable Ca^{2+} and Mg^{2+} (Mesifin, 2007), (Tessema et al., 2008) (Chimdi, 2014). In general to decrease soil acidity problem and increase exchangeable base it is recommended to apply compost, lime, organic wastes, and farmyard manure and practicing plantation of forests, involve water and soil conservation practice and avoid livestock trampling on the boarder of cultivated as well as grazing lands. The highest exchangeable K^{+} was recorded from the surface top soil of the forest land as compared to the cultivated and the grazing lands. The highest (4.07 mg kg^{-1}) and lowest (2.3 mg $kg^{-1)}$ the K was recorded at the grazing land and forest land, respectively

Table 5. Main effect of land use types and slope gradients on soil chemical properties

	Exchangeable bases (mg kg^{-1})					
Treatments	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	CEC	PBS (%)
Land use type						
Cultivated	12.29^{c}	5.24^{c}	2.3^{c}	1.22^{c}	28.0^{c}	75.07^{c}
Grazing	13.52^{b}	6.41^{b}	3.05	1.5^{b}	32.2^{b}	78.74^{b}
Natural Forest	14.95^{a}	7.77^{a}	4.06^{a}	2.61^{a}	34.8^{a}	83.4^{b}
Slope gradient						
Upper	12.74^{b}	6.03^{bb}	2.97^{b}	1.6^{a}	32.9^{a}	71.68^{b}
Middle	14.37^{a}	6.7^{a}	2.94^{bb}	1.96^{b}	30.35^{b}	85.6^{ab}
Lower	13.64^{a}	6.53^{ab}	3.5^{a}	1.76^{c}	32.85^{ab}	80.03^{c}
LSD (0.05)	0.77	0.66	0.401	0.52	2.05	2.11
CV (%)	0 .7	10.37	12.77	18.5	6.41	10.41

Means within a column followed by the same letter are not significantly different at P ≤ 0.001;CEC= cation exchange capacity; PBS=Percent Base saturation.

Soil Cation exchange capacity (CEC) was significantly (P ≤ 0.001) affected by land use types. Higher (33.63%) and lower (30.46%) CEC were recorded under forest land and cultivated land, respectively. The lower soil CEC values in the cultivated land could be due to the low clay and OM contents. Cation exchange capacity showed strong positive correlation (r = 0.49**, 0.41**) with pH and OM, respectively (Table 6). This result agrees with (Achalu et al., 2012) who reported the highest CEC value in forest land and lowest under cultivated land. Reports also indicated that high CEC in forest land direct relation to OC content (Pal et al., 2013). Based on CEC ratings developed by (Hazelton & Murphy, 2007) the CEC of the soils was rated as moderate under all land use types. The PBS was significantly higher (P ≤ 0.05) under forest land than the remaining land use types. This might be due to the relatively high OM content and less leaching losses of basic cations from the forest land compared to cultivated and grazing lands. The present study was supported by the research work done by (Achalu et al., 2012; Ermias et al., 2016). The highest amount of PBS in the natural forest could also be because of the amount and nature of the clay particles and lower acidity status. The cultivated land of the study area was lowest in PBS due to intensive removal of crop residue from the agricultural field.

Table 6. Simple linear correlation coefficient on soil acidity assessment under different land use and soil nutrient properties measured with each other.

	BD	AP	TP	pH	TN	OM	PBS	CEC	Ca	Mg	K	Na	Ex.Acid	Ex.Al	Sand	Silt	Clay
BD	1	-0.8***	-1.0***	-0.6***	-0.57	-0.44*	-0.44*	-0.52**	-0.77**	-0.7***	-0.7***	-0.55**	0.74***	0.109	-0.41*	0.15-	0.33*
Av.P		1	.86***	.78***	0.20	0.54**	0.40*	0.57**	.76***	0.77***	0.82***	0.69**	-0.83***	-0.006	0.37*	-0.09*	-0.22*
TP			1	0.65**		0.05	0.44*	0.02**	.77***	0.7***	.55***	0.41**	-0.74***	-.0.000	0.41*	0.01	-0.33
pH				1	0-.48***	0.44*	0.41*	0.49**	0.56**	0.61***	0.84***	.67***	-0.59***	-0.09	0.18	0.09	-0.2
TN					1	0.49	0.12*	0.02*	-0.001	0.098*	0.35***	0.19*	-0.028	-0.022	0.03	0.07	-0.79
OM						1	0.37*	0.42*	0.36	0.47	0.7	0.4	-0.32	0.22	-0.008	-0.12	0.09
PBS							1	-0.26*	0.45	0.54	0.41	0.38	-0.29	0.11	0.24	0.11	-0.26
CEC								1	0.41*	0.49***	0.51**	0.37*	-0.61***	0.202	0.25	0.02	-0.21
Ca									1	0.78***	0.61**	0.66*	-0.66***	0.2	0.28	-0.09	-0.15
Mg										1	0.65***	.69***	-0.70***	0.09	0.32	0.04	-0.28
K											1	.63***	-0.70***	0.01	0.35	-011	-0.19
Na												1	-0.61***	0.052	0.13	0.041	-0.13
Ex.acid													1	0.026	-0.39	0.05	0.27
Ex_Al														1	-0.11	-0.35	0.34
Sand															1	0.11	-0.7***
Silt																1	-0.6***
Clay																	1

*** = Significant at $P \leq 0.05$; ** = Significant at $P \leq 0.01$; *** = Significant at $P \leq 0.001$; BD = Bulk density; OM = Organic matter; TN= total Nitrogen,Ex.Al =exchangeable Aluminum, AP= available phosphorus,**

PBS= percent base saturation

CONCLUSIONS

The result reveals that particle size distributions were significantly affected by land use types and slope gradients. Clay content was highest in cultivated land and lowest in forest land and highest in lower slope gradients. Sand content was highest in grazing land , lower in cultivated land and highest on upper slope .Exchangeable bases were significantly ($P \leq 0.05$)affected by all land use types and slope gradients. Exchangeable bases were highest in forest land when compared with cultivated land and grazing lands and highest on lower slope (Table 5). The higher CEC values in the forest land might be due to the high OM. CEC was strong positive correlation (r = 0.42*, 0.49**) with OM and pH, respectively (Table 1.6). Reports also indicated that high CEC in forest land was Associated with OC content (Pal et al., 2013).This might be due to the relatively high OM content and less leaching losses of basic cations of the forest land compared to cultivated and grazing lands. Available phosphorous was highly significant ($p<0.001$) and negatively correlated with level of exchangeable acidity (r=-0.83***) and it is strongly ($p<0.01$) and positively (r=0.78***) correlated with soil pH (H_2O). The Availability of P was strongly influenced by soil pH. In study area there is series soil acidity problem in cultivated and grazing lands as compared with forest land. This may be due to intensive cultivation, continuous use of inorganic fertilizers, leaching of basic cations by crop harvesting, over grazing. Therefore, the study focused that soil acidity is a critical problem in study area and recommend all responsible bodies' to intervene and manage the soil acidity problem in the study areas.

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