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The Impact of Soil Acidity in Soil and Water Conservation and the Current Practices of Soil and Water Conservation Response to Acid Affected Soils in Ethiopia: A Review

Zeleke Melese
Ethiopia agricultural research institute Pawe agricultural research center

Abstract
Land degradation is a global negative environmental process that causes the decline in the productivity of land resources' capacity to perform their functions. Ethiopia has an experience long term in soil and water conservation efforts since1970s and it has established six national Ethiopian Soil Conservation Research Programs were initiated in 1981 and their focus over agro-ecology, land physiographic, climate and farming system but not considerable soil mechanics, hydraulic and geotechnical processes. Agronomic or biological measures are in helping to minimize the soil erosion by increasing soil surface cover, surface roughness, and surface depression storage, soil infiltration and decapitating potential and kinetic energy. In acid affected soil, before installed biological or agronomic soil and water conservation measures should be identified suitable technologies or recommendation either acid soil tolerant or reclaim the soils. Biological soil and water conservation and soil management measure more rehabilitee acid affected soils than physical soil and water conservation due to addition of bio mass, resulting decomposition improve soil structure, aeration, apparition infiltration ultimate reduction of soil erosion functions .
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1. INTRODUCTION

Approximately, 50% of the world's potential of arable land is affected by acid soil (Kochian *et al*., 2004; Sade *et al*., 2016), due to land degradation subsequently, negative impact of on crop, pasture and fiber production resulting between 25 and 80 % of yield losses depending upon the plant species (Sade *et al*.,2016), but also cons for rehabilitation efforts designed to promote soil and water conservation measures (Zhang *et al.,* 2015). Acid soils (pH 5.5 or lower) are globally, distributed and comprise approximately 30% of the total area of the earth (Von *et al*., 1995).

Several studies have coined that the major causes of soil acidity or soil acidification are natural and/or anthropogenic activities. High amount of rainfall resulting in leaching base forming cations (Brady and Weil, 2016; Rahman *et al*., 2018), nature of parent materials and mineralogy. For, example, granitic parent material (Wilson, 2019), continuously synthetic fertilizer application. For instance, ammonium fertilizers (Singh, 2018) decomposition of organic matter (Brady and Weil, 2016), nutrient uptake by crops and root exudates (Goulding, 2016), low buffer capacity from clay and organic matter (Kamprath, 2003), and aluminum-silicate minerals (Abebe, 2007) as shown Fig.1.

Soil acidity depends on soil reaction (soil pH) which is a key factor that controls soil nutrient availability, soil microbial activities, and crop growth and development (Zhang *et al.,* 2019). It also affects the physical properties of soils including the shear strength and Atterberg limits (Gratchev and Towhata, 2013). For instance, plant nutrient deficiency (Phosphorus(P), Molybdenum(Mo), Nitrogen(N), Calcium(Ca), Magnesium(Mg), potassium(K) and Sulfur(s)) when soil pH decreases conversely, toxicity of metals such as Aluminum(Al), Hydrogen(H), Iron(Fe) and manganese(Mn) effects on plant ecology in acid soils (Von Uexküll and Mutert, 1995; Läuchli and Stephen 2012). Moreover, bacterial communities are deteriorated in quantity and quality lead to be less active and less diversification in soil ecosystem (Brady and Weil, 2016).

In recently, a few studies showed that soil acidity indirectly affects soil and water conservation practices. For instance, at lower soil pH (<4.0) soil erosion by water promotes due to physical characteristics of soil changes (Matsumoto *et al.,* 2018).

In Ethiopia, large areas of highlands with altitude of >1500 masl located in almost all regional states of the country are affected by soil acidity. An earlier study reported indicate that about 41% of the Ethiopian agricultural lands are affected by soil acidity: 13% strongly acidic (pH<4.5), 28% moderately to slightly acidic (4.5-5-5) ((Abebe, 2007) whereas in recent time, reported by Ethiosis (2015) about 43% of the Ethiopian arable land is affected by soil acidity.

Some of the well-known areas severely affected by soil acidity in Ethiopia include Gimbi, Nedjo, Hosanna, Sodo, Endibir, Chencha, Hageremariam and Awi (Abebe, 2007; Agegnehu *et al*., 2019). Generally, soils developed on non-calcareous parent materials are inherently acidic. Acid Nitisols (pH <5.5) occur widely in

Ethiopian highlands where the rainfall intensity is high and crop cultivation has gone for many years (Agegnehu and Bekele, 2005).

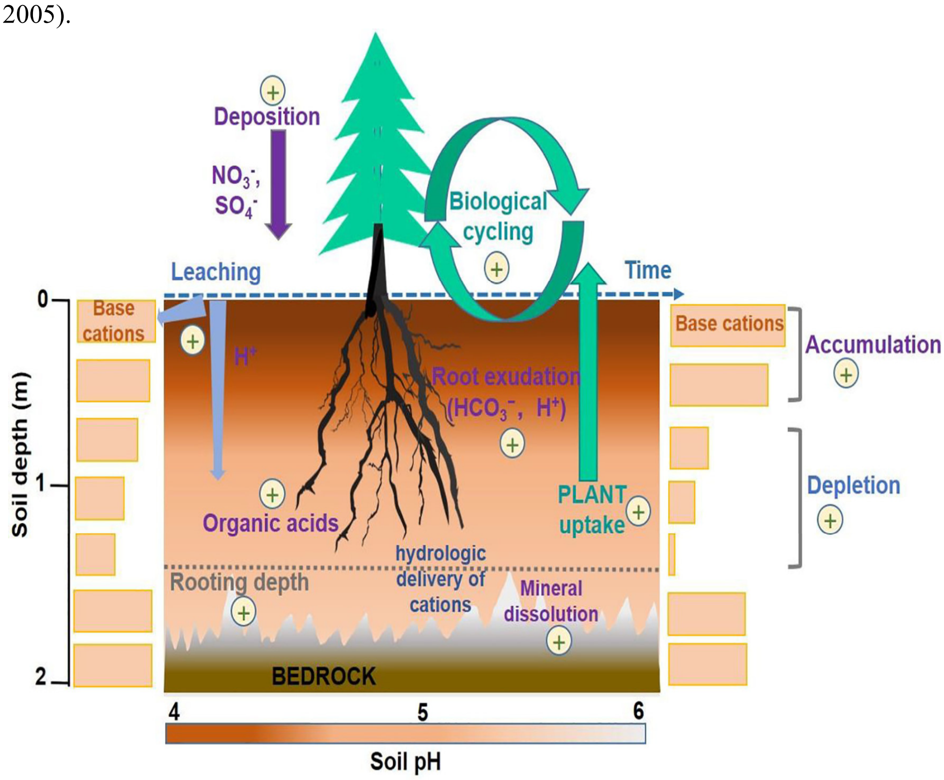

Figure 1. Conceptual diagram of the effects of global change on soil acidification of a soil profile (sources: Yu et al., 2020)

To combat land degradation in Ethiopia, for over four decades soil and water conservation has been implemented by governmental and non-governmental organizations to improve or maintain ecosystem services (Haregeweyn *et al*., 2015), however, the impact of soil acidity in soil and water conservation associative information review is limed. Therefore, the objective of this review is to review the impacts of soil acidity in soil and water and the current practices association with soil and water conservation in Ethiopia.

2. LITERATURE REVIEW

2.1. Impacts of acid soil on physical soil and water conservation

Ethiopia has an experience long term in soil and water conservation efforts since1970s and has established six national Ethiopian Soil Conservation Research Program was initiated in 1981 and their focus over agro-ecology, land physiographic, climate and farming system but not considerable soil mechanics, hydraulic and geotechnical processes (Haregeweyn *et al*., 2015; Zegeye *et al.,* 2016).

The physical characteristics of soils including attraction force among soil particles, Atterberg limits, such as the liquid limit and plastic limit indicate the soils' susceptibility to degradation, and soil particle size also contributes to erosion (Deng *et al.,* 2017). For example, low liquid limit soils easily transform into viscous liquids with increasing water content and are easily transported by rainwater, making them susceptible to soil water erosion. Moreover, electrochemistry (soil pH) at the surface of soil particles in soils is related to important physical phenomena, such as flocculation, erosion susceptibility, and dispersion of soil particles (Ribeiro *et al.,* 2012). Small particles formed by soil dispersion resulting from electric repulsion between particles are easily detached from the soil surface and transported by rainwater. Thus, the physical properties of soils strongly affect the development of erosion by water (Marcus, 1997). Gratchev and Ikuo (2013) reported that Soil acidity and acidification changes the physical properties of soils, including the shear strength and Atterberg limits. These changes in soil physical properties resulting from the acidic condition can prompt the soil erosion by water (Fig.4).Thu, shear strength and Atterberg limits are in general influenced by many soil properties, but primarily by organic matter and clay content.

Matsumoto *et al*. (2018) conducted research in Indonesia to evaluate the effects of pH-induced changes in soil physical characteristics on the development of soil water erosion. These authors explored whether the effects of pH-induced changes in soil physical characteristics on the development of soil water erosion. The findings showed that as soil pH approaches from neutral to extremely acidic condition (6.0-2.0) the liquid limit, plastic limit, and plastic index were decreased (Figure 2) and then decreased as pH increased further to 10.0. Primarily clay minerals are depends on Atterberg limits i.e particle-size distribution. The soil pH is either decreased or increased from 6.0, the liquid limit, plastic limit, and plastic index reversal resulting in the soil erosion is accelerating (Figure. 2, 3 and 4).

Since as pH decreases from neutral (6.0) the primary clay minerals are increases in size such as aluminum species ($Al^{3+,}Al(OH)^{2+}$, $Al(OH)_2{}^{+}$) increases and these clay minerals could good soil aggregation, however, the summation of liquid limit, plastic limit, plastic index, and cohesive forces decreases (hydraulic processes). Thus, soil pH decreases from 6.0 to 2.0 the soil loss increases per year (Figure. 4). In addition, as soil pH decreases from 6.0 to 2.0 the positively charged clay mineralogy accumulation increases in other words the negative clay mineralogy removed and Electrostatic forces and shear strength loses (geotechnical processes) (Figure 3). This idea haven been supported by White (1949) obtained that on the plastic clays would indicate that the Atterberg Iimits increase with decreasing particle size. For example, plastic limit of attapulgite > montmorillonite >illite > kaolinite; that the liquid limit of sodium montmorillonite > calcium montmorillonite = attapulgite > illite > kaolinite; and that the plastic index of sodium montmorillonite > calcium montmorillonite > attapulgite > illite > kaolinite. In summary, pH has significant role on the physical properties of soils, although the mechanism varies. Clay minerals rich such as montmorillonite, illite, and kaolinite the difference in pH values causes the changes in physical properties of the soils affects in development of soil water erosion.

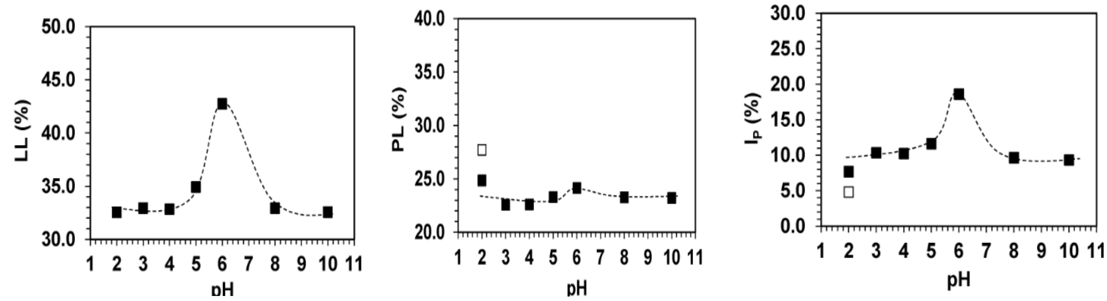

Figure 2. Change of liquid limit, Plastic liquid, and index plastic at different pH values ranging from 2.0 to 10.0 (sources, Matsumoto *et al*., 2018).

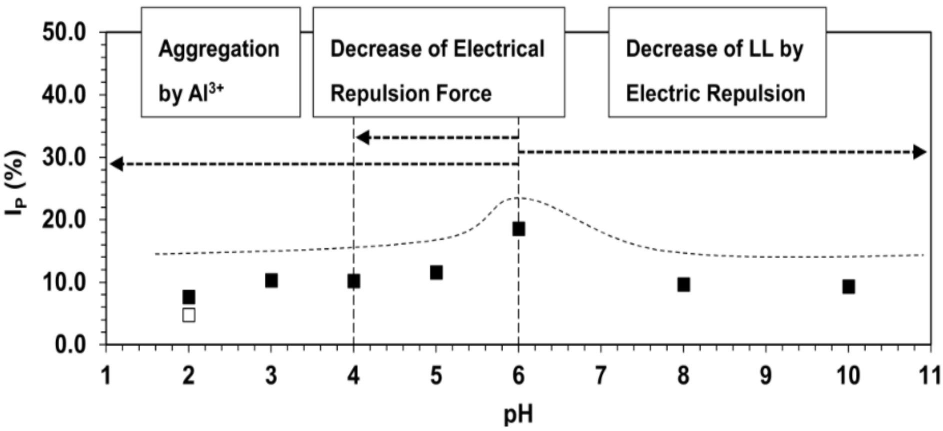

Figure 3. Summary of the effects of different pH conditions on the change of index plastic of the simulated soils (sources, Matsumoto *et al*., 2018).

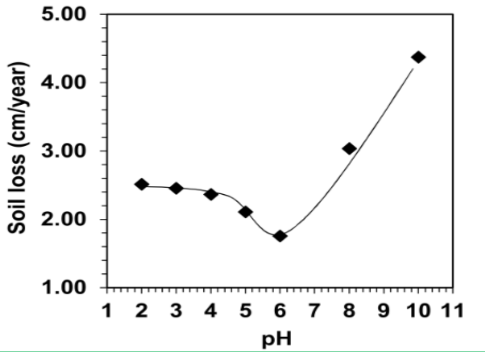

Figure 4. Annual rate of soil water erosion at different pH values ranging from 2.0 to 10.0. (Sources, Matsumoto *et al*., 2018).

2.2. Soil acidity impact on biological soil and water conservation

Agronomic or biological measures are in helping to minimize the soil erosion by increasing soil surface cover, surface roughness, and surface depression storage, soil infiltration and decapitating potential and kinetic energy (Mitiku *et al*., 2006). Because of soil acidification biological or agronomic soil and water conservation measures could not be survival (Yu *et al.,* 2020). Due to essential plant nutrient are deficiency (P, Mo, N, Ca, Mg, S). When soil pH lower and toxicity of metals (Mn, Fe and Al) for plant growth in acid soils (Von Uexküll and Mutert, 1995; Läuchli and Stephen 2012), therefore, these measures might not be involved metabolic process (photosynthesis, respiration and bio-oxidation) or could not complete their life cycle .in other hand, no bio- mass production no erosion function. Moreover, soil biota communities are deteriorated in quantity and quality lead to be less active and less diversification (Brady and Weil, 2016). As result of, reduction of biological activities in eco system services. When the soil pH drops below 5, Al is solubilized into the soil solution and create rhizotoxic of Al species resulting inhibition of root growth could not compute sun light, nutrient and moisture (Kochian *et al*., 2004). This idea was supported by Matzne and Fortmann, (1986) investigated that inhibit root growth and induce high root mortality forested areas of Germany under acid soil condition.

Brady and Weil (2016) conducted the research in different grass species under acid soil condition in Figure 5. The result showed that as Al concentration increases in soil solution, dramatically the seed germination decreases. Due to Al toxicity but some species (green lines) were little affected by even high levels of Al. Therefore tended to dominate the most acid soils. Seed germination for the most Al-sensitive plants (red lines) declined dramatically when Al concentration increases in soil solution (Figure 5). Therefore, under acid soil condition implemented biological or agronomic soil and water conservation practices may malfunction on soil erosion function.

Generally, acid soils (pH<5) causes diminishes soil microorganism in quality and quantity resulting passive in decomposition organic materials subsequently less interaction with many plants facilitates uptake of nitrogen and phosphorus in exchange of carbon less soil aggregation ultimately causes the negative impact on growth and productivity of forest trees and crop plants as whole eco system services .

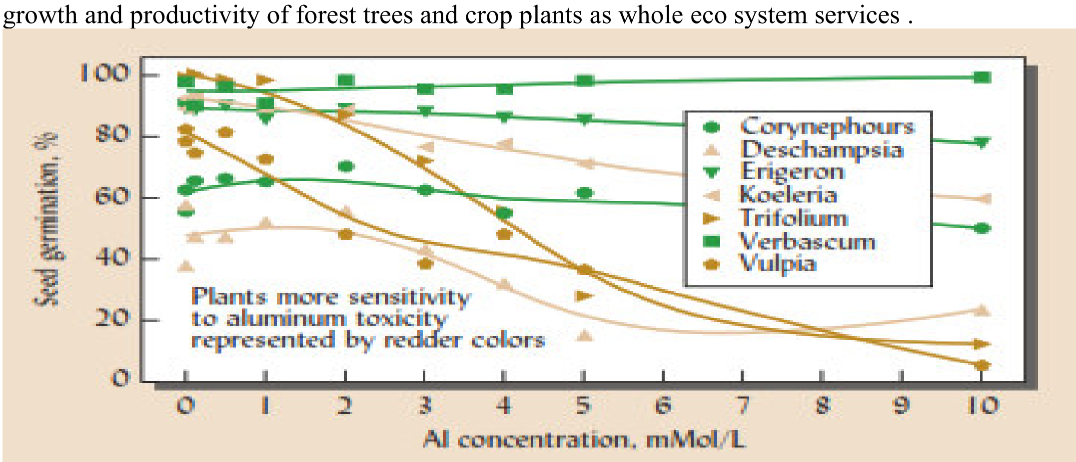

Figure 5. soil pH levels bring toxic Al into solution and influence plant ecology under acid soil condition Ma, H and Fe toxicity also occurred when taken up in excessive quantities on Plants species (sources Brady and Weil, 2016).

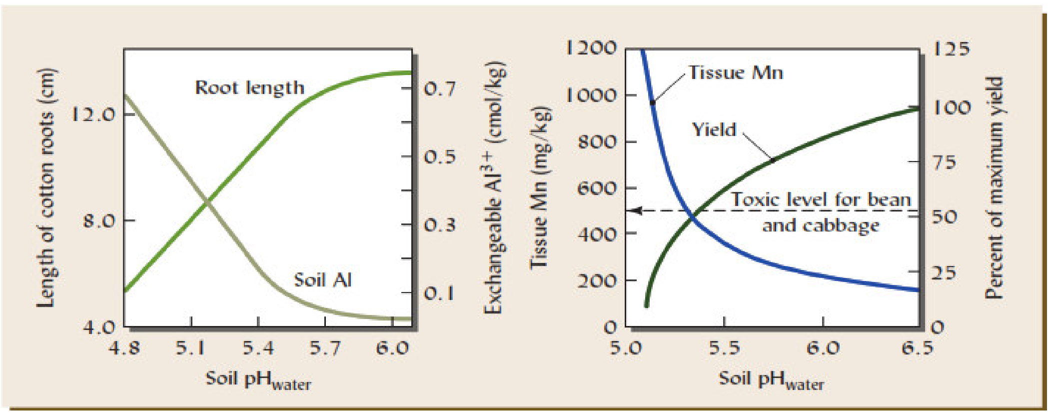

Figure 6. Plant responses to toxicity of Al (left) and Mn (right) at low soil pH (Left) (sources Brady and Weil, 2016).

As soil pH water drops below figure 7 Aluminum tolerances can operate by preventing or reducing Al uptake by plants or by detoxifying once it is in the plant tissue. Exclusion of Al from the plant may operate in several ways as shown in Figure 7 influence of pH on the growth of shoots and roots from two wheat varieties, one sensitive and one tolerant to aluminum. Note the stunted shoot growth and extremely stunted, stubby root system of the sensitive variety in the low-pH treatment.

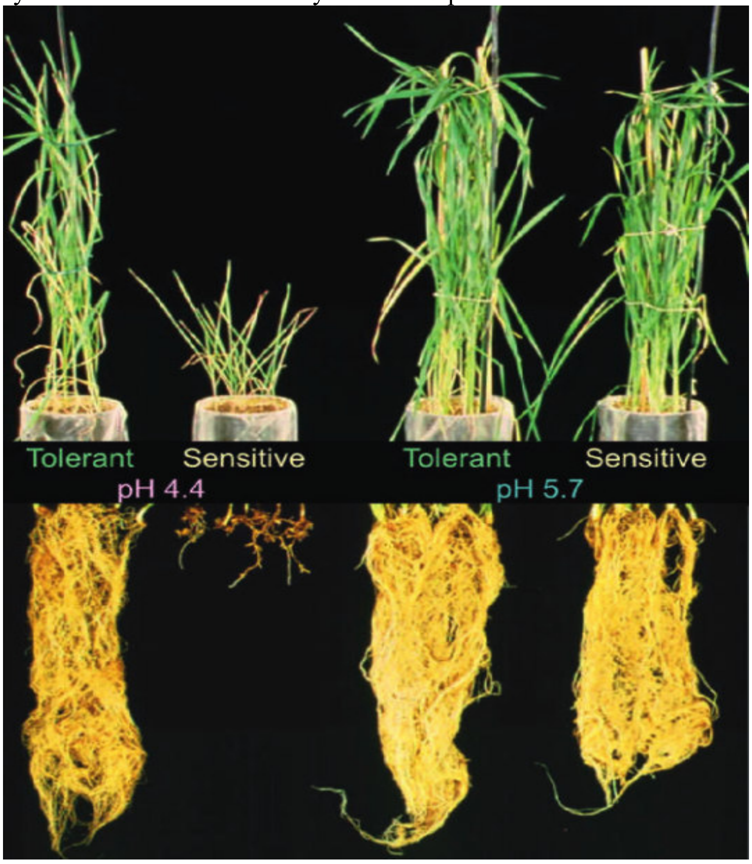

Figure 7. Influence of pH on the growth of shoots and roots from two wheat varieties, one sensitive and one tolerant to aluminum (sources Brady and Weil, 2016).

2.3. Current practices of soil and water conservation responses to acid soils in Ethiopia

2.3.1. Impact of physical soil and water conservation on acid soil

According to Tefere *et al.* (2020) have been conducted research at slightly acidic Geda sub-watershed central high land of Ethiopia findings that within sub watershed split plots that was treated and untreated and in treated plots clay content, electric conductivity, total nitrogen, available phosphorus, potassium and Organic carbon were highly significant as untreated plot in watershed. Similarly, Abebe *et al.* (2020) reported that at Guder and Aba Gerima watershed total organic carbon and total nitrogen increased under well managed land under strong acid soil condition. Giday (2018) findings indicated that under different land use types in relation to their effect on soil acidity and fertility in northern Ethiopia, higher pH and lower exchangeable acidity 6.34 and 0.44, respectively, at homestead conversely, at cultivated land soil lower pH and higher exchangeable acidity (5.92 and 4.79). Due to continuous removal of basic cations by crops and soil erosion leaching whereas the better soil condition on homestead unplanned of application manure and wood ash. Similarly, Abate *et al.* (2016) also evaluated Soil acidity under different land uses small-holders' mixed-farming system of northwest Ethiopia (Banja, Gozamin and Mecha) the higher soil pH at homestead and natural forest across the study arears. Belay and Eyasu (2017) conducted study in Guba-Lafto Woreda of North Wollo. The result showed that the soil pH was higher in treated (6.2) than that of untreated (5.1); soil organic carbon (9.0,7.7), available phosphors (3.6, 1.7), exchangeable potassium (0.28 ,0.26) and cation exchangeable capacities (24.4,19.7) were statically significantly difference (at t and p-value) treated and untreated watershed, respectively. But the total nitrogen was highly significant ($P<1\%$) in treated (0.08) that of non-treated (0.3). Similarly, Tesfaye and Fanuel (2019) reported that in southern Ethiopia, there were positive impacts on soil and crop productivity of cultivated lands (Table 1).

As summarized Table 2, the mean soil texture under physical soil and water conservation measures application was obtained sand, silt and clay in percentage of 31.27, 28.77and 39.80, respectively, whereas, in non-conserved plots the soil texture was recorded sand, silt and clay in percentage of 31.70, 28.34 and 40.03, respectively (Table 1). The results showed that the soil texture was more or less constant. Based on the Table 1 the mean CEC in conserved plots were more recorded (31.1 $Cmol_c$ kg^{-1}) than that of untreated plots (27.4 Cmolc kg^{-1}). Similarly, even though the result was inconsistent, the mean soil pH (5.9) was higher in treated plots than that of non-conserved (5.7) plots. This result might to be because of conservation structures reducing the horizontal movement of water (leaching) of ca^{2+}, Mg^{2+}, k^{+} and Na+ resulting increases the CEC. Table 2 results showed that conserved plots increased available P and 11.5 ppm as compared to non-conserved plots (7.4 ppm). This could be due to the synergetic effect of prevent wash out available P soil and water conservation structures and relatively increases of soil pH. The soil organic carbon also in conserved plots were more recorded (2.4%) than that of non-conserved plots (1.9%).

Table 1. Impacts of Physical soil and water conservation response to acid soil condition in Ethiopia

Types of physical soil and water conservation	Treated							Untreated							Location	References
	Soil pH	CEC (Cmol kg^{-1})	Sand	Silt	clay	SOM	AP (ppm)	Soil pH	CEC (Cmol kg^{-1})	Sand	Silt	clay	SOM	AP (ppm)		
Terraces	5.4	20.86	29.9	36.6	33.3	2.2	22.50	5.3	22.5	31.9	28.2	40.2	1.9	11.82	Ya'ee Chabo Watershed O romia	Mohammed *et al.*,2020
Fanya juu soil bund	5.6	31.8	39.5	31.9	28.7	2.12	1297	5.56	31.7	41.5	34.0	24.7	1.96	1057.2	Ambo, Oromia	Hailu *et al*., 2012
Stone Bund	6.0	34.05	31.4	37.7	31.6	2.06	28.19	5.80	35.03	25.1	39.2	35.6	1.91	8.44	Gondar Zuriya	Hailu, 2017
Stone faced soil bund	5.9	34.84	27.9	38.1	31.0	2.15	20.66	5.80	35.03	25.1	39.2	35.6	1.91	8.44		
Stone Bund	5.55	38.24				3.42	12.12	5.61					2.87		Adaa Berga, Oromia	Challa *et al.*, 2016
integrated soil conservation	5.26	39.05	24.3	27..61	51.0	3.81	12.12	4.67	32.22	22.56	26.28	51.17	1.93	8.07	Wollega, Oromia	Bekele *et al.*,2016
Soil and Water Conservation	5.33	26.5	52.44	17	30.6	3.23	3.23	5.18	20.5	47	14.33	40	2.42	2.4	Ezha, southern Ethiopia	Shafi *et al*.,2019
Integrated	6.34	30.45	20.2	22.9	56.5	2.7	3.6	6.19	29.29	16.9	19.6	63.4	2.5	3.4	Mecha, Amahara	Alemayehu and Fisseha, 2018
Soil bunds and Fanya juu	6.2		29.8	30.1	40.5	3.2	2.58	6.4		29.2	33.6	37.2	3	1.82	Gojeb river catchment, Ethiopia	Dagnachew *et al.,* 2020
Physical soil water conservation	5.7	33.6	7.83	24.3	67.8	2.5	6.96	5.6	31.9	10.3	29.2	60.5	1.6	7.9	Gumara watershed	Belayneh *et al*., 2019
stone-faced soil bund	6.48	36.51	25.1	33.5	41.3	2.20		5.90	22.86	33.5	31.7	34.6	1.44		Lole watershed	Guadie *et al*., 2020
Stone bund	6.51	30.06	24.6	33.7	41.5	1.76		5.90	22.86	33.5	31.7	34.6	1.44		Lole watershed	Guadie *et al*., 2020
Level soil bund	5.6	16.75	46.0	18	36.0	1.57	9.4	5.6	18.33	47.8	18.1	34.0	1.68	8.8	Loma, Southern	Wolka *et al*., 20211
Stone bund	6.6	31.57	48.6	23.6	27.6	0.69	5.2	6.8	26.4	47.8	23.3	28.8	1.01	13.0		

2.3.2. Soil management response to acid soils

Appropriate Soil management one the one the strategy to optimize acid affected soils. Kebede et al.(2020) reported that application soil conditioner materials under acid soil, the soil pH was increased lime application followed by combined polyacrylamide and lime, polyacrylamide and gypsum 6.75, 5.14, 5.09 and 4.85, respectively, over control (4.84) (Table 2). In two-month incubation experiment was conducted acidic soils western Highlands of Ethiopia by Bekele *et al,* (2018) findings that the highest soil pH, CEC and organic carbon and available phosphorus was recorded at application of combined vermi-compost (VC) and rather than sole lime and VC (Table 2) but the content of organic carbon in combined and sole VC almost similar while, the soil organic carbon content applied lime and control almost no difference. Therefore, application organic sources not only soil conditioner but also improve or maintain soil quality and soil health.

Dawud *et al*. (2018) reported that the palpation combined lime and compost the soil pH and available phosphorus increases as compare to control (Table 2). Therefore soil management techniques such as liming by agricultural 1iming materials, application organic matter and combination is one of the best options for management of acid affected soils. As compare to physical soil and water conservation, soil management fast response to acid affected soil (compare Table 1and 2). This might be soil management in put system or addition but physical soil and water conservation in natural system so that it will be take long term.

Table 2. soil management influenced on acid soil in Ethiopia

Types of physical soil management	Treated							Untreated							Location	References
	Soil pH	CEC (Cmol kg^{-1})	Sand	Silt	clay	SOM	AP (ppm)	Soil pH	CEC (Cmol kg^{-1})	Sand	Silt	clay	SOM	AP (ppm)		
Polyacrylamide (PAM)	5.09	15.48	-	-	-	-	-	4.84	16.35	-	-	-	-	-	Arid Land Research Center of Tottori University	Kebede et al., 2020
PAM+ Gypsum	5.11	17.78	-	-	-	-	-	4.8	16.35	-	-	-	-	-		
Gypsum	4.85	16.18	-	-	-	-	-	4.8	16.35	-	-	-	-	-		
Lime	6.75	19.23	-	-	-	-	-	4.8	16.35	-	-	-	-	-		
PAM+lime	5.14	16.86	-	-	-	-	-	4.8	16.35	-	-	-	-	-		
lime	6.0	10.49	-	-	-	2.28	6.2	4.8	7.98	-	-	-	2.15	4.67	Ebantu District, Western Highlands of Ethiopia	Bekele et al., 2018
VermiCompost	5.46	12.95	-	-	-	3.99	6.3	4.8	7.98	-	-	-	2.15	4.67		
Vermin-compost+lime	6.05	13.38	-	-	-	4.10	7.3	4.8	7.98	-	-	-	2.15	4.67		
Lime+compost	5.0	34.7	-	-	-	1.9	1.4	4.0	35	-	-	-	1.5	0.9	Jimma Agricultural Research Center	Dawud *et al*., 2018
Lime	6.72	33.3	-	-	-		6.7	5.0	17	-	-	-		6.3	Sodo	Adane, 2014
Lime+comost+FYM	6	24	-	-	-		11	4.9	4.0	-	-	-	5.9	1.27	Lay Gayint district	Fekadu *et al.,* 2018
Lime+Biocher	8.4	14.69	-	-	-	20.7	18.9	5.4	14.69	-	-	-	1.66	12.8	Koka watershed	Anteneh *et al.*,2013

2.3.3. Biological or agronomical soil and water conservation response to acid soils in Ethiopia

Installing biological or agronomical soil and water conservation whether or not reclaim acid soil affected lands several soil physico-chemicals research have been conducted in different par of Ethiopia. Mamuye *et al*. (2020) reported that Short-term improved fallows of Tephrosia vogeliiand Cajanus cajan research was conducted Omo-Nada districts of south western Ethiopia strong acid soil condition. The result showed that sparingly, soil pH, CEC, organic carbon and available phosphorus was increased 6.6, 34.2, 3.4 and 4.8 as compare to controls (5.2,11.9,1.2and 0.1, respectively (Table 3). This could be nitrogen fixer green manure either or both incorporated their biomass improved the soil properties or reduced soil erosion. Another research also have conducted Hadiya Zone Hadiya Zone, Southern Ethiopia by Sinore et al.(2018) reported installing leguminous and non-leguminous biological soil and water conservation measures under modernly acid soil condition. The soil texture proportion had shifted from sand to silt to clay as compare to controls but also as compare to leguminous and non-leguminous more shift from sand to silt to clay. This might to be shifted from kaolinite to illite colloids of clay minerals. The chemical properties of soil both leguminous and non-leguminous measures changes as compare to control but leguminous measure was more changes in soil pH, CEC, SOC and available phosphorus as compare to non-leguminous. This may be addition of atmospheric nitrogen and lowering C: N ratio conducive environment for decomposers of microorganisms.

Tiki *et al.,* (2015) and Descheemaeke *et al*.(2006) have been conducted Tigray Region nother parts of the on area enclosure land management practices evaluated effect of on soil properties unfortunately, the areas were slightly acid and alkaline and soil pH was shifted from alkaline to neutral when area is closed (Table 3).

Table 3 .Biological or agronomical soil and water conservation response to acid soils in Ethiopia

Types of Biological or agronomical soil and water conservation	Treated								Untreated								Location	References
	Soil pH	CEC (Cmol kg^{-1})	Sand	Silt	clay	SOM	AP (mg/kg)	Bd	Soil pH	CEC (Cmol kg^{-1})	Sand	Silt	clay	SOM	AP mg/kg	BD	Southern , Ethiopia	Mamuye et al.,2020
improved fallows Tephrosia vogelii	6.6	34.2				3.4	4.8		5.2	11.9				1.2	0.1			
Cajanus cajan	6.1	25.4				2.3	3		5.2	11.9				1.2	0.1			
Natural fallow	5.6	21.2				1.5	1.6		5.2	11.9				1.2	0.1			
sesbania	6.1	32.7	22.5	28.5	49.0	2.2	3.9	1.2	5.5	22.5	27.5	41.0	31.5	1.9	2.9	1.3	Lemo District, Southern Ethiopia	Sinore et al.,2018
elephant grass	6.0	30.9	23.5	29.5	47.0	2.2	3.5	1.1	5.5	22.5	27.5	41.0	31.5	1.9	2.9	1.3		
Area exclosure	5.6	28.8	19.8	33.3	43	2.3	6.1	1.1	5.3	26.9	21.0	34.3	41	1.9	4.8	1.2	Wera Sub-Watershed Southern Ethiopia	Umer and Tamirat.2019
Closed without SWC	7.5		54.3	8.67	34	2.2			7.9		55.3	10. 7	34	1.0		1.1	Hawassa Zuria District	Tiki et al., 2015
Closed with SWC	7.1		51.3	10	38.7	2.4			7.9		55.3	10.7	34	1.0		1.1		
Old closed area	7.9						2.9		8.4					0.32	1.28		Tigray ighland	Descheemacke et al., 2006
Long term area closure	7.7	33.3				39.0		0.8	8.5	33.5				18.9		0.8	Tigray Regional State	

3. Effect of soil acidity on crop yield in Ethiopia

Soil acidity has become a serious threat to crop production in most highlands of Ethiopia (Abebe, 2007, Legesse *et al.,* 2013; Agegnehu *et al.,* 2019). As summarized **Table 4**, several authors have conducted to evaluate impact of soil acidity on grain yield and some selected chemical soil properties (Abewa *et al*.,2014; Dawud *et al*., 2018; Anbesa *et al*., 2018; kuma *,* 2019; Desalegn *et al*., 2017; Ayalew, 2019; Asrat, 2020). The yield increases by applying acid soil ameliorating materials over the control (no ameliorated) at the different locations and crops yield advantage were 48 and 99.5% minimum and maximum, respectively (Table 4). The positive response of crop when acid soil ameliorating materials due to the soil pH increasing conversely decreasing exchangeable acidity and aluminum ions precipitated with hydroxyl insoluble in soil solution. In addition, Al toxicity decreased in root vicinity. When soil pH is optimum macro nutrients and some micro nutrients are available (Table 4) for plant growth resulting yield and yield components were increased. However, varies from location to location the soil pH was differences that might to be the quality as well as quantity of ameliorating materials.

Abate *et al*. (2016) also evaluated Soil acidity under different land uses small-holders' mixed-farming system of northwest Ethiopia (Banja, Gozamin and Mecha) the higher soil pH at homestead and natural forest across the study arears. Asnake and Elias (2019) conducted study in Guba-Lafto Woreda of North Wollo. The result showed that the soil pH was higher in treated (6.2) than that of untreated (5.1); soil organic carbon (9.0,7.5), available phosphors (3.6, 1.7), exchangeable potassium (0.28 ,0.26) and cation exchangeable capacities (24.4,19.7) statistically significantly difference (at t and p-value) treated and untreated watershed, respectively. But the total nitrogen was highly significant ($P<1\%$) in treated (0.08) that of non-treated (0.3). Due to acid soil have managed either liming or application of organic matter or combination resulting increases yield advantage of 42 to 99.5 % as compared to control(Table 4).

Table 4. Effect of ameliorating and non-ameliorating acid soil yield and some chemical soil properties change in acid soil affected areas of Ethiopia.

. Location	Unlimed grain yield tone/ha	limed grain yield tone/ha	Crop type	Change of soil properties										Change of yield increment over the control	Reference
				before					After						
				pH	Exc. Acidity (Cmol kg)	Av P (mg /kg)	CEC (Cmolc/kg)	OC (%)	pH	Exc. Acidity (Cmol/ kg)	Av P (mg /kg)	CEC (Cmolc/kg)	OC (%)		
Jimma Southwestern Ethiopia	1.9	4.2	Maize	4.6	3.4	0.9	35.9	1.5	4.6	3.4	0.9	35.9	1.5	55%	**Dawud et al., 2018**
Assosa	0.65	3.6	sorghum	5.02	2.36	2.2	8.25		5.9	0.4	3.2			82% spilt application	Tamene *et al.,* 2018
Assosa	2.5	3.9	Sorghum	5.02	2.36	4.1	8.25		6.3	0.2	4.7			56%	Anbesa *et al.*,2018
Koga watershed	1.4	2.7	tef	5.4	0.60	12.8	14.69	1.66	8.4	0.5	18.9	20.7	1.91	48%	Abewa *et al.*,2014
Centeral Ethiopia	2.5	4.3	Barley	4.8	1.32	6.40	19.36	2.46	5.8	0.12				42%	Desalegn *et al.*, 2017):
Awi	0.6	2.6	Wheat	5.1	2.1	16.3		27	5.4	0.6	20.8		27	76%	Kuma *et al.,* 2019
Asosos	0.5	2.5	Sorghum	5.02	2.27	3.2			5.8	0.36	3.8			80%	Dereje *et al.,* 2018
Gozamin East Gojam	0.9	2	Tef	5.1	1.8	0.6	19	1.35						55	Asrat , 2020
	0.89	2.1		5.1	1.8	0.6	19	1.35						57	
Dolla	0.68	1.5	Haricot bean	5.3		1		0.15	5.6		6.1		0.31	55	Kassa, *et al.*, 2014
Gununo	0.67	1.48	Haricot bean	5		0.6		0.1	5.4		5.2		1.7	55	Kassa,*et al.*, 2014
Banja	1.0	2.1.	Faba Bean											52	Ayalew, 2019
Sodo			Haricot Bean	5.0	1.67	5.3	17		6.7	0.36	7.0	33			Buni 2014
Bedi			barley	4.8	1.3	6.4		2.4		5.3				99.5%	Alemu *et al.,* 2017

5. Conclusion and recommendation

Soil pH, is a master variable that affects a wide range of soil physico- chemical and biological properties of soil in ecosystem

In highly degraded area and extremely acidic affected prone areas, before installing soil and water conservation measures knowing about Atterberg limits, hydrologic and geotechnical the determinant factors so indispensable.

In acid affected soil, before installed biological or agronomic soil and water conservation measures should be identified suitable technologies or recommendation either acid soil tolerant or reclaim the soils

Biological soil and water conservation and soil management measure more rehabilitee acid affected soils than physical soil and water conservation due to addition of bio mass, resulting decomposition improve soil structure, aeration, apparition infiltration ultimate reduction of soil erosion functions .

REFERENCES

Abdissa, Bekele, Kibebew Kibret, Bobe Bedadi, Markku Yli-Halla, and Tesfaye Balemi. "Effects of lime, vermicompost, and chemical P fertilizer on selected properties of acid soils of Ebantu District, Western Highlands of Ethiopia." Applied and Environmental Soil Science 2018 (2018).

Abebe, Mesfin. "Nature and management of acid soils in Ethiopia." (2007).

Abewa, Anteneh, Birru Yitaferu, Yihenew G. Selassie, and Tadele Amare. "The role of biochar on acid soil reclamation and yield of Teff (Eragrostis tef [Zucc] Trotter) in Northwestern Ethiopia." *Journal of Agricultural Science* 6, no. 1 (2014): 1.

Agegnehu, Getachew, and Taye Bekele. "On-farm integrated soil fertility management in wheat on Nitisols of central Ethiopian highlands." Ethiopian Journal of Natural Resources 7, no. 2 (2005): 141-155.

Agegnehu, Getachew, Chilot Yirga, and Teklu Erkossa. "Soil acidity management." *Ethiopian Institute of Agricultural Research (EIAR). Addis Ababa, Ethiopia. pp* 21 (2019).

Alemayehu, Tigest, and Getachew Fisseha. "Effects of soil and water conservation practices on selected soil physico-chemical properties in Debre-Yakob Micro-Watershed, Northwest Ethiopia." *Ethiopian Journal of Science and Technology* 11, no. 1 (2018): 29-38.

Alemu, Getachew, Temesgen Desalegn, Tolessa Debele, Ayalew Adela, Geremew Taye, and Chelot Yirga. "Effect of lime and phosphorus fertilizer on acid soil properties and barley grain yield at Bedi in Western Ethiopia." *African Journal of Agricultural Research* 12, no. 40 (2017): 3005-3012.

Anbesa, Bekele, Getahun Dereje, Dessalegn Tamene, and Bogale Walelign. "Response of Sorghum and Soybean to Furrow Application of Lime and its Effect on the Acidity of Soils." *Soil Fertility and Plant Nutrient Management* (2018).

Asnake, Belay, and Eyasu Elias. "Effect of Soil and Water Conservation (SWC) Measures on Soil Nutrient and Moisture Status, a Case of Two Selected Watersheds." *Journal of Agricultural Extension and Rural Development* 11, no. 4 (2019): 85-93.

Asrat, Mekonnen, Markku Yli-Halla, and Mesfin Abate. "Effects of Lime, Manure and Kitchen Ash Application on Yield and Yield Components of Faba Bean (Vicia faba L.) on Acidic Soils of Gozamin District." *Journal of Plant Sciences* 8, no. 2 (2020): 17-28.

Bekele, A., Kibret, K., Bedadi, B., Balemi, T., & Yli-Halla, M. (2018). Effects of lime, vermicompost and chemical P fertilizer on yield of maize in Ebantu District, Western highlands of Ethiopia. *African Journal of Agricultural Research*, *13*(10), 477-489.

Bekele, Mathewos, Mulugeta Lemenih, and Alemayehu Regassa. "The effects of integrated soil and water conservation practices on soil physicochemical properties: the case of Menesibu District, West Ethiopia." *J Nat Sci Res* 6, no. 23 (2016): 35-45.

Belayneh, Mengie, Teshome Yirgu, and Dereje Tsegaye. "Effects of soil and water conservation practices on soil physicochemical properties in Gumara watershed, Upper Blue Nile Basin, Ethiopia." *Ecological Processes* 8, no. 1 (2019): 36.

Brady, Nyle C., and Ray R. Weil. The nature and properties of soils. Pearson, 2016.

Buni, Adane. "Effects of liming acidic soils on improving soil properties and yield of haricot bean." *J. Environ. Anal. Toxicol* 5, no. 1 (2014): 1-4.

Challa, Abay, Abdu Abdelkadir, and Tefera Mengistu. "Effects of graded stone bunds on selected soil properties in the central highlands of Ethiopia." *International Journal of Natural Resource Ecology and Management* 1, no. 2 (2016): 42-50.

Dagnachew, Melku, Awdenegest Moges, Asfaw Kebede, and Adane Abebe. "Effects of Soil and Water Conservation Measures on Soil Quality Indicators: The Case of Geshy Subcatchment, Gojeb River Catchment, Ethiopia." *Applied and Environmental Soil Science* 2020 (2020).

Dawud, J., Kebede, T., & Bekere, W. (2018). Integrated Nutrient Management on Maize Grown on Acid Soils. *Soil Fertility and Plant Nutrient Management*, *3*(2), 4.

Deng, Yusong, Chongfa Cai, Dong Xia, Shuwen Ding, Jiazhou Chen, and Tianwei Wang. "Soil Atterberg limits of different weathering profiles of the collapsing gullies in the hilly granitic region of southern China." *Solid earth* 8, no. 2 (2017): 499.

Dereje, Getahun, Dessalegn Tamene, Bekele Anbesa, and Bogale Walelign. "Response of Sorghum and Soybean to Lime and Phosphorus, Application and its Subsequent Effect on Acidity of Soils in Assosa Area." *Soil Fertility and Plant Nutrient Management* (2018).

Desalegn, Temesgen, Getachew Alemu, Ayalew Adella, and Tolessa Debele. "Effect of lime and phosphorus fertilizer on acid soils and barley (Hordeum vulgare L.) performance in the central highlands of Ethiopia." Experimental Agriculture 53, no. 3 (2017): 432-444.

Descheemaeker, Katrien, Jan Nyssen, Jean Poesen, Mitiku Haile, Bart Muys, Dirk Raes, Jan Moeyersons, and Jozef Deckers. "Soil and water conservation through forest restoration in exclosures of the Tigray highlands." *Journal of the Drylands* 1, no. 2 (2006): 118-133.

Getachew Agegnehu , Chilot Yirga, and Teklu Erkossa. "Soil acidity management." Ethiopian Institute of Agricultural Research (EIAR). Addis Ababa, Ethiopia. pp 21 (2019).

Goulding, K. W. T. "Soil acidification and the importance of liming agricultural soils with particular reference to the United Kingdom." *Soil use and management* 32, no. 3 (2016): 390-399.

Gratchev, Ivan, and Ikuo Towhata. "Stress–strain characteristics of two natural soils subjected to long-term acidic contamination." *Soils and foundations* 53, no. 3 (2013): 469-476.

Gratchev, Ivan, and Ikuo Towhata. "Stress–strain characteristics of two natural soils subjected to long-term acidic contamination." *Soils and foundations* 53, no. 3 (2013): 469-476.

Hailu, Worku. "Impact of physical soil and water conservation structure on selected soil physicochemical properties in Gondar Zuriya Woreda." *Resources and Environment* 7, no. 2 (2017): 40-48.

Haregeweyn, Nigussie, Atsushi Tsunekawa, Jan Nyssen, Jean Poesen, Mitsuru Tsubo, Derege Tsegaye Meshesha, Brigitta Schütt, Enyew Adgo, and Firew Tegegne. "Soil erosion and conservation in Ethiopia: a review." *Progress in Physical Geography* 39, no. 6 (2015): 750-774.

Haynes, R. J., and M. S. Mokolobate. "Amelioration of Al toxicity and P deficiency in acid soils by additions of organic residues: a critical review of the phenomenon and the mechanisms involved." Nutrient cycling in agroecosystems 59, no. 1 (2001): 47-63.

Kamprath, E. J. "Exchangeable aluminum as a criterion for liming leached mineral soils 1." Soil Science Society of America Journal 34, no. 2 (1970): 252-254.

Kamprath, Eugene J. "Soil acidity and liming." Century of Soil Science. North Carolina, Soil Science Society of North Carolina (2003): 103-107.

Kamprath, Eugene J. "Soil acidity and liming." Century of Soil Sience. North Carolina, Soil Science Society of North Carolina (2003): 103-107.

Kassa, Mesfin, Belay Yebo, and Abera Habte. "The response of haricot bean (Phaseolus vulgaris L.) varieties to phosphorus levels on nitosols at Wolaita Zone, Ethiopia." *Greener Journal of Plant Breeding and Crop Science* 2, no. 4 (2014): 82-87.

Kassahun, Behailu. "Soil fertility mapping and fertilizer blending." Ethiopian Agricultural Transformation Agency (Ethiopian ATA) report, Addis Ababa (2015).

Kebede, Birhanu, Atsushi Tsunekawa, Nigussie Haregeweyn, Amrakh I. Mamedov, Mitsuru Tsubo, Ayele Almaw Fenta, Derege Tsegaye Meshesha et al. "Effectiveness of Polyacrylamide in Reducing Runoff and Soil Loss under Consecutive Rainfall Storms." *Sustainability* 12, no. 4 (2020): 1597.
Kebede, Birhanu, Atsushi Tsunekawa, Nigussie Haregeweyn, Amrakh I. Mamedov, Mitsuru Tsubo, Ayele Almaw Fenta, Derege Tsegaye Meshesha et al. "Effectiveness of Polyacrylamide in Reducing Runoff and Soil Loss under Consecutive Rainfall Storms." *Sustainability* 12, no. 4 (2020): 1597.
Kochian, Leon V., Owen A. Hoekenga, and Miguel A. Pineros. "How do crop plants tolerate acid soils? Mechanisms of aluminum tolerance and phosphorous efficiency." *Annu. Rev. Plant Biol.* 55 (2004): 459-493.

Kuma Megersa, Mesfin. "Effects of Lime and Phosphorus Levels on Selected Soil Chemical Properties and Bread Wheat (Tritium Aestivum L.) Yield on Acidic Soil of Banja District, North Western Ethiopia." PhD diss., Haramaya University, 2019.

Läuchli, Andre, and Stephen R. Grattan. "Soil pH extremes." *Plant stress physiology* (2012): 194.

Legesse, Hirpa, R. Nigussie-Dechassa, Setegn Gebeyehu, Geremew Bultosa, and Firew Mekbib. "Response to soil acidity of common bean genotypes (Phaseolus vulgaris L.) under field conditions at Nedjo, western Ethiopia." Science, Technology and Arts Research Journal 2, no. 3 (2013): 03-15.

Mamuye, Melkamu, Amsalu Nebiyu, Eyasu Elias, and Gezahegn Berecha. "Short-term improved fallows of Tephrosia vogelii and Cajanus cajan enhanced maize productivity and soil chemical properties of a degraded fallow land in Southwestern Ethiopia." *Agroforestry Systems* (2020): 1-11.
Mamuye, Melkamu, Amsalu Nebiyu, Eyasu Elias, and Gezahegn Berecha. "Short-term improved fallows of Tephrosia vogelii and Cajanus cajan enhanced maize productivity and soil chemical properties of a degraded fallow land in Southwestern Ethiopia." *Agroforestry Systems* (2020): 1-11.
Marcus, Jerrold J. "Mining environmental handbook: effects of mining on the environment and American environmental controls on mining." (1997).

Matsumoto, Shinji, Shunta Ogata, Hideki Shimada, Takashi Sasaoka, Akihiro Hamanaka, and Ginting Jalu Kusuma. "Effects of pH-induced changes in soil physical characteristics on the development of soil water erosion." *Geosciences* 8, no. 4 (2018): 134.

Matzne, E., D. Murach, and H. Fortmann. "Soil acidity and its relationship to root growth in declining forest stands in Germany." *Water, Air, and Soil Pollution* 31, no. 1-2 (1986): 273-282.

Mekonnen, Asrat,. "Amelioration of Acidic Soil to Increase Tef (Eragrostis tef (Zucc) Trotter) Yield on Smallholder Farmer Fields in Ethiopian Highlands." Journal of Plant Sciences 8, no. 1 (2020): 1-11.

Melsew, Ayalew Muluye. "The Effects of Lime on Acid Properties of Soil and on Faba Bean Yield in Banja District. The Case of Sankit Lideta, Awi Zone Amhara Regional State, Ethiopia." *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)* 57, no. 1 (2019): 109-123.

Naramabuye, F. X., and Richard J. Haynes. "Effect of organic amendments on soil pH and Al solubility and use of laboratory indices to predict their liming effect." Soil science 171, no. 10 (2006): 754-763.

Rahman, Md Jiaur, Priyatharini Ambigaipalan, and Fereidoon Shahidi. "Biological Activities of Camelina and Sophia Seeds Phenolics: Inhibition of LDL Oxidation, DNA Damage, and Pancreatic Lipase and α-Glucosidase Activities." *Journal of food science* 83, no. 1 (2018): 237-245.

Rawat, Jyoti, Jyoti Saxena, and Pankaj Sanwal. "Biochar: a sustainable approach for improving plant growth and soil properties." In Biochar-An Imperative Amendment for Soil and the Environment. IntechOpen, 2019.

Rengel, Zed. "Availability of Mn, Zn and Fe in the rhizosphere." *Journal of soil science and plant nutrition* 15, no. 2 (2015): 397-409.

Ribeiro, Bruno Teixeira, José Maria Lima, Nilton Curi, and Geraldo César Oliveira. "Electrochemical attributes of soils influenced by sugarcane vinasse." *Bioscience Journal* 28, no. 1 (2012).

Sade, Hemalatha, Balaji Meriga, Varalakshmi Surapu, Jogeswar Gadi, M. S. L. Sunita, Prashanth Suravajhala, and PB Kavi Kishor. "Toxicity and tolerance of aluminum in plants: tailoring plants to suit to acid soils." Biometals 29, no. 2 (2016): 187-210.

Scholz, Sebastian M., Thomas Sembres, Kelli Roberts, Thea Whitman, Kelpie Wilson, and Johannes Lehmann. Biochar Systems for Smallholders in Developing Countries: Leveraging Current Knowledge and Exploring Future Potential for Climate-Smart Agriculture. World Bank Studies. Washington, DC: World Bank. doi:10.1596/978-0-8213-9525-7. License: Creative Commons Attribution CC BY 3.0 IGO

Shafi, Abdrahman, Achalu Chimdi, Teshome Yitbarek, and Ethiopia Ambo. "Effects of Soil and Water Conservation Practices in Selected Soil Physicochemical Properties: The Case of Ezha District, Southern Ethiopia." (2019).

Singh, Bijay. "Are nitrogen fertilizers deleterious to soil health?" Agronomy 8, no. 4 (2018): 48.

Sinore, T., Kissi, E., & Aticho, A. (2018). The effects of biological soil conservation practices and community perception toward these practices in the Lemo District of Southern Ethiopia. *International soil and water conservation research*, *6*(2), 123-130.

Tamene, Dessalegn, Bekele Anbesa, Getahun Dereje, and Bogale Walelign. "Response of Sorghum and Soybean to Split Application of Lime." *Soil Fertility and Plant Nutrient Management* (2018).

Tesfaye, Tanto, and Fanuel Laekemariam. "Impacts of soil and water conservation practices on soil property and wheat productivity in Southern Ethiopia." Environmental Systems Research 8, no. 1 (2019): 1-9.

Tiki, Lemma, Menfes Tadesse, and Fantaw Yimer. "Effects of integrating different soil and water conservation measures into hillside area closure on selected soil properties in Hawassa Zuria District, Ethiopia." *Journal of Soil Science and Environmental Management* 6, no. 10 (2015): 268-274.

Umer, Solomon, and Tamrat Sinore. "Effects of Area Exclosure on Soil Properties and Farmers' Awareness Towards the Practice in Wera Sub-Watershed at Analemo Woreda, Southern Ethiopia." *International Journal of Agricultural and Environmental Sciences* 4, no. 1 (2019): 1.

Von Uexküll, H. R., and E. Mutert. "Global extent, development and economic impact of acid soils." Plant and soil 171, no. 1 (1995): 1-15.

Von Uexküll, H.R.; Mutert, E. Global extent, development and economic impact of acid soils. In Plant-Soil Interactions at Low pH: Principles and Management, Proceedings of the Third International Symposium on Plant-Soil Interactions at Low pH, Brisbane, Queensland, Australia, 12–16 September 1993; Date, R.A., Grundon, N.J., Rayment, G.E., Probert, M.E., Eds.; Springer: Dordrecht, The Netherlands, 1995; pp. 5-19.

White, W. Arthur. "Atterberg plastic limits of clay minerals." *American Mineralogist: Journal of Earth and Planetary Materials* 34, no. 7-8 (1949): 508-512.

Wilson, M. J. "The importance of parent material in soil classification: A review in a historical context." Catena 182 (2019): 104131.

Wilson, M. J. "The importance of parent material in soil classification: A review in a historical context." *Catena* 182 (2019): 104131.

Wolka, Kebede, Awdenegest Moges, and Fantaw Yimer. "Effects of level soil bunds and stone bunds on soil properties and its implications for crop production: the case of Bokole watershed, Dawuro zone, Southern Ethiopia." *Agricultural Sciences* 2, no. 03 (2011): 357.

Yao, Luhua, Xiangyu Yu, Lei Huang, Xuefeng Zhang, Dengke Wang, Xiao Zhao, Yang Li et al. "Responses of Phaseolus calcaltus to lime and biochar application in an acid soil." PeerJ 7 (2019): e6346.

Yu, Zaipeng, Han YH Chen, Eric B. Searle, Jordi Sardans, Philippe Ciais, Josep Peñuelas, and Zhiqun Huang. "Whole soil acidification and base cation reduction across subtropical China." Geoderma 361 (2020): 114107.

Zegeye, Assefa D., Eddy J. Langendoen, Cathelijne R. Stoof, Seifu A. Tilahun, Dessalegn C. Dagnew, Fasikaw A. Zimale, Christian D. Guzman, Birru Yitaferu, and Tammo S. Steenhuis. "Morphological dynamics of gully systems in the subhumid Ethiopian Highlands: the Debre Mawi watershed." *Soil* 2, no. 3 (2016): 443-458.

Zhang, Ling, Jinman Wang, Zhongke Bai, and Chunjuan Lv. "Effects of vegetation on runoff and soil erosion on reclaimed land in an opencast coal-mine dump in a loess area." *Catena* 128 (2015): 44-53.