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Assessment of physicochemical properties of acidic soils of western wollega Zone, Oromia region, Ethiopia

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Abstract

Herein, we have reported an assessment of the physicochemical properties of acidic soils from selected districts of the western Wollega Zone of Oromia Regional State. The soil samples were collected from Boji Dirmaji, Kiltu Kara, Mene Sibu, and Nedjo with the objective to assess the physicochemical properties and fertility status of selected soils. A total of four soil samples were collected randomly at a depth of 0-20 cm by using a soil sampling auger. The pH of the soil in the study area was found to be in the range of 4.35-5.06 which is classified as very strong acid to strong acid. The Electrical conductivity is 0.019-0.08 dS/m which is non-saline, organic carbon classified as low and organic matter is 0.88-1.80 % range which is very low to low. For BD and MS soil samples OM and OC were highly correlated (r = 1.00*) at 0.05 level and similar for KK and NE soil samples (r = 1.00**) at 0.01 level. Exchangeable acidity (meq/100 g) is rated as very high to low. Available Pt he of studied area (3.53-10.11 mg/kg) and it was rated as low, and medium for total P (0.33-0.55 g/kg) range. Total nitrogen (0.03-0.22 %) and is rated as very low to medium range. Extractable Fe and Mn by dithionite and oxalate were classified as high, and Fe_d and Fe_{ox} highest extraction was from Kiltu Kara (1.02 g/kg) and Kiltu Kara and Boji Dirmaji (0.27 g/kg) which are comparable and lower at Mena Sibu (0.3 and 0.12 g/kg) soil samples respectively. By the same way for Mn_d and Mn_{ox} higher extraction were from Mena Sibu (0.43 g/kg) and Nedjo (0.1 g/kg) and lower at Nedjo (0.03 g/kg) and Kiltu Kara (0.06 g/kg) soil samples respectively. Total P and Fe_d are inversely correlated (r = -0.87) for BD. Soil textures of studied areas were generally classified as sand clay loam in texture in all soil samples. Data were analyzed by SAS software to now the significance difference between each soil samples and SPSS to see correlation between soils.

Keywords: Dorper crossbred, Gubalafto, Kalu, Local sheep, Perception

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Introduction

Soils are inherently heterogeneous in nature, diverse and dynamic system (Kavian, 2012) and acts as a thin layer of earth's crust which serves as a natural medium for the growth of plants and it is the unconsolidated mineral matter influenced by genetic and environmental factors (Wodaje and Alemayehu, 2014;

Manimegalai and Sukanya, 2014). It is a natural body consisting of layers (soil horizons) of mineral constituents of variable thicknesses, which differ from the parent materials in their morphological, physical, chemical, biological properties and other constituents (Sumithra et al., 2013; Manimegalai and Sukanya, 2014). Estimating spatial variability of soil properties is important for evaluating the environment. Also Crop productivity and soil fertility are thus synonymous and they are go together. Soil tests are usually performed to measure fertility and indicate deficiencies that need to be remedied and this test can be divided into four steps (1) sampling, (2) analysis, (3) interpretation, and (4) recommendations (Suryawanshi Sampatrao, 2018). Since 1945, it is estimated that 38% of the cultivated areas in the world have been degraded. Annually, approximately 24 billion tons of topsoil is lost. This is equivalent to about 9.6 million hectares of land. Therefore, soil degradation and/or changes in soil quality that result from wind and water erosion, salinization, losses of organic matter and nutrients, or soil compaction are of great concern in every agricultural region in the world (Liu et al., 2006). When soil pH drops (pH < 5) active form of Al becomes soluble and results in reduced nutrient uptake in most heavy rain area. Inadequate crop growth on acid soils is usually a direct result of Al and Fe saturation (Acahlu, 2014). Due to this acidic nature, most of the soils of the highlands of Ethiopia are deficient in inherent available phosphorus content and P is not easily available for plant growth. Likewise, in most areas of Western Oromia Region, soil acidity and P fixation are the major limiting factors and serious problems to phosphorus-use efficiency (Zhou *et al*., 2018) and has detrimental influences on the growth performances of acid sensitive crop productionlikebarley (Achalu *et al*., 2012 b). The physicochemical studyof paramete rs is important to agricultural chemists for plants growth, for estimating the level of soil nutrient and soil management. Because, in acidic soils, plant growth is often limited by Al and Fe toxicity and this is characterized by marked reduction in shoot and particularly roots growth by preventing the plants from using available soil P and other nutrients effectively and moreover, nutrients deteriorated land, like the cultivated land may indicate risk to the sustainable crop production and soil fertility (Curtin and Syres, 2001; Achalu *et al*., 2012a). Soil acidity due to high aluminum toxicity is a common problem that has major ramifications for plant growth such as barley, wheat and causes significant losses in production, especially in the high rainfall areas of western Oromia. Therefore, evaluating the fertility status of a soil is important to know the productivity of a soil as soil fertility is one of the parameters of soil productivity. Now a day, in Ethiopia the problem of soil acidity caused by Al and Fe saturation in the high rainfall area like West Wollega has become a national issue or main problem. Besides, to the best of our knowledge there is no related work on the problem of soil acidity of soil districts of West Wollega Zone was not yet studied and rated in sufficient detail.

Therefore, to fill the gap the present study explored the severity of soil acidity farmer lands and its extents as well as rating of the soil acidity of the selected districts of West Wollega Zone (Boji Dirmaji, Kiltu Kara, Mene Sibu and Nedjo Soil) were studied.soselected physicochemical prope rties like pH, electrical conductivity (EC), organic carbon (OC), organic matter (OM),total nitrogen (TN*)* B_d = bulky density, cation exchange capacity (CEC), exchangeable acidity (Ex.A), exchangeable alumni (Ex.Al), exchangeable hydrogen ($Ex.H^+$), available of phosphorus*(*P_{av}), total phosphorus (P_T), iron extracted by dithionite (Fe_d), manganese extracted by dithionite (Mn_d), iron extracted by oxalate (Fe_{ox}) and manganese extracted by oxalate (Mn_{ox}) were analyzed.

Materials and Methods

Experimental Site

Analyses of different physicochemical properties of the selected soil samples were performed at Debre Berhan University Chemistry Department laboratory and Soil laboratory.

Description of Study Area

Acidic soil samples were collected from West Wollega Zone, Oromia Region, Ethiopia located at about 477 - 575 km west of Addis Ababa with a geographical location of 09^o 51' 28" - 09^o 25' 33" N latitude and 35^o 36' 28" - 35^o 02' 13" E longitude with an elevation between 1845 and 1930 meters. The location map of the sampling sites is presented in Figure 1.

The altitude, the mean annual rainfall, the minimum and maximum temperature of these areas range from 1300 to 1800 masl, 1000 to 2400 $mmyr^{-1}$ and 12.5 to 29 ^oC, respectively (Achalu *et al*., 2012b). The soil samples were collected from four districts of western wollega zone, Boji Dirmaji (BD), Kiltu Kara (KK), Mene Sibu (MS) and Nedjo (NE) which are acidic in nature (Abdenna, 2013). Soil samples were collected during January 2018. The soil was randomly collected from farmers‟ crop fields. Four (4) sub-samples were collected from each sampling sites to make one composite samples. According to FAO (1990) soil classification system, the soil class of the study zone was Nitisol and reddish in colour. This soil contains about 12.5% of Ethiopian soil. Nitisols are inherently fertile, but large areas in Ethiopia have now been depleted due to continuous cultivation, leaching and erosion.

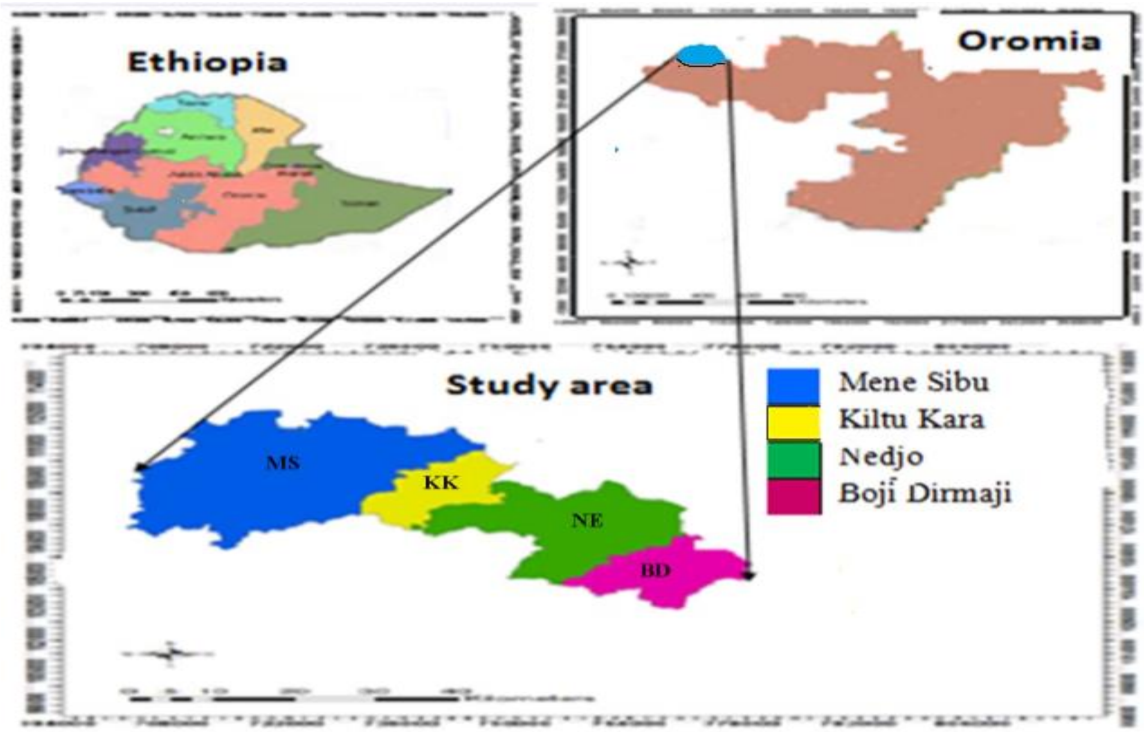

Figure 1. Map of the study area and soil sampling sites.

The major crops grown in the study zone include cereals (Maize, Teff, Millet, Sorghum, Coffee and Barley), pulses (Faba bean and Field peas) and oil crops (Niger seed, Rapeseed and Sesame). Surface soil samples (0-20 cm depth) were randomly collected from each sampling site in each district in January 2018 by using stainless steel augur (Poggio *et al.*, 2008). The randomly collected soil samples were thoroughly mixed to form one composite sample for each site and a total of three composite soil samples were collected for each sites and packed in plastic bags and labelled with labelling tags and transported to Debre Berhan University for laboratory analysis. Then the soil samples were air dried at room temperature (25 $^oC \pm 2\ ^oC$) for 7 days, ground and passed through a 2 mm sieve. The soil physico-chemical parameters (pH_{H2O}, pH_{KCl}, electrical conductivity, organic carbon, organic matter, total nitrogen, exchangeable acidity, exchangeable Al, exchangeable hydrogen, available phosphorus, total phosphorus, cation exchange capacity, bulk density, extractable Fe_d, Mn_d, Fe_{ox} and Mn_{ox}) and soil texture were analyzed.

Apparatus, Instruments and Chemicals

The apparatus and Instruments used in the present studies includes; Erlenmeyer flasks, different sizes of beakers, burettes, funnels, graduated cylinders, volumetric flasks, capped test tubes, droppers, watch glass, pipettes, spatula, measuring cylinder, pH meter (MP 220 JENWAY, Japan), Uv-Visible spectrophotometry (Uv-professional), and Orbital shaker (S01 Stuart, UK), Flame atomic absorption spectrophotometer ((Model 210/211 VGP, UK) and Micro Kjeldahl distillation unit and Kjaldahl digestion stand, Conductometry (model CO155), Centrifuge (Centurion scientific, UK), Refrigerator and Hydrometer

Chemicals and reagents, Potassium dihydrogen phosphate (KH_2PO_4) (99-101% High-tech healthcare, India), Sodium bicarbonate ($NaHCO_3$) (99.5-101% FINKEM) Potassium chloride (KCl, 99.0% loba, India), Ammonium fluoride (NH_4F, 99.5%, Switzerland), Hydrogen peroxide (H_2O_2, 30% Central drug house LTD, New Delhi, India), Potassium dichromate ($K_2Cr_2O_7$,99.9% BDH chemicals LTD Poole England), Sulfuric acid (H_2SO_4, 98%, loba, India), Potassium sulphate (K_2SO_4, 99.0% loba , India), Boric acid (H_3BO_3, 99.8% BDH chemicals Ltd, England), Buffer pH (4,7 and 9) (Blulux Ltd England). Nitric acid (HNO_3) (69% LR, Breck land Scientific Supplies, U. K), Copper sulfate ($CuSO_4$, 99% Loba Merk , India), Selenium powder (Se, 99.7%, Germany), Ferrous sulfate heptahydrate ($FeSO_4.7H_2O$) (97% BDH chemicals Ltd England), Potassium antimony tartarate ($KSbC_4H_4O_7$ (98.5% BDH chemicals Ltd, England),Ethanol (C_2H_5OH) (97% Fine chemical general trading, Ethiopia).Ammonium molybdate tetra hydrate ($Mo_7O_{24}.6(NH_4).4(H_2O)$)(81- 83 % Riedel DeHaen AG), Ascorbic acid, ($C_6H_8O_6$) (99% Blux laboratory reagents), Sodium carbonate (Na_2CO_3, Blulux Lab, India), Sodium hexametaphosphate ($Na(PO_3)_6$ (Fine CHEM industries, India), Ammonium oxalate ($(NH_4)_2C_2O_4$. H_2O, 98% BDH chemicals Ltd Poole, England), Oxalic acid solution ($H_2C_2O_4.2H_2O$) (99%, Switzerland), Sodium hydrosulfite (dithionite) ($Na_2S_2O_4$) (Fisher scientific company, USA), Sodium citrate ($Na_3C_6H_5O_7{\cdot}2H_2O$) (BLULUX laboratories (P) Ltd, India). Hydrochloric acid (HCl, 36-37%, BDH chemicals Ltd, England) and Sodium hydroxide (NaOH, 97.5% BDH chemicals Ltd, England), Bromo crosel green (BDH chemicals Ltd Poole, England) and methyl red (BDH chemicals Ltd, England) were the chemicals and reagents used. All chemicals and reagents were analytical grade and they were used without further purification.

Physicochemical Properties of Soil Samples

Soil pH in water and KCl of the samples were determined by dispersing 20 g of dried soil in 50 mL of water and 50 mL of 1 M KCl separately. After 2 h of end-over-end shaking at 20 rpm, the pH of soil suspension was determined (Freese *et al.*, 1995). *Electrical Conductivity*

Soil to water suspension with 1:5 ratios was prepared by mixing 10 g air-dried soil (<2 mm) with 50 mL of deionised water in a beaker. The conductivity meter was calibrated according to the manufacturer's instructions using the KCl (Achalu *et al.*, 2014).

Soil Texture was determined by the hydrometer method after destroying organic matter and dispersing the soil (Bouyoucos, 1962). A 50 g of soil sample was measured and added to 200 mL of beaker. Then 100 mL of calgon or dispersing solution was added. The solution was stirred for 5 minutes, transferred to 1000 mL graduate cylinder and rinsed by distilled water and mixed. First with 40 second measured and later with interval of 2 h soil samples were measured and the percent of each soil texture were calculated. Finally soil texture class was determined according to USDA (2014) international equilateral triangles model. *Bulk density* was determined gravimetrically after oven drying soil sample for 24 h at 105 ^oC (Day, 1965). It was expressed as gram of soil per unit volume. *Soil Organic Carbon* was determined by oxidation with 1 N $K_2Cr_2O_7$ (Walkley and Black, 1934; Gemechu *et al.*, 2015). A weighed amount (1 g) of the dried, grounded soil samples were treated with 10 mL of 1 N potassium dichromate solution ($K_2Cr_2O_7$) followed by addition of 20 mL of concentrated sulfuric acid. The mixture was gently swirled and left at room temperature in a fume hood for 25 minute.

$$2Cr_2O_7^{2-} + 3C + 16H^+ \rightarrow 4Cr^{3+} + 8H_2O + 3CO_2\uparrow$$

The excess dichromate was back titrated potentiometrically with the standard 0.2 N ferrous sulfate solution in which diphenyl used as indicator. Blank titration of the acidic dichromate with ferrous ammonium sulfate solution was performed at the beginning of the batch analysis using the same procedure with no soil addition.

$$\text{Organic carbon (\%)} = \frac{(B-S) \text{ x N of } Fe^{+2} \text{ X } 12}{\text{gram of soil x } 4000} \text{ x } 100 \quad (1)$$

Where B is the volume of ferrous solution used in the blank titration, S is the volume of ferrous solution used in the sample titration; 12/4000 is milliequivalent weight of carbon in grams. No correction factor was applied to the OC co ntent calculation. *Soil organic matter* was determined by multiplying percent soil organic carbon by a factor of 1.724 following the assumptions that organic matter is composed of 58% carbon.

Soil total nitrogen was determined by the Kjeldahl method using micro Kjeldahl distillation unit and Kjaldahl digestion stand (Jackson, 1958; Taddesse *et al*., 2008a; Ochwoh *et al*., 2016). Weighted amount 1 g, of each soil samples were measured and added to Kjeldahl distillation and at a time one blank was prepared for each soil sample to be analyzed. On the above steps, one spoon of K_2SO_4, $CuSO_4$ and selenium powder and 7 mL of concentrated H_2SO_4 acid were added to each soil samples and digested in fume hood for 2 h. Then the samples attached to the distiller containing sodium hydroxide and the product collected in conical flask. A 20 mL of 2% H_3BO_3, bromocresol green and methyl red indicator were added to the solution. Determined blank on reagents using same quantity of standard acid in a receiving conical flask. Finally the obtained product was titrated with 0.1 N H_2SO_4 until the green color changes to pink and the total nitrogen determined according to equation 2.

$$\%N = \frac{(a-b)}{s} \text{x N x } 0.014 \text{ x } 100 \text{ x mcf} \quad (2)$$

a = mL of H_2SO_4 required for titration of sample. b = mL of H_2SO_4 required for titration of blank, N = Normality of H_2SO_4

0.014 = Meq. Weight of nitrogen in g mcf = moisture correction factor s = weight of dry soil sample

Exchangeable Acidity (Ex Al + Ex H^+) was determined by saturating (10 g) of the soil samples with 100 mL of 1 M standard potassium chloride solution. Then 25 mL of aliquot was taken and titrated with sodium hydroxide (0.02 M NaOH). On above step few drop of 0.02 M HCl and 10 mL of NH_4F added until solution become colorless. From the same extract, exchangeable Al in the soil sample was determined titrating with a standard solution of hydrochloric acid (0.02 M HCl). Finally, exchangeable H^+ was obtained by subtracting exchangeable Al fromexchangeableacidity (Gemechu *et al*., 2015).

Cation Exchange Capacity was determined by taking 5 g of soil sample and added to the beaker and washed with 100 mL of ammonium acetate (1 M NH_4OAc) four times (pH 7) as described in Thomas (1982) which extract cations (Fe^{3+}, Al^{3+}, Ca^{2+}, Mg^{2+}, Na^+, K^+). Then soil sample was washed with 75 mL of ethanol to remove excess NH_4OAc. Then after, the sample was leached with 25 mL 10% NaCl solution four times in 100 mL volumetric flask and filled up to the mark with NaCl. Then it was titrated with 0.1 N NaOH and CEC of soil sample calculated.

Available P of the soil sample was determined using Bray and Kurtz (1945) extraction by (Bray II) method (0.03 M NH_4F + 0.1 M HCl) and quantified using spectrophotometry (at wave length of 882 nm) colorimetrically. Weighted amount (2 g) of soil sample was added to flask and 20 mL of bray II extracting solution was added. The soil sample was shaken for 10 minute and filtered by whatmann filter paper of No 42. Then 2 mL of filtrate was mixed with 2 mL of mixed reagent and P analyzed colorimetrically at 882 nm. *Total soil P* (TP) was determined on sub samples of 0.5 g soil with the addition of 5 mL concentrated H_2SO_4 and heating to 360 ^oC on a digestion block with subsequent stepwise (0.5 mL) additions of H_2O_2 until the solution become clear (Thomas *et al*., 1967; Taddesse *et al*., 2008a) and the absorbance was measured by spectrophotometry at wave length of 882 nm.

Phosphate Bounded Fe and Mn

The phosphate bounded Fe and Mn in the soil samples were determined by dithionite–citrate and acid ammonium oxalate methods (Mehra and Jackson, 1960). Ammonium oxalate extractable Fe and Mn were determined by shaking 0.5 g of soil with 20 mL of ammonium oxalate extracting solution in the dark in 250 mL of polyethylene bottle for 4 h and then filtered using whatman No. 42 filter paper and ammonium oxalate extractable Fe and Mn were determined by FAAS and (Jackson *et al*., 1986; Olayinka *et al*., 2015). Dithionite-Citrate Fe and Mn were determined using soil conservation method (Soil Survey Staff, 2006). A 0.5 g of soil sample was grounded and pass through 2 mm sieve was weighed and added into a 15 mL plastic centrifuge tube. A 5 mL of the sodium citrate ($Na_3C_6H_5O_7 \cdot 2H_2O$) (0.68 M) solution and 0.2 g of dithionite (sodium hydrosulphite, $Na_2S_2O_4$) were added to soil samples. After that the mixture was mixed well with a stirring rod and the tubes were placed into a water bath at 80 ^oC and stirred every 2-3 minutes throughout a 15 minute extraction period. After the tubes were removed from the bath, 1 mL of saturated NaCl solution was added and mixed. Then centrifuge tubes were covered tightly and centrifuged for 5 minutes at 1500-1600 rpm. The centrifuge was poured off into a 100 mL volumetric flask. The supernatant was filtered and Fe and Mn in the soil samples were determined by flame atomic absorption spectrophotometry (FAAS).

Statistical analysis

The separations of significant differences between each soil samples were made by one way analysis of variance (ANOVA) using SAS (Statistical Analysis System, 2004) at each sites (using paired t test and summing the numbers that were significant or not at $P < 0.05$). Pearson's correlation coefficient was executed using Statistical Package for Social Science (SPSS version 9.1). Different rates of classification of soil samples were made by comparing with different researcher to classify soil samples of the studied areas.

Results and discussion

Physicochemical properties of the soil samples

Soil Texture and Bulk Density

The relative percentage of soil separates (sand, silt and clay) of a given soil is referred to as soil texture. Soil samples from the studying districts comprised percent of Sand (58.0, 65.96, 65.91 and 70.97) Silt (15.0, 6.97, 12.02 and 8.0) and Clay (27.0, 27.01, 21.99 and 20.97) for Boji Dirmaji, Kiltu Kara, Mene Sibu and Nedjo sampling locations, respectively. The common textural classes, as recognized by USDA (2014) are given in equilateral triangles or international equilateral triangles model. Accordingly, the studied districts soil texture can be classified as sandy clay loam. Crops could grow well in such soils areas and it has a potentially well-balanced capacity to retain water, form a stable structure and provide adequate aeration (Mulugeta, 2015).

The Bulk density value was significantly different for each soil samples ($\alpha = 0.05$), However, numerically the highest mean (1.33 g/cm^3) value of bulk density was recorded at the Kiltu Kara and the lowest mean (1.14 g/cm^3) value under the Boji Dirmaji soil (Figure 2). Generally all soil samples had low bulk density except Kiltu Kara which had moderate bulk density (Table 1). Bulk density value of about 1.33 g/cm^3 was generally considered optimum for plant growth (Ashenafi and Bobe, 2016).

Soil pH

Soil pH is among the important environmental factors, which can influence plant growth. In this study, both pH (H_2O) and pH (KCl) of the soil were analyzed at (α = 0.05) and even though the pH variation is not so large, there was significance difference between each soil samples (Table 1).

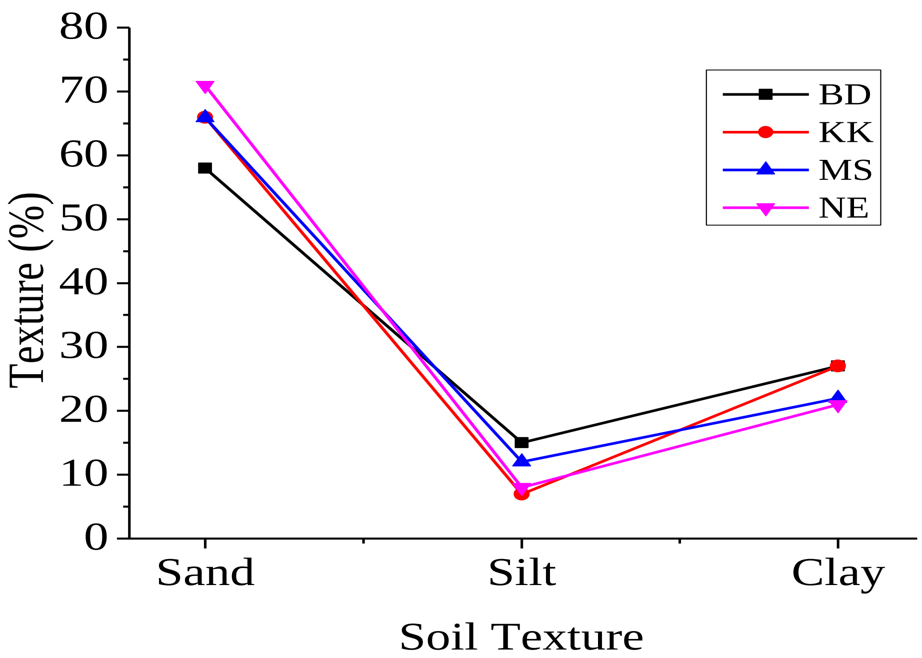

Figure 2. Graph represents Soil Texture of studied area where BD= Boji Dirmaji Soil, KK= Kiltu Kara Soil, MS =Mene Sibu Soil, NE = Nedjo Soil

Accordingly, soil collected from Boji Dirmaji with pH (4.35) can be categorized as very strongly acidic and soil collected from Nedjo with pH (5.06) could be categorized as strongly acidic (Tekalign, 1991; Hazelton and Murphy, 2007; Abdenna, 2013) (Table 1). According to Abreha *et al*. (2012) decreasing of the soil pH (increasing acidity) in western and southern Ethiopia was due to intensive rainfalls that can leaches soluble nutrients such as calcium and magnesium and with subsequent replacement by Al^{3+} and H^{+} ions. A pH value of less than 5.5 is considered as a problematic for most microbial activities, and this directly influences availability of nutrients to plant (Solomon, 2008).

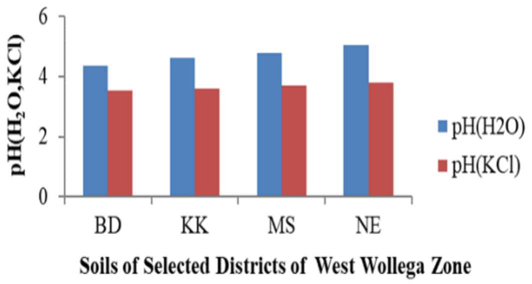

Figure 3. Soil pH values using (H_2O and KCl) of the selected districts of West Wollega Zone BD= Boji Dirmaji Soil, KK= Kiltu Kara Soil, MS =Mene Sibu Soil, NE = Nedjo Soil

The pH (KCl) test is the more accurate of the two pH tests, as it reflects what the plant experiences in the soil. The values of pH (KCl) have similar trend with pH (H_2O): BD < KK< MS< NE but lower than pH (H_2O) by about one (1) unit (Table 1 and Figure 3). A useful, but not consistently accurate, conversion is to subtract 1 unit from the pH (H_2O) to obtain a pH (KCl) value because it may be less or more than the range depend on the soil type (Gavriloaiei, 2012; Gemechu *et al.*, 2015). As addition the pH measured in chloride solution is lower than pH measured in water because of the larger amount of H^+ ion forced to soil solution when Al^{3+} or Fe^{3+} are replaced by K^+ on the exchange sites (Asmare et al. 2015). The main advantage of the measurement of soil pH in salt solution is the tendency to eliminate interference from suspension effects and from variable salt contents, such as fertilizer residues (George *et al.*, 2013). Most plants and soil organisms prefer pH range between 6.0 and 7.5 (Hazelton and Murphy, 2007).

Electrical Conductivity

Electrical conductivity (EC) is a measure of soil salinity. The ability of soil solutions to conduct electricity (i.e. conductance) depends on the concentration of the ions present and their electrical charge. Significance difference (α = 0.05) among soil samples were observed for this parameter.All of the soil samples have an electrical conductivity values ranging from 0.019 - 0.080 dS/m and lies at lower limit of saline soil (EthioSIS, 2014). Hence the soil samples are non saline soils may due to low ions in soil soution.

Soil Organic Carbon

Organic carbon (OC) was comparatively higher in Nedjo and lower in Mene Sibu. According to Tekalign (1991) ratings of organic carbon content as very low < 0.50, low 0.5 - 1.5, medium 1.5 - 3.0, and high > 3.00. Based on this category, all the studied soil samples fall in the low range despite the various amount extracted from the soils. Tekalign and Haque (1987) and Dawit *et al.* (2002) reported OC as the main source of available P, but the availability of P in most soil of Ethiopia decline by the impacts of fixation, abundant crop harvest and erosion.

When OC analyzed (α = 0.05) there is significant dif erence among the studied soils.

Table 1. Selected physicochemical properties of the acidic soil samples studied (n = 3)

Parameters		BD	KK	MS	NE	LSD (5%)
		Soil Samples				
pH (1:2.5)	H_2O	4.35 ± 0.024^{d}	4.62 ± 0.003^{c}	4.80 ± 0.003^{b}	5.06 ± 0.011^{a}	0.03
	KCl	3.54 ± 0.010^{d}	3.61 ± 0.006^{c}	3.70 ± 0.001^{b}	3.79 ± 0.006^{a}	0.01
EC (dS/m)		0.019 ± 0.101^{d}	0.08 ± 0.050^{a}	0.022 ± 0.401^{c}	0.033 ± 0.134^{b}	0.001
Ex A.		4.16 ± 0.006^{a}	3.48 ± 0.028^{b}	2.73 ± 0.002^{c}	1.69 ± 0.009^{d}	0.03
Ex Al.		3.37 ± 0.030^{a}	2.61 ± 0.005^{b}	2.62 ± 0.005^{b}	1.18 ± 0.002^{c}	0.03
Ex H^+.	meq/100g	0.79 ± 0.029^{b}	0.87 ± 0.002^{a}	0.11 ± 0.031^{d}	0.51 ± 0.008^{c}	0.04
%OC		0.95 ± 0.006^{b}	0.69 ± 0.014^{c}	0.51 ± 0.009^{d}	1.05 ± 0.011^{a}	0.02
%OM		1.64 ± 0.011^{b}	1.18 ± 0.025^{c}	0.88 ± 0.015^{d}	1.80 ± 0.019^{a}	0.03
%TN		0.18 ± 0.003^{c}	0.22 ± 0.003^{a}	0.21 ± 0.004^{b}	0.03 ± 0.001^{d}	0.01
CEC	meq/100g	24.37 ± 0.651^{c}	19.33 ± 0.640^{d}	32.40 ± 0.800^{a}	26.43 ± 1.040^{b}	1.51
P_{av}	mg/kg	3.53 ± 0.017^{d}	10.11 ± 0.047^{a}	5.62 ± 0.056^{c}	9.95 ± 0.062^{b}	0.09
P_T	g/kg	0.33 ± 0.151^{d}	0.39 ± 0.468^{c}	0.41 ± 0.695^{b}	0.55 ± 0.549^{a}	0.94
Fe_{ox}		0.27 ± 0.530^{a}	0.27 ± 0.010^{a}	0.12 ± 0.150^{c}	0.15 ± 1.000^{b}	1.07
Mn_{ox}	g/kg	0.069 ± 0.020^{c}	0.06 ± 0.001^{d}	0.07 ± 0.060^{b}	0.10 ± 0.050^{a}	0.84
Fe_d		0.83 ± 0.050^{b}	1.02 ± 0.040^{a}	0.30 ± 0.020^{d}	0.80 ± 0.050^{c}	0.08
Mn_d		0.10 ± 0.080^{b}	0.08 ± 0.040^{c}	0.43 ± 0.080^{a}	0.03 ± 0.050^{d}	0.12
B_d	g/cm^3	1.14 ± 0.003^{d}	1.33 ± 0.001^{a}	1.16 ± 0.003^{c}	1.26 ± 0.006^{b}	0.01
	% Sand	58.00 ± 0.04^{c}	65.96 ± 0.05^{b}	65.91 ± 0.18^{b}	70.97 ± 0.06^{a}	0.19
Soil Texture	% Silt	15.00 ± 0.09^{a}	6.97 ± 0.06^{d}	12.02 ± 0.08^{b}	8.00 ± 0.20^{c}	0.14
	% Clay	27.01 ± 0.30^{a}	27.00 ± 0.09^{a}	21.99 ± 0.18^{b}	20.97 ± 0.03^{c}	0.25
	Class	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	

Mean values in the rows with different letters a, b, c and d are significantly different (α = 0.05). BD= Boji Dirmaji Soil, KK= Kiltu Kara Soil, MS =Mene Sibu Soil, NE = Nedjo Soil, P_{av} = Availability of P, B_d = Bulky density, CEC = Cation exchange capacity, EC = Electrical conductivity, Ex.A =Exchangeable acidity, Ex.Al=Exchangeable alumni, Ex.H^+= Exchangeable hydrogen, OC = Organic carbon, OM = Organic matter, TN = Total nitrogen, P_T =Total phosphorus, Fe_d = Iron extracted by dithionite, Mn_d = Manganese extracted by dithionite, Fe_{ox} = Iron extracted by oxalate, Mn_{ox} = Manganese extracted by oxalate, LSD =Least significance difference (5 %), n = Number of replication.

Among studied soil samples OM of Mene Sibu soil rated as very low, while the other have low organic matter (Murphy, 1968) (Table 1) in which MS < KK< BD < NE. Organic matter has an important influence on soil physical and chemical characteristics, soil fertility status, plant nutrition and biological activity in the soil (Brady and Weil, 2002). Even though a significant difference was observed among the soil (α = 0.05) the organic matter is de ficient for plant growth and this may also come from loss of OC.

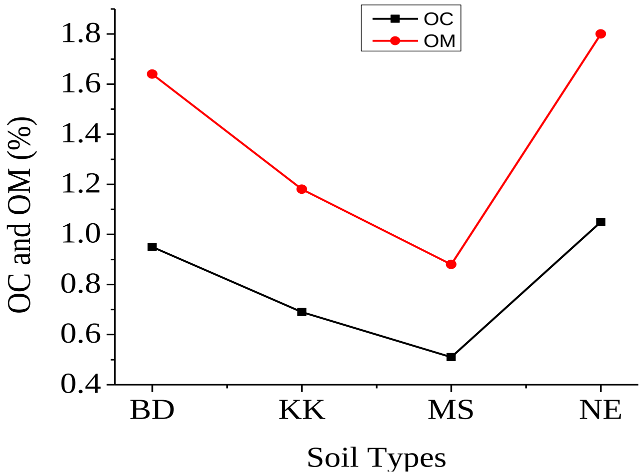

Figure 4. Percent of Organic carbon (OC) and organic matter (OM) in the soil samples where BD= Boji Dirmaji Soil, KK= Kiltu Kara Soil, MS =Mene Sibu Soil, NE = Nedjo Soil, Organic carbon (OC) and organic matter (OM)

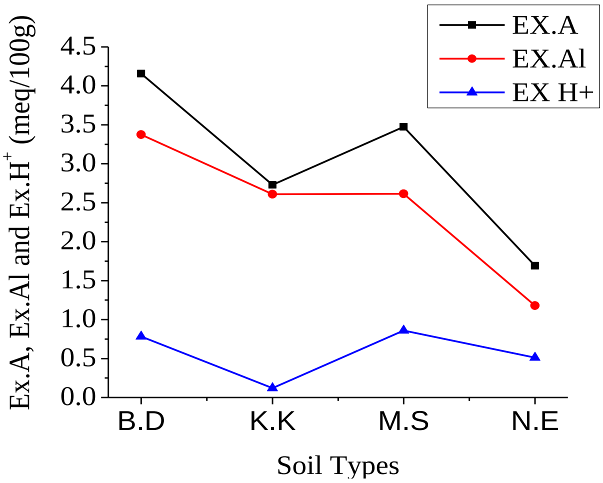

Figure 5. Soil Exchangeable acidity (Ex.A), Exchangeable alumni (Ex.Al) and Exchangeable hydrogen (Ex.H+) of studied Area where BD= Boji Dirmaji Soil, KK= Kiltu Kara Soil, MS = Mene Sibu Soil, NE = Nedjo Soil, Ex.A =Exchangeable acidity, Ex.Al=Exchangeable

Total Nitrogen

Total nitrogen contents of the soil was analyzed and there was significance difference (α = 0.05) among the soil. Among studied soil samples, total nitrogen was rated as very low at Nedjo (0.027%) and medium in other soils (Boji Dirmaji, Kiltu Kara and Mene Sibu) (Bruce and Rayment, 1982; Havlin *et al.*, 2013).

Cation Exchange Capacity

CEC of study area were rated as moderate at Boji Dirmaji and Kiltu Kara (24.36 and 19.33 meq/100g) and higher at Mene Sibu and Nedjo (32.40 and 26.43 meq/100g) soils respectively (FAO, 2006; London, 2014) (Table 1). CEC value was significantly different for each soils (α = 0.05). The variation in CEC among the soils might be due to the difference in OM content, the pH range in which the soils exist and clay mineralogy between some soil forms (Bereket *et al.*, 2018). Additionally researcher reported that soil pH and soil OC are regarded as the main factors influencing the variation in exchangeable cations (YuGe *et al.*, 2013).

Exchangeable Acidity

Exchangeable acidity is an important parameter to describe the acidity of soil, which is the combined total exchangeable aluminum and reactive hydrogen ions; according to this study, it shows soil of study areas were very acidic, in which all treatments have >2 meq/100g except Nedjo (1.691 meq/100g). The high soil exchangeable acidity in the Bodji Dirmaji (4.16 meq/100g) might be associated with occurrence of lower soil pH (Gemechu *et a l.*, 2015).

Extractable aluminum closely follows the pH of the soil and becomes a problem when the pH (water) is less than 5.5 (in soils which contain significant aluminum). When extractable aluminum > 2, sensitive plants will be affected. Higher Ex.Al (3.37 meq/g) were observed at BD soil and lower (1.18 meq/100g) at NE soil. The concentration of the H^+ in soil to cause acidity is pronounced at pH values below 4 while excess concentration of Al^{3+} is observed at pH below 5.5 (Table 1). When exchangeable acidity analyzed ($\alpha = 0.05$) and it was significantly different except Ex.Al of KK and MS which was not significantly different (Table 1).

Available and Total Phosphorus

The available P of the soil of the study areas were in general found to be low (Jones, 2003) (Table 1) and relatively lower at BD (3.53 g/kg) and comparatively higher at KK (10.11 g/kg). The low available P observed in the soil of the study area was in agreement with the results reported by Murphy (1968) and the availability of phosphorus under most soils of Ethiopia decline by the impacts of fixation, abundant crop harvest and erosion. Variations in available P content in soils are also related with the intensity of soil weathering or soil disturbance, the degree of P fixation by Fe, Al and Ca (Sanchez et al., 2003; Achalu et al., 2012a,b, Asmare et al., 2015). Some reports shows low available P status may also be related mainly to the presence of low pH and high exchangeable acidity (Pa ulos, 1996; Abreha et al., 2012) and there was signifycance difference ($\alpha = 0.05$) be tween each soil samples. The distribution of total P content followed a similar pattern to available P distributions and ranged from 331.10 to 547.48 mg/kg. As per the ratings of Landon (1984), medium total P content was observed in all acidic soil of the studied districts, however numerically higher in the Nedjo (547.48 mg/kg) and lower in Boji Dirmaji (331.10 mg/kg). The total P contents of Ethiopian soil as reported by many studies ranged from 185 to 1981 mg/kg (Tekalign and Haque, 1991), 226 to 1570 mg/kg (Duffera and Robarge, 1996), 553 to 976 mg/kg (Achalu *et al*., 2012a) and

685 to 1432 mg/kg (Asmare et al., 2015). Generally there was significance difference (α = 0.05) of P_T between each soil samples studied area.

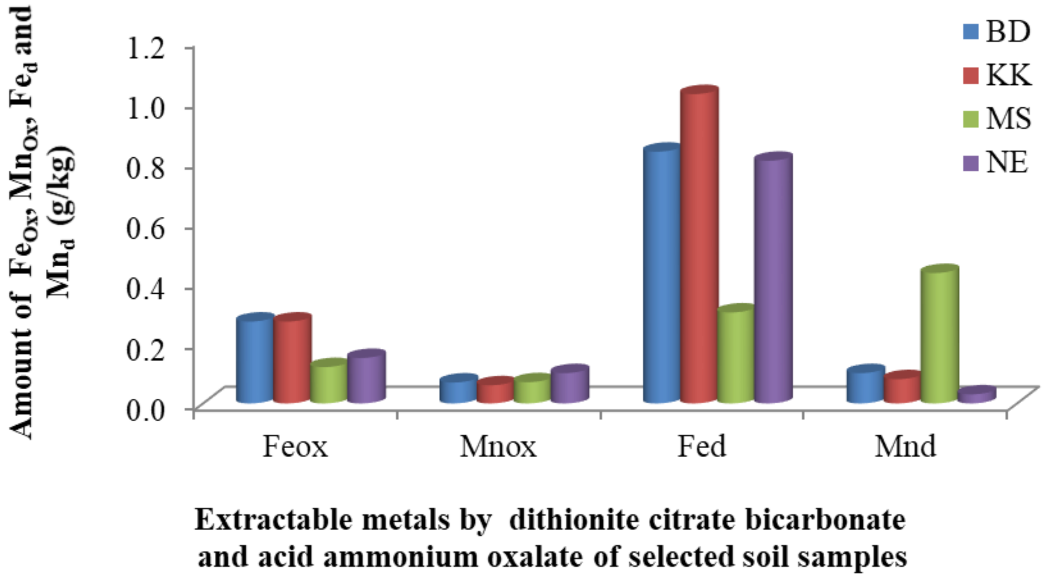

Figure 6. Amount of Iron (Fe) and Manganese (Mn) extractable by using dithionite citrate bicarbonate and acid ammonium oxalate from soil samples.

Phosphate Bounded Fe and Mn

The percentages of Fe and Mn extracted by dithionite citrate bicarbonate and acid ammonium oxalate methods are shown in Table 1. Generally, the amount of Fe_{ox}, Mn_{ox}, Fe_d and Mn_d extracted were found to be significant (α = 0.05) among the studied soils. Even though the dithionite citrate bicarbonate extracted elements are higher, the ammonium oxalate extractable Fe and Mn are also high evidencing the involvement of poorly crystalline and amorphous forms of Fe and Al in the soil.

From this work, Fe_d and Fe_{ox} highest extraction was from Kiltu Kara (1.02 g/kg) and Kiltu Kara and Boji Dirmaji (0.27 g/kg) and lower for both at Mena Sibu (0.3 g/kg and 0.12 g/kg) soil samples respectively. By the same way for Mn_d and Mn_{ox} higher extraction were from Mena Sibu (0.43 g/kg) and Nedjo (0.1 g/kg) and lower at Nedjo (0.03 g/kg) and Kiltu Kara (0.06 g/kg) soil samples respectively. Poorly crystalline and amorphous forms have an extensive surface area to sorb P and make P not easily available for the plant growth (Sharpley, 1983). Many researcher reported that organic matter in soil inhibits Al oxides crystallization and not easily extractable.

Correlation of Soil Parameters

The correlation analysis is a bivariant method which was applied to describe the relation between two different parameters. The relationships between contents of physicochemical were analyzed by Pearson's correlation coefficient for each soils. The high correlation coefficient or r (near +1 or −1) means a good relation between two variables and correlation around zero means no relationship between them at a significant level of 0.05 and 0.01 (Table *S1*, Table *S2*, Table *S3* and Table *S4*) for soil samples from Boji Dirmaji, Kiltu Kara, Mena Sibu and Nedjo Soils. Correlation can be also strongly correlated, if r > 0.7, whereas r values between 0.5 and 0.7 show moderate correlation between two different parameters (Sharma and Raju, 2013). When we see correlation Table SI-1 and Table SI-3 for BD and MS soil samples, OM and OC were highly correlated (r = 1.00*) at 0.05 level and similar for KK and NE soil samples (r = 1.00**) at 0.01 level. Total P and Fe_d are inversely correlated (r = -0.87) for BD and similar with Fe_{ox} (r = -0.84) for KK soil sample. These ideas almost support total P bounded to them (Fe and Al) and not easily available for plants. Available P and Total P are almost positively correlated to each other (r = 0.90). However, the degree to which two securities are negatively or positively correlated might vary over time and are almost not all time exactly. This condition may happen sometimes because one physicochemical properties may affect other and it may make to don't have consistent.

Conclusions

The present study demonstrates that the physicochemical parameters of studied area like pH (4.35-5.06) was range from very strongly acidic to strongly acidic, Electrical conductivity (0.019-0.08 dS/m) range and classified as non-saline. Organic carbon of studied soil was classified as (0.51-1.05 %) low and organic matter rated as very low to low and it may come from loss of organic carbon. Total nitrogen was low at Nedjo soil and medium in other soils. Cation exchange capacity (19.33-32.40 meq/100g) and it was moderate at Boji Dirmaji and Kiltu Kara and higher in Mene Sibu and Nedjo soils. The higher Exchangeable acidity (4.16) was observed at Boji Dirmaji and this may related to lower pH and lower at Nedjo (1.69) soil with higher pH compared to other soils, and similar trends for others Ex.Al and Ex H^+. Availibity of phosphorus (3.53-10.11 mg/kg) was generally in low range and this may be due to loss of P by continuous cultivation, erosion and heavy rain and medium for total P. For instance, the soil pH, electrical conductivity, organic matter, organic carbon, total nitrogen and available phosphorus were significantly at ($P< 0.05$) and the OM was positively and significantly correlated with OC (r = 1.00*) at the 0.05 confidence level and (r = 1.00**) at the 0.01 level. The percentages of Fe and Mn extracted by dithionite citrate bicarbonate and acid ammonium oxalate methods were analyzed. Generally, the amount of Fe_{ox}, Mn_{ox}, Fe_d and Mn_d extracted were found to be significant (α = 0.05) among the studied soils. Even though the dithionite citrate bicarbonate extracted elements are higher, the ammonium oxalate extractable Fe and Mn are also high. As general use of basic fertilizers,organic manure, modeling lime and acid tolerant cr op varieties can be are remedy which can raise the crop yield. In the future, further study should be done to investigate the different levels of heavy metals of study areas.

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Conflicts of interest

The authors stated that no conflicts of interest.

References

Abdenna Deressa. 2013. Evaluation of soil acidity in agricultural soils of smallholder farmers in south western Ethiopia. *Science, Technology and Arts Research Journal*, 2(2): 01-06.

Abreha kidanemariam, Heluf Gebrekidan, Tekalign Mamo and Kibebew Kibret. 2012. Impact of altitude and land use type on some physical and chemical properties of acidic soils in tsegede highland, north Ethiopia. *Open Journal of Soil Science*, 2(3): 223-233.

Achalu Chimdi, Heluf Gebrekidan, Kibebew Kibret and Abi Tadesse. 2012a. Status of selected physicochemical properties of soils under different land use systems of Western Oromia, Ethiopia. *Journal of Biodiversity and Environmental Sciences*,2(3):57-71.

Achalu Chimdi, Heluf Gebrekidan, Kibebew Kibret and Abi Tadesse. 2012b. Response of barley to liming of acid soils collected from different land use systems of Western Oromia, Ethiopia. *Journal of Biodiversity and Environmental Sciences*, 2(5): 37-49.

Achalu Chimdi. 2014. Assessment of the severity of acid saturations on soils collected from cultivated lands of east wollega zone, Ethiopia. *Science, Technology and Art Research Journal*, 3(4): 42-48.

Ashenafi Worku and Bobe Bedadi. 2016. Studies on soil physical properties of salt affected soil in amibara area, central rift valley of Ethiopia. *International Journal of Agricultural Sciences and Natural Resources*, 3(2): 8-17.

Asmare M, Heluf G, Markku YH, Birru Y (2015) Phosphorus status, inorganic phosphorus forms, and other physicochemical properties of acid soils of Farta District, Northwestern Highlands of Ethiopia.

Corp Appl Environ Soil Sci. https://doi.org/10.1155/2015/748390.

Brady, N.C. and Weil, R. R. 2002. *The Nature and properties of soils 13th (Ed)*. Person Educated Ltd, USA.960.

Bray R.H. and Kurtz, L.T. 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Science*, 59: 39-45.

Bereket Ayenew, Abi M. Taddesse, Kibebew Kibret and Asmare Melese.2018. Chemical forms of phosphorous and physicochemical properties of acid soils of Cheha and Dinsho districts, southern highlands of Ethiopia. Environmental Systems Research, 7:15.

Bouyoucos, G.J.1962. Hydrometer method improved for making particle size analysis of soil. *Journal of Agronomy*, 54: 464-465.

Bruce, R. C. and Rayment, G. E.1982. Analytical methods and interpretations used by the agricultural chemistry branch for soil and land use surveys. Queensland Department of Primary Industries. Bulletin QB8 (2004), Indooroopilly, Queensland.

Day, P. R. 1965. *Particle fractionation and particle size analysis*. In C. A. Black, editor.Methods of soil analysis. American Society of Agronomy, Madison, Wisconsin, USA545-566.

Dawit, S., Fritzsche, F., Tekalign, M., Lehmann, J. and Zech, W. 2002. Phosphorus forms and dynamics as influenced by land use changes in the sub-humid Ethiopian highlands. *Geoderma*, 105: 21-48.

Duffera, M. and Robarge, W.P. 1996. Characterization of organic and inorganic phosphorus in the highland pleateau soil of Ethiopia. *Communications in Soil Science and Plant Analysis*, 27: 2799-2814.

EthioSIS (Ethiopian Soil Information System). 2014. Soil Fertility and Fertilizer recommendation atlas of Tigray Region. Minis try of Agriculture (MoA) and Agricultural Transformation Agency (ATA).

FAO (Food and Agriculture Organization). 1990. Soil map of the world: Revised legend FAO (Food and Agriculture Organization), Rome, Italy.

FAO (Food and Agriculture Organization). 2006. *Plant nutrition for food security*: A guide for integrated nutrient management. FAO, Fertilizer and Plant Nutrition Bulletin *16*. FAO, Rome, Italy.

Freese, D., Lookman, R., Merckx, R. and van Riemsdijk, W.H. 1995. New method for the Assessment of long term phosphate desorption from the soil. *Soil Science of American Journal*, 59: 1295-1300.

Gavriloaiei, T. 2012. The Influence of electrolyte solutions on soil pH measurements. *Revista de Chimic-Bucharest*, 63 (4): 396-401.

Gemechu Shumi, Abi Tadesse and Tesfahun Kebede. 2015. Phosphorus desorption study using dialysis membrane tube filling Fe-Al-Mn ternary mixed nanocomposite from different farming practice of acidic soil. *Chemistry and Materials Research*, 7(8): 82-91.

George, E., Rolf, S. and John, R. 2013. Methods of soil, plant, and water analysis: *A manualfor the West Asia and North Africa Region, 3rd Edin*. International center o f Agricultural Research in the Dry area.

Havlin, J. L., Tisdale, S.L., Nelson, W.L. and Beaton, J. D. 2013. *Soil fertility and fertilizers: an introduction to nutrient management, 8th Edition*. Prentice Hall, New Jersey, USA. 528.

Hazelton, P. and B. Murphy, 2007. *Interpreting soil test results: What do all the numbers mean? 2nd edition*. CSIRO Publishing.

Jackson, M. L.1958. Soil Chemical Analysis: Prentice-Hall, Englewood Cliffs, 498.

Jackson, M.L., Lim, C.H. and Zelazny, L.W. 1986. Oxides, Hydroxides and Aluminosilicates. In: Klute, A., Ed., *Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, 2nd Edition*, Agronomy Monogram 9, ASA and SSSA, Madison, 101-150.

Jones, J.B. 2003. Agronomic Handbook: Management of crops, soils, and their fertility. CRC Press LLC, Boca Raton, FL, USA. 482.

Liu, X., Herbert, S. J., Hashemi, A. M., Zhang, X. and Ding, G.2006. Effects of agricultural management on soil organic matter and carbon transformation–a review. *Plant, Soil and Environment*, 12: 531-543.

London, T.R. 2014. Booker tropical soil manual: a hand book for soil survey and Agricultural land evaluation in the tropic and subtropics. Routledge, Abingdon, UK. 532.

Kavian, H., EsmaliOuri, A., JafarianJeloudar, Z. and Kavian, A.2012. Spatial Variability of Some Chemical and Physical Soil Properties in Nesho Mountainous Rangelands. *American Journal of Environment Engineering*, 2: 34-44.

Manimegalai, K. and Sukanya, S. 2014. Assessment of physicochemical parameters of soil of Muthannan Kulam wetland, Coimbatore, Tamilnadu, India. International Journal of Applied Sciences & Biotechnology 2(3):302-04.

McKeague, J.A. 1967. An evaluation of 0.1 M pyrophosphate and pyrophosphate–dithionite in comparison with oxalate as extractants of the accumulation products in Podzols and some other. *Canadian Journal of Soil Science*, 47: 95-99.

Mulugeta Aytenew. 2015. Effect of slope gradient on selected soil physicochemical properties of dawja watershed in enebse sar midir district, Amhara national regional state. *American Journal of Scientific and Industrial Research*, 6(4): 74-81.

Murphy, H.F. 1968. *A report on fertility status and other data on some soils of Ethiopia*. Collage of Agriculture HSIU. Experimental Station Bulletin No. 44, Collage of Agriculture.

Ochwoh, V. A., Nankya, E., De Jager, P. C. and Claassens, A. S. 2016. The impact of phosphorous applications and incubation periods on P-desorption characteristics with successive DMT-HFO-P extractions on P fixing soils. *International Journal of Plant and Soil Science*, 13(6): 1-14.

Olayinka, O.O., Yetunde, O. and Gbade, O.O. 2015. Assessment of dithionite and oxalate extractable iron and aluminium oxides on a landscape on basement complex soil in south-western Nigeria. *Open Journal of Soil Science*, 5: 266-27.

Paulos Dubale.1996. Availability of phosphorus in the coffee soils of southwest Ethiopia. 119-129. *In*: Tekalign Mamo and Mitiku Haile (Eds.). Soil: The Resource Base for Survival. *Proceeding of the 2nd Conference of the Ethiopian Society of Soil Science (ESSS)*, 23-24 September 1993, Addis Ababa, Ethiopia.

Poggio, M., Hepperle, E. and Marsan, A.M. 2008. Metals pollutions and human bioaccessibility of topsoils in Grugliasco, Italy. *Environmental Pollution*, 157: 680-689.

Sanchez, P.A., Palm, C.A. and Buol, S.W. 2003. Fertility capability soil classification: a tool to help assess soil quality in the tropics. *Geoderma*, 114: 157-185.

Sharpley, A. N. 1983. Effect of soil properties on the kinetics of phosphorus desorption. *Soil Science Society of America Journal*, 47(3): 462-467.

Sumithra, S., Ankalaiah, C., Janardhana, R.D. and Yamuna, R.T. (2013). A case study on physicochemical characteristics of soil around industrial and agricultural area of Yerraguntla, Kadapa district, A.P, India. International Journal of Geology, Earth and Environmental Sciences 3(2): 28–34.

Suryawanshi Sampatrao B. 2018. Environmental Sciences Studies of the Physicochemical Parameters of soil samples of Khed Taluka Dist: Pune (Maharashtra), *Int. Res. Journal of Science & Engineering, Special* Issue A3 111-115.

Taddesse, A.M., Claassens, A.S. and De Jager, P.C. 2008a. Long-term phosphorus desorption using dialysis membrane tubes filled with iron hydroxide and its effect on phosphorus Pools. *Journal of Plant Nutrition*, 31(8): 1507-1522.

Taddesse, A.M., Claassens, A.S. and De Jager, P.C. 2008b. Long term kinetics of phosphate desorption from soil and its relationship with plant growth. *South African Journal of Plant and Soil*, 25(3): 131-134.

Tekalign, M. and Haque, I. 1987. Phosphorus status of some Ethiopian soils. I. Sorption characteristics. *Plant and Soil*, 102: 261-266.

Tekalign Tadesse. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis manual. Working Document No. B13. *Soil Science and Plant Nutrition Section, International Livestock Center for Africa*, Addis Ababa, Ethiopia.

Thomas, G.W. 1982. Exchangeable cations. In A.L. Page et al. (*2nd Edn.*) *methods of soil analysis*, Agronomical Monographs. 9. ASA and SSSA, Madison, WI. 159-164.

Thomas, R.L., Sheard, R.W. and Moyer, J.R. 1967. Comparison of conventional and automated procedures for nitrogen, phosphorus, and potassium analysis of plant material using a single digestion. *Agronomy Journals,* 59: 240-243.

USDA (United States Department of agriculture). 2014. Online, soil texture calculator. USDA NRCS. (Accessed on October, 2014).

Walkley, A. and Black. I.A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, 37: 29-37.

Wodaje Addis and Alemayehu Abebaw. 2014. Analysis of Selected Physicochemical Parameters of Soils Used for Cultivation of Garlic (Allium sativum L.). *Science, Technology and Arts Research Journal*, 3(4): 29-35.

YuGe Z, ZhuWen X, DeMing J, Yong J. 2013. Soil exchangeable base cations along a chronosequence of *Caragana microphylla* plantation in a semiarid sandy land, China. J Arid Land 5(1):42–50

Zhou, X., Xu, M., Wang, B., Cai, Z. and Colinet, G. 2018. Changes of soil phosphorus fractionation according to pH in red soils of China: An incubation experiment. *Communication in Soil Science and Plant Analysis*, 49: 791-802.