JIMMA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
COLLEGE OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

M.Sc. THESIS ON:

ASSESSING THE EFFECT OF LAND USE TYPES ON SOIL PHYSICAL AND CHEMICAL PROPERTIES IN SITO KEBELE, DEDO DISTRICT JIMMA ZONE, OROMIA REGION, SOUTHWEST ETHIOPIA.

OCTOBER, 2017
JIMMA, ETHIOPIA

ASSESSING THE EFFECT OF LAND USE TYPES ON SOIL PHYSICAL AND CHEMICAL PROPERTIES IN SITO KEBELE, DEDO DISTRICT, JIMMA ZONE, OROMIA REGION, SOUTHWEST ETHIOPIA.

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DEDICATION

This thesis is especially dedicated to his wife**,** Nini Eshetu and his son Kalid Mekonnen for their patience during his stay in study.

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LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
Av. P	Available Phosphorus
BD	Bulk density
CEC	Cation Exchange Capacity
DTPA	Diethylene Triamine Pentaacetic Acid
EC	Electrical Conductivity
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
LSD	Least Significance Difference
Masl	Meter above sea level
OC	Organic carbon
OM	Organic Mater
PD	Particle density
SEM	Standard Error of Mean
SAS	Statistical Analysis System

ABSTRACT

The study was conducted at the Sito kebele, which is located in the Dedo District of Jimma zone, Oromia Region. The aims of the study were to investigate the influence of land use systems on the degree and directions of quality of soil resources and within and among land use types and soil depth. The influence of land use systems on soil properties were analyzed using the analysis of variance general linear model procedure of SAS software. Mean differences due to land use, soil depth and their interaction effect were identified. The results showed that most of the soil physicochemical properties varied with land use systems as well as soil depth. For instance soil texture (sand, and clay), bulk density, total porosity, pH (H_2O), OM, Total N, available P, CEC, exchangeable K, exchangeable Na, exchangeable acidity and available micronutrient(Fe, Mn, Zn and Cu) studied were significantly affected ($P \leq 0.05$ by land use. In contrast, particle density, exchangeable Ca and Mg were not significantly ($P > 0.05$) affected by different due to land use. Bulk density increased from 1.20 g cm^{-3} in grazed soils to 1.31 g cm^{-3} in cultivated land soils. Clay fractions increased from 29.05% in the grazing lands to 33.15% in the soils of the cultivated land .Soil pH-H_2O decreased from 5.86 to 4.9 in grazed to the cultivated land soils. The soil attributes under the cultivated land showed an overall change towards the direction of loss of its fertility compared to the adjacent grazing land soils.

INTRODUCTION

1.1. Background of the Study

Land use types is one of the main drivers of environmental change being a major issue of global environmental change and an important component in understanding the sequence of changes in the characteristics and the interactions of the human activities with the environment. This change influences the basic reserves of land and a variety of natural process, including the soils which are not static and hence more susceptible to change in their nutrient and moisture content. Agriculture is an underlying basis of the economy of Ethiopia which forms the main source of livelihood for over 90% of its population, accounts for over 50% of the country's gross Domestic product and contributes to over 90% of its foreign exchange earnings [1]. Ethiopia is endowed with potentially rich natural resources, of which land is the Principal one. However, its productivity is continuously declining, due to continuous cultivation without adequate management methods.

Rapid increase in the world's population demands the production of ever increasing quantity of food, fiber and fuel from the land. To meet these needs, vast tract of land are being farmed more intensively, and large areas of grasslands are being overgrazed and degraded. Additionally, new and often marginal land is being brought into production. So, land must be carefully managed, if its productivity is to be maintained or increased. If it is not well managed, or used in a way that is beyond its potential, soil degradation will inevitably occur [2]. It is important to establish land use system that allow for the demands of increasing population while conserving the soil fertility in the long term. Soil resources are finite and non-renewable over human time frames and are prone to degradation by misuse and mismanagement [3].

Soil fertility maintenance is a major concern in tropical Africa, particularly with the rapid population increase, which has occurred in the past few decades. In traditional farming systems, farmers use bush fallow, plant residues, household refuse, animal manures and other organic nutrient sources to maintain soil fertility and soil organic matter. Soil organic matter not only plays a major role in soil fertility by affecting physical and chemical properties, but also controls soil microbial activity by serving as a source of mineralizable carbon and nitrogen. In mature and undisturbed tropical ecosystems, a balance exists between the organic carbon input and output of the soil because of mineralization and Leaching of dissolved OM [4]. In many management options such as keeping grasses in the crop rotation, returning all crop residues to the fields and cultivating no more than necessary, controlling erosion, using cover crops whenever possible, returning all manures to the soil and adding organic materials are considered as important sources of plant nutrients and improvement of soil physical and chemical properties [5].

Although this reliance on biological nutrient sources for soil fertility regeneration is adequate with low cropping intensity, it becomes unsustainable with more intensive cropping unless fertilizers are applied [6].The causes of land degradation in Ethiopia are cultivation on steep and fragile soils with in adequate investments in soil conservation or vegetation cover, erratic and erosive rainfall patterns, declining use of fallow, limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, deforestation and overgrazing [7]. Therefore, reducing resource degradation, increasing agricultural productivity, reducing poverty, and achieving food security are major challenges of the countries in tropical Africa. Thus, every effort should be directed to maintain the physical, biological and socio- economic environment for production of food crops, livestock, wood and other products through sustainable use of the ecosystem. The continuous use of land for cultivation and grazing purposes for centuries have resulted in disastrous loss of soil nutrients particularly in the highlands where erosion is more severe [8]. As a result, agriculture in the country has gradually expanded from gentle slopping surfaces in the highlands on to steeply sloped places of the nearby hills and mountain surfaces [9].

The different land use and land management systems significantly contribute to the variation in soil physicochemical properties. Physical and chemical characteristics of the soils on land under continuous cultivation vary from the land that remains uncultivated for a long period of time [10]. The land use system affects basic processes such as erosion, soil structure and aggregate stability, nutrient cycling, leaching, carbon sequestration and other physical and biochemical processes. The disturbance of soils has had the ultimate effects of adding to or subtracting from.

Soil fertility and plant nutrition are two closely related subjects that emphasize the forms and availability of nutrients in soils, their movement to and their uptake by roots, and the utilization of nutrients within plants [11]. Without maintaining soil fertility, one cannot talk about increment of agricultural production in feeding the alarmingly increasing population. Therefore, to get optimum, sustained-long lasting and self-sufficient crop production, soil fertility has to be maintained.

In the Ethiopian highlands, population pressure which accounts for 85% of the country's total population as well as 67% of its livestock population has pushed cultivation and livestock grazing to steep slopes and fragile lands causing serious overgrazing and soil erosion. The highland of the Oromia Region particularly in Jimma zone specialy in Dedo District where the present study were conducted are exceptions of these problems. However, no little effort has been done to maintain the fertility of the soils in the area and the locally available data of soil fertility status are insufficient. As a consequence of continuous cultivation and intensive grazing of land without proper management resulted in decline in soil physical, chemical and biological properties which aggravate crop yield reduction and food shortage. Nowadays, due to increasing population pressure and shortage of new innovation in the area land degradation and free grazing activities are being carried out on previous land which used for many years. This in turn has led to declining soil productivity and shortage of livestock fodder. The soils of Sito kebele, Dado District have been continuously cultivated, overgrazed, inappropriate soil management system and erosion. Although knowledge of soil physical and chemical properties plays a vital role in enhancing productivity and production of the agricultural sector on stainable basis, very little information is available in the study area. Therefore, this study was conduct with the specific objective of assessing the effect of land use systems on selected soil physical and chemical properties along soil depth.

1.2 Statement of the Problem

In Ethiopia about 85% of the population depends on agriculture and continuously cultivating a single plot of land so as to meet their needs. Continuous use of a single plot of land leads disastrous loss of soil nutrients because of seeker erosion .Thus; in order to sustain soil fertility continues monitoring physico - chemical properties of soil is one mandatory foot step. Meanwhile, there is no a formation study on physico – chemical properties of soil in the titled area, Therefore, this study targets to assesses the effect of land use types on physic-chemical properties of soil in Sito kebele, Dedo District, Jimma Zone through giving satisfying answer for the following question.

1. What are the effects of land use types on different soil properties?
2. What are the differences of physico-chemical properties of the two land use types?
3. What is the impact of soil depth on selected physicochemical properties of soils of the study area?

1.3 Objective of the Study

1.3.1. General objective

The main objective of the study was to assess the effect of land use types and soil depth on physicochemical properties of soils.

1.3.2. Specific objectives

The specific objectives of the present study were to:

- ✓ determine selected soil parameters of different land use types of the study area.
- ✓ evaluate the effect of land use types on selected soil quality parameters.
- ✓ evaluate the impact of soil depth on selected soil physicochemical properties of the study area.

1.4 Significance of the Study

Land use is one of the most rapidly growing research areas. The researcher may get benefit from this study to develop scientific research writing skill and literature collecting skill. This research will help for other researchers to develop a new learning process by using various experimental methods. This research also will help for policy makers and concerned persons to know about the fertility of the soil of the study area. Also the result of this study may contribute to the area of assessing land in giving some background information and guiding activities for those who need to conduct further research on this study area.

2. LITERATURE REVIEW

2.1. Land and Land use

Land is a delineable area of the earth's terrestrial surface embracing all attributes of the biosphere immediately above or below this surface, including those of the near surface climate, the soil and terrain forms, the plant and animal populations, the human settlement pattern and Physical results of past and present human activity [12]. Land is a fundamental factor of production, and through much of the course of human history, it has been tightly coupled with economic growth [13]. As a result, control over land and its use are off ten objects of intense human interaction. Human activities that make use of, and hence change or maintain, attributes of land cover are considered the proximate sources of change. They range from the initial conversion of natural forest into cropland to on-going management [14]. Land use practices affect the distribution and supply of soil nutrients by directly altering soil properties and by influencing biological transformations in the rooting zone. It can either help or hinder soil erosion, and thus land use is the main factor that impact physical, chemical and biological processes of the soils.

2.1.1. Impact of land use system on soil fertility

These days, land use changes are operating over an immeasurably greater proportion of the globe's land area. Different time spans have been observed for the occurrence of these changes after sedentary agriculture was started. Some changes were very short and of an exploitative nature, while others were long and stable [15]. In developing countries, including Ethiopia, the amount, rate and intensity of land use changes are very high. Human impacts upon the land are still very great and increasing [16]. Extensive deforestation and conversion of natural forests into agricultural fields is the most widespread change in land use system in Ethiopian ecosystems. In the past 100 years only, the total area of land covered by forest in Ethiopia has declined from about 40% to as estimated 2.4% in 1990 [17]. The rate of deforestation is estimated to be between 150,000 and 200,000 ha per annum [18] .from which as a result one can see the scale of clearance has been massive. Destruction continued unabated especially in south and the south western parts of the country where most of the remnant sub-humid tropical forests are found [19]. Few studies were conducted to monitor and quantitatively describe the land use changes undergone in the last half a century across different parts of the country. Findings revealed a general decline in forest land with subsequent expansion of cultivated land [20]. Reported a 99% decline in forest cover and a95% subsequent expansion in cultivated land between1957 and 1995, in south-western Ethiopia. The authors attributed this to two reasons that partially explain the small increase in cultivated areas, the reasons being either the areas left uncultivated were not suitable for cultivation or they were under the protection of the Ministry of Agriculture.

2.2. Physical Properties of Soils

The physical properties of soils determine their adaptability to cultivation and the level of biological activity that can be supported by the soil. The physical properties of the soil are influenced by the size, proportion, arrangement and mineral composition of the soil particles. Soil physical properties also largely determine the soil's water and air supplying capacity to plants. Many soil physical properties change with changes in land use system and its management such as intensity of cultivation, the instrument used and the nature of the land under cultivation, rendering the soil less permeable and more susceptible to runoff and erosion losses [21].

2.2.1 Soil texture

Soil texture (the proportion of sand, silt and clay) is an inherent property of soil and changes little with land use or management practice. It can be measured qualitatively in the field or quantitatively in the laboratory and is an important property because it determines the amount of water a soil can hold when fully wet and the rate at which water and dissolved solutes are potentially available for vine uptake.

Soil texture determines a number of physical and chemical properties of soils, such as infiltration and retention of water, soil aeration, and absorption of nutrients, microbial activities, and tillage and irrigation practices [22]. It is also indicative for some other related soil features such as type of parent materials, homogeneity and heterogeneity within the profile, migration of clay and intensity of weathering of soil material or age of soil [23]. The fine and medium textured (clay loam, silt clay loam, silt loam) soils are favorable for agriculture because of their high retention of available water, OM and exchangeable nutrient contents [24]. The same authors reported that soils relatively higher in clay content tend to be stabilized and retain more OM than those low in clay content. Soil texture forms the inherent property of soils and textural classes are not subject to easy modification in the field [25]. Whereas, this property is subject to change under conditions of land use change, which leads to varied, soil management practices that may contribute indirectly for changes in particle size distribution. Under land use changes, which usually involve conversion from forest to cultivated lands, the soil protective cover loosens and erosion prevails. Whilst soil erosion takes place, fine particles are preferentially moved, resulting in a greater concentration of clay and silt in the sediments than in the original soil [26]. This ultimately caused to change the particle size fraction composition of the original soil. This phenomenon is observed in the Ethiopian highlands where severe soil erosion prevails. Over a very long period, pedogenic processes such as erosion, deposition, elevation and weathering can alter the textures of various soil horizons [27].

2.2.2 Bulk density particle density and porosity

Bulk density is the weight of dry soil solids per unit volume of total soil including the pore space. Bulk density is a soil property required for calculating soil pore space, as an indicator of aeration status and water content. Study indicate that values of bulk density range from < 1 g cm^{-3} for soils high in OM, 1.0 to 1.4 g cm^{-3} for well- aggregated loamy soils and 1.2 to 1.8 g cm^{-3} for sandy soil and compacted horizons in clay soils. Bulk density normally decreases as mineral soils become finer in texture. Soils having low and high bulk density exhibit favorable and poor physical conditions, respectively [28]. Bulk densities of soil horizons are inversely related to the amount of pore space and soil OM which is highly influenced by land use and management practice [29]. Any factor that influences soil pore space will also affect the bulk density.

Particle density, the mass per unit volume of solid soil particle; affects soil porosity, aeration and rate of sedimentation of particles. In most mineral soils (3.5% OM), the particle density ranges from 2.60 to 2.75 g cm^{-3} with the mean density of 2.65 g cm-3 for arable mineral surface soils, but the presence of iron oxide and heavy minerals increases the average value of particle density and the presence of OM lowers it [30]. The surface soil layer had lower particle density value than the subsoil horizons and the highest particle density (2.93 g cm^{-3}) was obtained at the subsoil horizons of soil in different land use systems at different elevations [31]. This is attributed to the lower OM content in the subsoil than in the surface horizons.

The total porosity of the soils usually lies between 30 and 70%, and may be used as a general indication of the degree of compaction in a soil in the same way as bulk density is used. In soils with the same particle density, the lower the bulk density, the higher is the percent pore space (total porosity). Apart from quantities and distribution, the porosity and continuity of pores are important features influencing aeration, water movement and root penetration in soils, but they are less easily measured and in most surveys, only qualitative observation are made [32]. The arrangement of soil particles determines the amount, shape and direction of pore space. As soil particles vary in size and shape, pore spaces also vary in size, shape and direction [33]. Coarse textured soils tend to be less porous than fine texture soils, although the mean size of individual pores is larger in the former than in the latter.

2.3. Soil chemical properties

The primary function of soil in relation to chemical properties is to provide nutrients for plant and crop growth. In addition, the soil's chemical properties need to be suitable for nutrient uptake. Soil chemical properties are the most important among the factors that determine the nutrient supplying power of the soil to the plants and microbes. The chemical reactions that occur in the soil affect processes leading to soil development and soil fertility build up. Minerals inherited from the soil parent materials overtime release chemical elements that undergo various changes and transformations within the soil.

2.3.1 Soil pH and electrical conductivity

Soil pH is a measure of its acidity or alkalinity and is an important property because of its influence on the supply of nutrients (cations and anions) to plants, the chemical Behavior of toxic elements and the activity of microorganisms. Soil pH is a useful soil quality indicator because it influences, and is influenced by so many other soil properties. For example, it affects the rate of chemical weathering of soil minerals, decomposition, Al-toxicity, mummifications, formation of new minerals, activity of soil microorganisms, and availability of nutrient to plants and growth of many agricultural crops. Therefore, it is a good guide for predicting which plant nutrients are likely to be deficient [34]. A number of soils fertility characters can be interpreted from the soil pH. The higher pH could have contributed to increased negative charge surfaces (of mineral or humid substances), consequently leading to a higher CEC and increased availability of phosphate ions [35]. Electrical conductivity (EC) measurements, using either a saturated extract from soil paste (ECe) or a 1:5 soil: Water suspensions provide an estimate of the total soluble salts. Electrical conductivity of saturation extract (ECe) of the soil is heavily dependent on Climatic conditions of the area in consideration. In soils of sub-humid tropics where there Is sufficient rainfall to flush out base forming cations from the root zone, EC is found too low, usually, less than 4 dS/m [36]. Accordingly, owing to the high soil acidity levels (slightly acidic to very strongly acidic), the EC values are negligible and there were no apparent differences in electrical conductivity among the different soil management systems in the soils of western Ethiopia [37].

2.3.2 Soil organic matter

Organic matter (OM) is usually expressed in the form of organic carbon (OC). OC is readily available as a carbon and energy source and is important because of its association with nutrients and the beneficial contributions. Soil organic matter is a large reservoir of carbon that can act as a sink or source of atmospheric CO_2 [38]. Its effects are sound far out of proportion to the small quantities present, hence, considered the single most important indicator of soil quality [39]. Meanwhile, many factors that change soil organic matter levels and forms are controlled by management, and also processes governing its dynamics are complex. These found it to be the most sensitive soil characteristics to land use change [40]. These differ across eco-regions and strongly interact with land use, farming systems and soil/crop management systems [41]. The changes in land use impact soil OM pools and fluxes. The impact due to land use change on OM content depends on a number of factors such as the old and new land use types, the soil type, management and climate [42, 43]. These changes typically result in differing rates of soil erosion, aggregate formation, biological activity, and drainage all of which have a profound impact on OM accumulation and CO_2 evolution. However, forest and pasture lands make up the potential to build up large amounts of OM, whereas conversion of natural ecosystem to croplands which results in high rate of its turnover led to decline level of OM [44].

Extensive deforestation and conversion of natural forests into agricultural lands in Ethiopian ecosystems led to significant decline in forest-derived OM levels of these tropical soils. The conversion of forest land into cultivation and grazing led to a drop down of OM to 87% and 85%, respectively at Chemoga watershed, the sub humid tropical agro ecosystem [45]. In favor of this, the intensive cultivation decreased soil OM content as compared to the uncultivated counterpart of the same soil. Similarly, Solomon *et al* reported a drop down of OM by 55% (32.0 Mg ha^{-1}) at Wushwush and by 63% (40.2 Mg ha^{-1}) at Munessa following conversion of natural forest to cultivated fields after 25 and 30 years of continuous cultivation, respectively [46]. In general, one can confirm that losses of forest-derived OM were not fully compensated by OM input from the cereal crops due to its low OM inputs and removal of residues from cultivated fields. This indicates that land use practices that have detrimental effects on OM level and composition have far-reaching implications because of the multiple roles that OM plays in soil quality and link with soil fertility [47].

2.3.3. Total nitrogen and C: N ratio

In view of high nitrogen requirements of plants and low levels of available N in virtually. All type of soils, it is considered most important and dynamic nutrient element in managed ecosystems. Soil total N (TN) composed of inorganic (NH_4^+, NO_3^- and NO_2^-) and organic forms (OM) are subject to change due to various factors. Management (cropping, fertilization, erosion and leaching) and climate (temperature and moisture) determine its level and dynamics [48]. Climatic conditions, especially temperature and rainfall generate dominant influence on the amounts of nitrogen and organic matter found in soils. As one moves from warmer to cooler zones, the OM and nitrogen contents of comparable soils tend to increase [49]. At the same time, the C: N ratio increases to some extent. However, it is quite susceptible to changes in management practices that cause changes in level of OM content [50].

2.3.4. Available phosphorus

Phosphorus (P) is known as the master key to agriculture because lack of available P in the soils limits the growth of both cultivated and uncultivated plants [51]. Following N, P has more wide spread influence on both natural and agricultural Ecosystems than any other essential elements. In most natural ecosystems, such as forests and grasslands, P uptake by plants is constrained by both the low total quantity of the element in the soil and by very low solubility of the scarce quantity that is present [52]. It is the most commonly plant growth-limiting nutrient in the tropical soils next to water and N [53]. Erosion tends to transport predominantly the clay and OM fractions of the soil, which are relatively rich in P fractions. Thus, compared to the original soil, eroded sediments are often enriched in P by a ratio of two or more [54]. The natural soil will contain from 50 to over 1,000 mg of total P per kilogram of soil. Of this quantity, about 30 to 50% may be in inorganic form in mineral soils [55]. The main sources of plant available P are the weathering of soil minerals, the Decomposition and mineralization of soil OM and commercial fertilizers. Most of the soils in Ethiopia and other acid soils are known to have low P contents, not only due to the inherently low available P content, but also due to the high P fixation capacity of the soils [56].

2.3.5. Cation exchange capacity

The Cation exchange capacity (CEC) of soils is defined as the capacity of soils to adsorb and exchange cations [57]. The cation exchange capacity (CEC) of a soil represents the capacity of the soil to hold and exchange positively charged cations. It is an important property since it influences the structural stability and pH of soil, the availability of nutrients for plant growth, and the soil's reaction to fertilizers and other ameliorants. Cation exchange capacity is an important parameter of soil because it gives an indication of the type of clay minerals present in the soil, its capacity to retain nutrients against leaching and assessing their fertility and environmental behavior. Generally, the chemical activity of the soil depends on its CEC. In the mineral soils, the clay fraction is largely responsible for cation exchange properties [58]. Cation exchange consists of an interchange between cations adsorbed on charged surfaces and actions in the soil solution. The cation exchange mechanism is a dominant and pervasive factor in soil chemistry. Over 99% of the cations are adsorbed on the colloidal surfaces and less than 1% is present in solution (except in saline soils and a few very highly weathered soils) [59]. Cation exchange capacity is essentially a property of the colloidal fraction of soil, derived mainly from the clay and OM fractions; although the silt sized particles sometimes contribute significantly [60].

2.3.6 Exchangeable potassium and sodium

Potassium (K) is the third most important plant growth-limiting nutrient just next to N and P. Its behavior in the soil is influenced primarily by soil cation exchange properties and mineral weathering rather than by microbiological processes. Unlike N and P, K causes no offsite environmental problems when it leaves the soil system. It is not toxic and does not cause eutrophication in aquatic system [61]. The increasing applied rate of K fertilizers displaced both exchangeable Ca and Mg into the soil solution from where they could be lost by leaching [62]. The variation in the distribution of K depends on the mineral present, particle size Distribution, degree of weathering, soil management practices, climatic conditions, Degree of soil development, the intensity of cultivation and the parent material from which the soil is formed. For instance, soils formed from sedimentary materials are generally low in K content, while soils formed from crystalline rocks contain relatively high K [63].

Exchangeable sodium (Na) alters soil physical and chemical properties mainly by inducing swelling and dispersion of clay and organic particles resulting in restricting water permeability and air movement and crust formation and nutritional disorders (decrease solubility and availability of calcium (Ca) and magnesium (Mg) ions) [64]. Moreover, it also adversely affects the population, composition and activity of beneficial soil microorganisms directly through its toxicity effects and indirectly by adversely affecting soil physical and as well as chemical properties. In general, high exchangeable Na in soils causes soil sodality which affects soil fertility and productivity.

2.3.7 Exchangeable calcium and magnesium

Calcium (Ca) and magnesium (Mg) are more strongly adsorbed by clay than K and Na because they are divalent cations and have the smallest hydrated radius. As a result of the small energy of adsorption of K and Na, it is more likely to exist in the soil solution and be removed from the soil by leaching [65]. Soils in the area of moisture scarcity, such as in arid and semi arid regions, have less potential to be affected by leaching of cations than do soils of humid and sub humid regions. The exchangeable Ca in a soil has an important relation to soil pH and the availability of several nutrient elements. The amount of Ca and other basic cations present in a soil decline as a soil become more acidic and increase as it becomes more alkaline [66]. Soils under continuous cultivation, application of acid forming inorganic fertilizers, high exchangeable and extractable Al and low pH are characterized by low contents of Ca and Mg mineral nutrients resulting in their deficiencies due to excessive leaching [67]. Exchangeable cations generally are available to both higher plants and microorganisms [68]. By cation exchange, H^+ ion from the root hair and microorganisms replace nutrient cations from the exchange complex.

2.3.8. Micronutrients (Fe, Mn, Zn and Cu)

The micronutrients in soils are of diverse groups of elements that are slowly released into the soil solution from the pedochemical and geochemical weathering of rocks and minerals. While the four cationic micronutrient elements namely iron (Fe), manganese (Mn), zinc (Zn) and cupper (Cu) occur mainly in the divalent form in soils; differences in the ionic characters of their chemical bonding are great enough so that only Fe^{2+} and Mn^{2+} can substitute extensively for each other. Micronutrient supply in plants and soils occur in much smaller concentrations, and the elements that are contained in plant tissues in amounts less than 100 mg kg-1[69]. Factors affecting the availability of micronutrients are parent material, soil reaction, land us soil texture, and soil OM [70]. The micronutrients have positive relation with the fine mineral fractions like clay and silt while negative relations with coarser sand particles [72]. This is because their high retention of moisture induces the diffusion of these elements. The presence of OM may promote the availability of certain elements by supplying soluble complexing agents that interfere with their fixation [73]. Intensive cropping, in which large amount of plant nutrients are removed in the harvest accelerates the depletion of micronutrient reserves in the soil and increase the likelihood of micronutrient deficiencies. Erosion of topsoil carries away a considerable soil OM, in which much of the potentially available micronutrients are held [74]. The diethylenetriamine pentaaceticacid (DTPA) extractable Fe, Cu and Mn were adequate, whereas Zn was low in different soils of Ethiopia [75].

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

The study was conducted at Sito Kebele which is located in Dedo District, Jimma Zone, Oromia National Regional State (ONRS), South west Ethiopia. It is situated 375 km away from Addis Ababa to Southwest and 20 km Southwest of Jimma town. Geographically, the elevation ranges from 2200 to 2700 meters above sea level (masl). It covers an area of about 1500 hectare (ha) and share with sheger kebele to the east, Aba koyi kebele in the west, Geshe and Ilala Keble in the south and Bilo and sharifi kebele in the north.

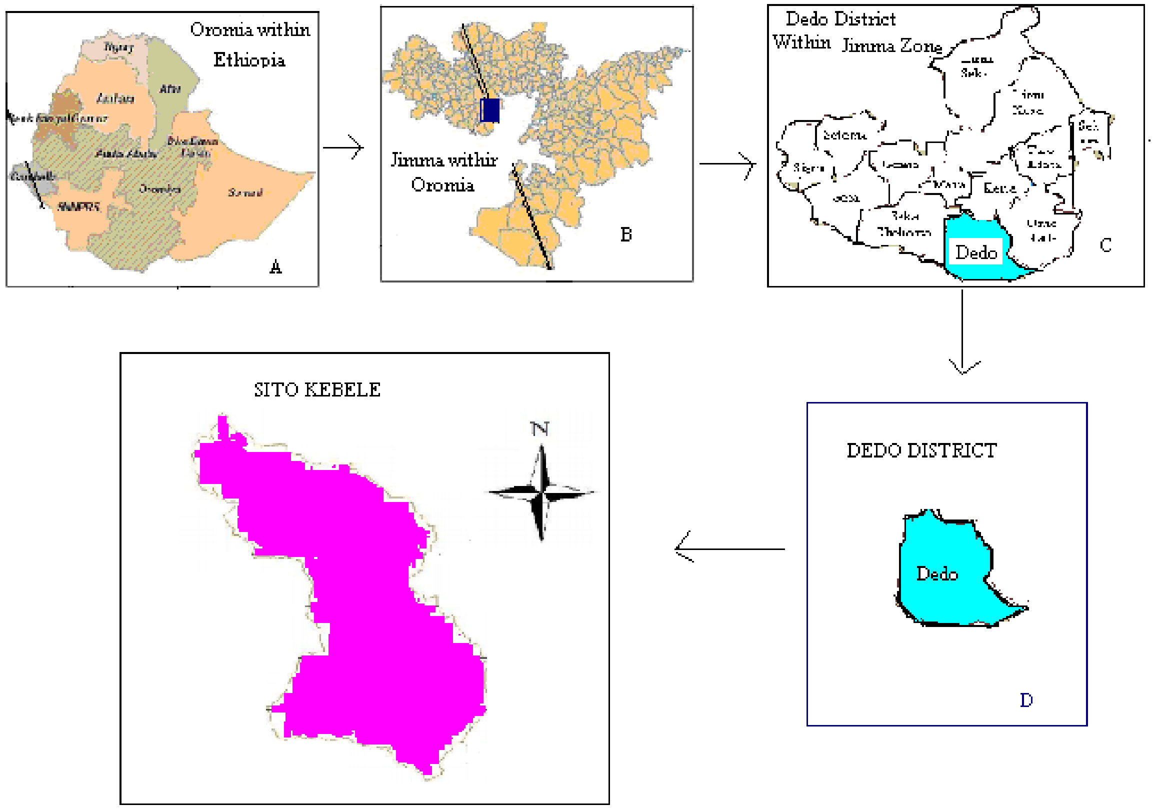

Figure 1. Soil map of the study area. A. Oromia within Ethiopia B. Jimmma zone within Oromia C. Dedo District within Jimma zone D. Dedo District E. Sito Kebele (The study Area)

3.1.2. Climate

The duration and pattern of rainfall influences the farmers cropping cycles and practices at the Sito area and the highlands in the District as a whole. The Sito area is characterized by uni-modal rainfall pattern, which extends from June to September and increases gradually in frequency to reach the maximum in August and then decline rapidly after the peak starting in September. The cessation of the rain is much more abrupt compared to its onset and abnormal cessation of the rain can have impact on crop yield [76]. The mean annual rainfall for the last 8 years is 1100 mm and the mean annual temperature is 15 ^{o}C with a mean minimum of 12 ^{o}C and mean maximum of 18 ^{o}C (Appendix Table 2). In general, it is representative of moist“dega” agro-climatic zone.

3.1.3. Land use and farming system

The catchment is suitable for large variety of crops, such as wheat, barley, maize, teff and pulses. The major crops grown during the main rainy season are beans, Wheat as well as teff. The major crops grown in Sito kebele by the farmers include wheat, teff, and vegetable crops are also grown on small-scale levels. The command area of the study area is characterized by an average slope of 6 to 23% which is not suitable for irrigation development with regards to slope as well as climate conditions of the soils. The farm economy of the study area is based on crop production and small number of livestock production system characterized by traditional practice of subsistence nature. Food crop for household consumption, income required to meet households and non-food needs are mainly originated from the existing subsistence farming practice. In this area, wheat is the major crop while teff is grown in small quantity. The average land holdings in the study area are 0.75ha. The crop production of the kebele is bio -modal in terms of production season and it is mainly rain fed. Wheat is the major crops commonly produced rain fed agriculture. The other means on which the farming community depends to sustain their family life is small number animal husbandry. Livestock and their products are supplementary sources of food and income to the farmers in this area. This economic activity like the case in crop production is characterized by small holding and its subsistence nature.

3.2 Soil Sampling

Three main factors such as depth, sampling intensity per unit area of site sampled, and the sampling design are usually considered when developing soil-sampling protocols to monitor Change in major soil fertility parameters.[77] noted that sampling by fixed depths, rather than by generic horizon, underestimated soil carbon losses due to cultivation. There is considerable heterogeneity in soil properties at the spatial scale of a few meters or less, and this is particularly so for soil parameters. Representative soil sampling sites were then selected based on vegetation and cultivation history. Following the general site selection, two representative fields were selected from each land use types (cultivated and grazing lands) which were replicated three times and from each site, 12 soil sub-samples were collected from the depths of 0-20 cm and 20-40 cm each in a radial sampling scheme using an auger [78].

These samples were collected from nearly the same slopes to avoid or at least minimize the effect of topographical differences and thereby change in the level of response due to the same. One composite soil sample was then prepared from 12 sub samples for each soil depth. The soil samples collected from representative fields' with three replications were then air-dried, mixed well and passed through a 2 mm sieve for the analysis of selected soil physical and chemical properties. Separate soil core samples from the 0-20 and 20-40 cm depths were taken with a sharp-edged steel cylinder forced manually into the soil for bulk density determination.

3.3. Laboratory Analysis of Soils

The soil samples were collected from 0-20cm and 20-40cm depth levels of representative fields' with three replications. Totally, we had 12 soil samples. Collected samples were then air dried, mixed well and passed through a 2 mm sieve for the analysis of selected soil physicochemical properties. The major part of the soil physicochemical analysis was carried out at the Jimma University. Standard laboratory procedures were followed in the analysis of the selected physicochemical properties considered in the study.

3.3.1. Analysis of soil physical properties

Soil particle size distribution was determined by the Boycouos hydrometric method.[79] after destroying OM using hydrogen peroxide (H_2O_2) and dispersing the soils with sodium hexameta phosphate $(NaPO_3)_6$. Soil bulk density was determined by the undisturbed core sampling method [80] after drying the soil samples in an oven at 105 ^oC to constant weights, while particle density was estimated by the pycnometer method. Percentage total pore space was computed from the values of bulk density (BD) and particle density (PD) as:

$$\text{Total pore space (\%)} = (1\text{-}BD/PD) \times 100$$

3.3.2. Analyses of soil chemical properties

Soil samples were analyzed for the following parameters: The pH of the soils was measured in water and potassium chloride (1M KCl) suspension in a 1:2.5 (soil: liquid ratio) potentiometrically using a glass-calomel combination electrode [79]. The electrical conductivity (EC) of soils was measured from a soil water ratio of 1:2.5 socked for one hour by electrical conductivity method as described by [81]. The [82] wet digestion method was used to determine soil carbon content and percent soil OM was obtained by multiplying percent soil OC by a factor of 1.724 following the assumptions that OM is composed of 58% carbon.

Total N was analyzed using the Kjeldahl digestion, distillation and titration method as described by [80] by oxidizing the OM in concentrated sulfuric acid solution (0.1N H_2SO_4). Since the Olsen method is the most widely used for P extraction under wide range of pH. Available soil P was analyzed according to the standard procedure of[83] extraction method. Exchangeable acidity was determined by saturating the soil samples with potassium chloride solution and titrated with sodium hydroxide as described by [84]. The CEC and exchangeable bases (Ca, Mg, K, and Na) of the soil were determined from ammonium acetate saturated sample. The excess ammonium acetate was removed by washing with ethanol. Finally, the exchangeable Ca^{2+} and Mg^{2+} in the ammonium acetate leachate were measured by atomic absorption spectrophotometer (AAS), and K^+ and Na^+

were determined by flame photometer. Cation exchange capacity was thereafter estimated titrimetrically by distillation of ammonium that was displaced by sodium from NaCl solution (Chapman, 1965). Exchangeable acidity was determined by saturating the soil samples with 1M KCl solution and titrated with 0.02 M NaOH as described by [84].

A commonly used procedure called diethylenetriaminepentaacetic acid or DTPA [85] extraction was used to extract Cu, Fe, Mn and Zn from the samples. The micronutrients extracted with this method were measured by atomic absorption spectrophotometer at 248.3, 279.5, 324.7 and 213.9 nm wavelengths for Fe, Mn, Cu, and Zn, respectively.

3.3.3. Statistical analysis

The soil physical and chemical properties were subjected to analysis of variance using the general linear model procedure of the statistical analysis system [86]. The least significance difference (LSD) test was used to separate significantly differing treatment means after main effects were found significant at $P < 0.05$. Moreover, simple correlation analysis was executed with the help of Gomez and Gomez (1984) to reveal the magnitudes and directions of relationships between selected soil fertility parameters and within and among land use types and soil depths.

4. RESULTS AND DISCUSSION

4.1. Responses of Soil Physical Properties to Land Use Changes

4.1.1. Soil texture

The main physical properties of the soils are presented in Table.1. The particle size distribution data showed that textural differences were observed among the land use types and soil depths. The sand and clay fractions were significantly affected by land use, soil depth and the interaction of land use and soil depth.

Regardless of land use types ,the highest average (surface and subsurface) sand content (49%) was observed under the grazing land and the lowest (41.0%) was recorded in the cultivated land, Whereas the average clay fraction of the grazing and crop lands were (29.05) and(33.15%), respectively (Table.1 and Appendix Table.5). The grazing land soils were dominated by sand fractions while the cultivated soils were dominated by clay fractions.

Considering the two soil depths, , significantly higher sand and higher clay contents were observed in the 0-20 cm and the 20-40 cm soil depths, respectively, than in the 20-40 cm and the 0-20 cm soil depths. The higher mean sand fraction (60%) was observed within the surface soils (Table 1). Opposite to sand, higher clay fraction (37%) was found in the subsurface soil. The clay content in the soils ranged from 21.7 to 36.4 in the surface layer and 29.3 to 37.0 in the subsurface and the clay content increased down the profile. The sand fraction varied significantly across the land use and soil depth. As indicated in Table. 1, the highest average sand content (60%) was observed under the grazing land and the lowest (43%) was recorded in the cultivated land.

In all the land use types, the contents of sand fractions decreased with soil depth while clay and silt increased down the profile (Table 1 and Appendix Table 5). There were no textural class differences among the two land use types. The textural class of the surface (0-20 cm) and the subsurface (20-40 cm) soils were clay loam whereas the surface layer of the grazing land were sand clay loam (Table 2). Generally, there were significant differences in the soil particle size distribution among the land use types and between the soil depths.

Considering the interaction effects of land use by soil depth, the average clay fraction was found to be highest in the soils of the cultivated land (33.15%) and the subsurface soil layers (37.0%) whereas, it was lowest in the grazing lands (29.05%) and the surface soils (21.7%). The sand content was highest in the grazing land (49%) and the surface soils (60%) while the lowest was observed in the cultivated land (41%) and the subsurface soils (33%). The grazing land soils were dominated by sand fractions while the cultivated soils were dominated by clay fractions. The sand fraction varied significantly across the land use and soil depth. As indicated in Table. 1, the highest average sand content (60%) was observed under the grazing land and the lowest (43%) was recorded in the cultivated land. The average clay fraction (cultivated and grazing land soils) was found to be highest in cultivated soils (38.15%) whereas it was lowest in grazing lands (24.05%) of surface soils. in the two land use types, the contents of sand fractions decreased with soil depth (Table.1).

Table. 1. Interaction effects of land use and soil depth on particle size distribution of the soils of Sito kebele.

Land use	Sand		Silt		Clay		Textural Class		BD		PD		TP	
	Soil depth (cm)		Soil depth (cm)		Soil depth (cm)		Soil depth		Soil depth (cm)		Soil depth (cm)		Soil depth (cm)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
GL	60.0	48.0	18.3	25.6	21.7	26.4	SCL	CL	1.20	1.26	2.42	2.18	50.	42.2
CL	59.0	43.0	21.7	30.0	19.3	27.0	CL	CL	1.31	1.27	2.37	2.21	45	42.6
LSD (0.05)	0.0316		0.10579		0.00531				NS		NS		7.07	
SEM	0.01		0.1		0.01				0.02		0.44		2.27	

Main effect means within a column are not significantly different from each other at $P \leq 0.05$; NS = Not significant at $P > 0.05$; BD = Bulk density; PD = Particle density TP = Total porosity.SCL= sandy clay loam , CL = clay loam.

The increase in clay content and a decrease in the sand fractions in the lower soil layer observed in the present study may be attributable to the downward migration of clay particles in the soil profile as evidenced by its higher contents in the 20-40 cm depth as well as to the selective removal of finer soil particles from surface soils by erosion leaving behind the coarser (sand) fractions. These same reasons were also used by several authors including [7],[88], [89] and [90] to explain observations indicating increase in clay and decrease in sand fractions with soil depth in their respective studies.

Texture is an inherent soil property; however, management practices might have contributed indirectly to the changes in particle size distribution observed in the soils of the present study particularly in the surface layers as result of removal of soil by sheet and rill erosions and mixing up of the surface and the subsurface layers during continuous tillage activities. Therefore, differences in particle size distribution, which can be attributed to the impact of farming practices such as continuous tillage or cultivation and intensive grazing, can be observed.

Pedogeologic processes such as erosion, deposition, eluviations and weathering which are shaped by management practices can alter the texture of soils [91]. Under conditions of low vegetation cover, as in the case of the grazing and cultivated lands, the clay fractions are likely to be lost through processes of selective erosion and migration down the soil profile which ultimately increase the proportion of sand and silt contents in surface layers. This was evident from the fact that in the soil samples, the clay contents of the subsurface soil layers were found to be higher than their overlying soil layers (Table.1). The largest figure of clay observed in the cultivated soils surface layers may indicate the variation in particle size fractions across soil depths is the least for the cultivated soils as tillage activities are responsible to mix up soils in the upper 0-40 cm depths. In general, the results obtained from this study are in agreement with the findings reported by various authors [92]; [88]; [93]; [94]; [89], [90] working in different places of Ethiopia and abroad.

4.1.2. Bulk and particle densities

The soils of agriculture land had the highest bulk densities in comparison to grazing land use type that this difference was significant, while it was not significantly ($P > 0.05$) affected by soil depth and the interaction of land use by soil depth (Table.1). The highest mean (1.31 gcm^{-3}) value of bulk density was recorded on the cultivated land and the lowest mean (1.20 gcm^{-3}) value was observed under the grazing land (Table.1). The higher bulk densities observed on the cultivated land soils than that of the grazing land use systems in this study are in agreement with that of [95] and [96]. The higher bulk density under the cultivated land could be related to the intensive tillage practices which may temporarily loosen the tilled soil layer and in the long term leads to increases in bulk density. The continuous exposure of the soil surface to the direct impact of rain drops under fields with long period of continuous cultivation might have also contributed to the increment of bulk density as rain drop impacts cause soil compaction through disintegration of the soil structure. In addition, the smallest organic matter (OM) content available in the cultivated land soils also contributes to the highest bulk density. Cultivation has a negative impact on the soil OM due to the removal of crop residues and tillage effects, leading to lower structural stability and higher soil bulk density.

The average bulk density across the land use types did not also vary due to variation in soil depth (Table.1 and Appendix Table.5). 0n the other hand, bulk density increased from 0-20 to 20-40 cm layer under the grazing land and decreased under the cultivated lands (Table.1 and Appendix Table. 5). The lower bulk densities in the surface soil under grazed land compared to the sub soil may be due to higher OM in the surface (Table 2), which makes soils loose, porous and well aggregated. Bulk density value was not significantly ($P > 0.05$) affected by land use, soil depth or their interaction effects.

The highest mean value of particle density was obtained both under the grazing land (2.42gcm^{-3}) and the surface soil layers. Among the two land use types and soil depths considered in this study (Table.1). The results of the analysis of variance showed that particle density was not significantly affected by soil depth. The particle density under the different land uses decreased with increasing soil depth (Table.1 and Appendix Table.5). The particle densities under the different land uses were higher at the surface than in the sub surface layer (Table.1). These higher particle density values on the surface soil layers might be due to the presence of heavy minerals of Fe and Mn in the surface soil as indicated by the higher Fe and Mn contents in the surface layer (table 4) which was in agreement with previous reports by [97] and [88].

4.1.3. Total porosity

The total porosity of the soils, in general, varied with bulk density. Accordingly, total porosity increases as the bulk density decreases while it decreases as bulk density increases. The total porosity of the soils ranged between 45.0 – 42.6% and 50.5 -42.21% in the cultivated and grazing land use types respectively (Table. 1). The lowest (42.21) and highest (50.5%) total Porosity was observed in the grazing land use type. The higher values of total porosity corresponded to the higher amount of organic matter contents and lower bulk density values. Similar results were reported by [98] and [88]. The average (surface and subsurface) total porosity percentages of the grazing and the cultivated lands were 47.5% and 42.4%, respectively (Table.1 and Appendix Table.5). Percentage total porosity decreased from the surface soils (45.1%) to the subsurface soils (42.21%). Although this numerical variation was observed, total porosity was not significantly ($P > 0.05$) affected by land use, soil depth and the interaction of land use and soil depth (Table.1 and Appendix Table.5).

4.2. Responses of Soil Chemical Properties to Land Use Types

4.2.1. Soil reaction (pH) and electrical conductivity

The soils pH-H_2O value was significantly affected by land use and soil depth ($P \leq 0.05$), while it was not significantly affected by the interaction of land use by soil depth (Table 3 and Appendix Table.6). Considering the main effects of land use, the highest (5.65) and the lowest (4.9) soil pH-H_2O values were recorded under the grazing and the cultivated lands, respectively (Table.3). This variation can be attributed to two major reasons: the first is the loss of base forming cations down the soil profiles through leaching and drainage into streams in runoff generated from accelerated erosion. This in turn enhances the activity of Al^{3+} and H^+ in the soil solutions, which reduces soil pH and thereby increases soil acidity. The reduction of basic cations in crop harvest, as indicated in their reduction is the other cause for the fall in soil pH. The second reason is continuous use of ammonium based fertilizers such as diammonium phosphate, $(NH_4)_2HPO_4$, in such cereal based cultivated fields. Upon its oxidation by soil microbes it produces strong inorganic acids. These strong acids in turn releases H^+ ions to the soil solution that in turn lower soil pH. Generally, the pH values observed in the study area are within the ranges of moderately acidic to neutral soil reactions as indicated by [99](Appendix Table.6). Considering the two soil depths, the higher mean value of pH-H_2O (5.56) and pH-KCl (4.54) were observed within the surface soils. In general, pH values decreased within increasing soil depth (Table.2 and Appendix Table.6). The vertical trend has shown a generally decreasing pattern in soil pH (and increasing acidity) with increasing soil depth. This situation can be explained for two reasons; for one reason, the larger organic matter content observed in the surface soils across the land uses helped. Humified organic matter can bind tightly with aluminum ions and reduce their activity in the soil solution which thereby raise soil pH and reduce acidity. Secondly, basic cations such as Ca^{2+} and Mg^{2+} ions have shown decreasing trend with increasing depth. The adsorption of basic cations such as Ca^{2+} and Mg^{2+} ions onto the colloidal complex gives replacement of H^+ and Al^{3+} which lowers the percentage acid saturation causing an increase in the pH of the soil solution. Additionally, increasing clay percentage with depth also has the tendency to furnish hydrogen ions from clay colloidal surfaces to the soil solution again reducing which finally reduce soil pH.

According [99], soil pH level < 5.0 is rated as very strong acid, 5.1- 5.5 strong acid, 5.6-6.0 moderate acidic and, 6.1- 6.5 is rated as slightly acidic. Based on the above ratings, the surface soils of the cultivated land qualify acidic while the grazing lands qualify for moderate acidic status of soil pH.

Electrical conductivity (EC) of soils was not significantly affected by land use and their interaction, whereas significantly ($P \leq 0.05$) affected by the soil depth (Tables. 2). EC content is presenting soil soluble salts components and probably the adding chemical fertilizer is a proper reason for increasing EC in cultivated lands. Considering the main effects of land use types, the highest (0.187 dS/m) and the lowest (0.04 dS/m) EC of the soils were obtained under the grazing and the crop lands, respectively (Table. 2). The highest EC value under the grazing land might be due to its highest exchangeable Na content, whereas the lowest EC value under the cultivated land can be associated with the loss of base forming cations (Ca^+ and Mg^+) after intensive cultivation. Considering the interaction effect of land use by soil depth, the highest interaction mean value of EC (0.18 dS/m) was obtained in the subsoil (0-20 cm) layer of the grazing land, whereas the lowest value was observed in the subsoil layers of the cultivated land (Table 2 and Appendix Table 5).

Table 2. Main effects of land use and soil depth on selected chemical properties of the soils of Sito kebele.

Land Use type	pH-H_2O		pH-KCl		EC (dS/m)		Available P (mg kg-1)	
	Soil depth (cm)		Soil depth (cm)		Soil depth (cm)		Soil depth (cm)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Grazing	5.86	5.65	4.76	4.51	0.18	0.036	3.24	4.14
Cultivated	5.26	4.9	4.31	4.21	0.07	0.04	3.23	5.42
LSD(0.05)	0.31305		0.58389		0.53934		0.85438	
SEM	0.116						0.348	

Main effect means within a column followed are not significantly different from each other at $P \leq 0.05$; NS = Not significant

4.2.2. Soil organic matter

Soil organic matter is an important and dynamic property of soil. It affects most of the soil properties like cation exchange and the nutrient supplying capacities of soil. SOM has been reported as the most powerful indicator for assessing soil potential productivity in different land uses types and managements of the world.

Organic matter content was affected by land use, soil depth and the Interaction of land use by soil depth (Table. 3 and Appendix Table.6). Total organic matter content is higher in grazing land soils than those soils found under cultivated fields. The highest amount of soil organic matter (12.24 %) was recorded from the grazing land whereas the lowest (7.25 %) was from the cultivated (Table. 3). A relatively lower level of disturbance in grazed soils has in fact led to an increase in organic matter content as compared to those cultivated soils. While absence of such soil disturbance minimizes rapid loss of soil OM. cultivation intensifies soil organic matter decomposition whereas no- cultivated land preserves it.

The lower levels of SOM from cultivated land could be the result of high OM decomposition, insufficient organic materials inputs in the systems, residue removal and lack of crop rotation [100]; [101]. Rapid mineralization and loss of carbon from the soil might be another reason for low organic matter content in cultivated land use systems. [102] reported lower soil organic matter content from intensively tilled field. As well, leaching that can be attributed to the relatively high sand content and the resultant light texture of soils might also be the cause of OM reduction in the cultivated land. This is apparent because the clay particles unlike the sand particles, have substantial exchange surface areas, and therefore adsorb and stabilize OM and soil nutrients [103].

Table 3. Effects of land use and soil depth on OC and TN of the Soils of Sito kebele.

Land use type	OC (%)		OM (%)		TN (%)	
	Soil depth(cm)		Soil depth(cm)		Soil depth(cm)	
	0-20	20-40	0-20	20-40	0-20	20-40
Grazing	7.2	4.5	12.24	7.77	0.61	0.39
Cultivated	4.3	4.7	7.25	8.13	0.36	0.41
LSD(0.05)	0.33787		0.76765		0.073845	
SEM	0.105		0.232		0.02	

Main effect means within a column are not significantly different from each other at P ≤ 0.05; NS = Not significant; OM = Organic matter; TN=Total Nitrogen

With regard to the interaction effect of land use by soil depth, the highest soil OM contents were observed in the surface soils of grazing land while least figures were from subsurface layers of the cultivated soils (Table.3). Soil OM contents in the 0-20 cm and 20-40 cm soil depths were highest on the grazing lands and lowest under the cultivated lands (Table. 3). On the grazing land, soil OM content decreased with increasing soil depth. The OM content under the cultivated land was higher in the subsoil layers than in the surface layers. This might be due to soil OM incorporation from surface layer to subsoil layer as a result of the mixing effect of tillage activities and down ward movement due to its higher sand content. Furthermore, the substantial amount of organic materials added from root biomass after the crop is harvested as stated by [104] coupled with rapid decrease of soil microorganism activity with increasing soil depth may explain the higher soil OM stocks in the subsoil of the crop fields.

4.2.3. Total nitrogen

Total nitrogen contents of soils demonstrated significant variation between land uses, soil layer and interaction between the two factors. Total nitrogen content declined with shift of land uses from grazing into agricultural fields, and with increasing soil depth from 0-20 cm to 20-40 cm (Table.3). The variation paralleled that of change in soil organic matter contents. The average values of total N was highest (0.61%) on the grazing land and lowest (0.36%) under the cultivated land (Table. 3and Appendix Table.6). The mean N content decreased considerably from 0.61% in the surface (0-20 cm) to 0.39% in the subsurface (20-40 cm) soil layers (Table 3), suggesting that the main source of total N is soil OM. In general, the soil OM and total N contents of the cultivated lands were significantly lower as compared to that of the grazing lands. This revealed the effect of continuous cultivation enhancing OM oxidation and resulting in reduction of OM and total N. The results are in accordance with the findings of similar works reported by [89], [105] and [90].

4.2.4. Available phosphorus

The available phosphorus (P) was significantly ($P \leq 0.01$) affected by land use, soil depth and the interaction of land use with soil depth (Tables 2 and Appendix Table).The content of available P in the cultivated land was higher than its content in the grazing land. Accordingly, the highest (4.33 mg kg-1) and the lowest (3.68 mg kg-1) available P contents were observed under the cultivated land and the grazing land, respectively. Available P contents for the cultivated soils were not low, rather found to be better than those soils under the grazing land uses. Under such moderate acidic conditions which limit P availability, application of organic materials such as animal manures might have increased P availability. During microbial breakdown of these materials, phosphorus is released slowly. Beside this, the residual effect of P containing fertilizers like Diammonim Phosphate (DAP) may also contribute to this increment.

The data also revealed that available P was higher (5.42 mg/kg) in the subsoil (20-40 cm) than in the surface layer. Generally, variations in available P contents in soils are related with the intensity of soil weathering or soil disturbance, the degree of P- fixation with Fe and Ca and continuous application of mineral P fertilizer sources as indicated by [106. The low contents available P observed in the soil of the study area are in agreement with the results reported by many authors [107] that the availability of P under most soils of Ethiopia decline by the impacts of fixation, abundant crop harvest and erosion. The OM content of the cultivated land was lowest, available P content was highest under the cultivated land than the other land use types. These highest available P could be due to the application of diammonium phosphate (DAP) fertilizer on the cultivated land. Phosphorous shows a tendency to build up in soil with subsequent addition of phosphatic fertilizers from external sources. The residual effect of added phosphatic fertilizers might have caused a high level of phosphorous. The cultivated lands contained higher available P than the uncultivated lands, which could be due to the continuous application of P fertilizers in the former. [108] and [88] found similar results and reported that the low concentration of available P in the uncultivated lands could be due to the inherent P deficiency of the soil since little or no P fertilizers are applied.

4.2.5. Basic exchangeable cations

The content of exchangeable calcium (Ca) was not significantly affected by land use, soil depth and the interaction of land use by soil depth (Table.4). The mean values of exchangeable Ca under the grazing and the cultivated lands were 6.05 cmol (+) kg^{-1} and 5.77 cmol (+) kg^{-1}, respectively (Table. 4). The highest (6.79 cmol (+) kg^{-1}) and the lowest (4.76 cmol (+) kg^{-1}) value of exchangeable Ca were recorded at the subsurface layer (20 -40 cm) and the surface soil (0- 20 cm) layer of cultivated and grazing land, respectively.

Considering the two soil depths, it was higher (6.79 cmol (+)/kg) at the subsoil (20-40 cm) depth than at the surface layer. Considering the interaction of land use by soil depth, the highest (6.79 cmol (+)/kg) exchangeable Ca was recorded at the subsurface (20-40 cm) layer of the cultivated land, and the lowest (4.76 cmol (+)/kg) was obtained at the subsoil layer of the grazing land (Table. 4).

Exchangeable magnesium (Mg) content was not significantly ($P > 0.05$) affected by land use, soil depth and the interaction of land use by soil depth (Table.4 and Appendix Table. 6). Considering the main effects of land use, the mean exchangeable Mg value was highest (1.01 cmol (+) kg-1) under the grazing land and lowest (0.88 cmol (+) kg-^{1}) on the cultivated land. The highest (1.31 cmol (+) kg^{-1}) and the lowest (0.69 cmol(+) kg^{-1}) values of exchangeable Mg were recorded at the surface layer and at the subsoil layers, respectively (Table .4).

Table 4. Main effects of land use and soil depth on basic exchangeable cations (Ca, Mg, K and Na) of soils of Sito kebele.

Land use type	Ca		Mg		K		Na	
	Basic exchangeable cations (cmol(+)/kg)							
	Soil depth(cm)		Soil depth(cm)		Soildepth(cm)		Soil depth(cm)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Grazing	6.34	5.75	1.31	0.69	1.04	0.82	0.34	0.36
Cultivated	4.76	6.79	0.84	0.92	0.65	1.03	0.21	0.19
LSD(0.05)	NS		NS		0.32			0.035
SEM	1.43		1.32		0.06			0.01

Main effect means within a column are not significantly different from each other at $P \leq 0.05$; NS = not significant,

The contents of both exchangeable Ca and Mg decreased with soil depth except under the cultivated land (Table.4and Appendix Table.6.). These indicate that there was higher down ward leaching of basic cations in the crop field than in the grazing land use. The lowest values obtained on the cultivated land could also be related to the influence of intensity of cultivation and abundant crop harvest with little or no use of input as reported by [109] and [110].

Exchangeable K content was significantly affected by land use types. Considering the main effects of land use, exchangeable K content was highest (0.93 cmol(+) kg^{-1}) in the grazing land and lowest (0.85 cmol(+) kg-1) in the cultivated land (Table. 4). The highest content in the grazing land was related with its high pH value and was in agreement with study results reported by [111] that high K was recorded under high pH tropical soils.

Considering the interaction effects of land use by soil depth, the highest (1.04 cmol(+)/kg) and the lowest (0.65 cmol(+)/kg) exchangeable K contents were recorded at the surface (0-20 cm) layers of the grazing and the cultivated lands, respectively (Table. 4). The ranges of mean exchangeable K values observed in this study show that K^+ was above the critical levels (0.38 cmol (+)/kg) for the production of most crop plants as indicated by [112]. Generally, the lower exchangeable K contents in the cultivated than in the grazing lands might be due to its continuous losses in the harvested parts of the plants from the cultivated lands. Previous findings have also considered these factors and the application of acid forming fertilizers as major factors affecting the distribution of K^+ in soil systems mainly enhancing its depletion especially in tropical soils [88].

The content of exchangeable Na was significantly affected by land use ($P \leq 0.01$) and by the interaction of land use by soil depth (Tables. 4 and Appendix Table .6). On the other lad, it was not significantly ($P > 0.05$) affected by soil depth. Considering the main effects of land use, exchangeable Na content was highest (0.34 cmol (+)/kg) under the grazing land and lowest (0.21 cmol (+)/kg) in the cultivated land (Table. 4). Similarly, the highest (0.36 cmol (+)/kg) and the lowest (0.19 cmol (+)/kg) exchangeable Na contents as affected by the interaction of land use by soil depth were recorded at the subsoil layer of the grazing and the cultivated lands, respectively (Table .4).

In general, leaching, limited recycling of dung and crop residues in the soil, very low use of chemical fertilizers, continuous cropping and soil erosion have contributed to depletion of basic cations and CEC on the cultivated land as compared to the adjust grazed land. Although the farming system in the area is predominantly mixed crop-livestock, nutrient flows between the two components of the system are predominantly one sided, with feeding of crop residue to livestock but little or no dung returned to the soil.

4.2.6. Exchangeable acidity

The exchangeable acidity was affected by land use, while it was not significantly affected by soil depth and the interaction of land use by soil depth (Table.5). The highest (1.43

cmol (+)/kg) and the lowest (1.23 cmol(+)/kg) exchangeable acidity were recorded under the cultivated and the grazing lands, respectively (Table.5). These results show that, intensive cultivation and application of inorganic fertilizers leads to the higher exchangeable acidity content under the crop field. The results of this study were in agreement with those reported by different researchers [113]; [88], who reported that inorganic fertilizer application is the root cause of soil acidity. Furthermore, exchangeable acidity values decreased from the surface to the subsoil layer under both grazed and cultivated land use types (Table .5).

Table 5. Main effects of land use and soil depth on exchangeable acidity and CEC.

Land use type	Ex. Acidity **(cmol(+) kg^{-1})**		CEC **(cmol(+) kg^{-1})**	
	Soil depth(cm)		Soil depth(cm)	
	0-20	20-40	0-20	20-40
Grazing	1.21	1.21	20.72	21.61
Cultivated	1.43	1.4	20.37	20.42
LSD(0.05)	0.21		1.43	
SEM	0.08		0.44	

Main effect means with column are not significantly different from each other at $P \leq 0.05$; NS = not significant; Ex. acidity = exchangeable acidity

4.2.7. Cation exchange capacity

The cation exchange capacity (CEC) values of the soils in the study area were affected by land use and the interaction of land use by soil depth but not affected by soil depth (Tables 5). Considering the main effects of land use, the highest (21.61 cmol (+) kg-1) and the lowest (20.37 cmol(+) kg^{-1}) values of CEC were observed under the grazing and the cultivated lands, respectively (Table.5).

The CEC values in the agricultural land uses decreased mainly due to the reduction in OM content. Principally, CEC of soil is determined by the relative amounts and/or type of the two main colloidal substances; humus and clay. Organic matter particularly plays important role in the soil exchange processes because it provides more negatively charged surfaces than clay particles do. The CEC under the grazing and cultivated lands increased from the overlying to the underlying soil layer (Table.5), which might be attributed to the increase in clay and OM contents with depth, respectively.

Considering the interaction effect of land use by soil depth, the highest CEC value (21.61 cmol (+)/ kg) was recorded at the subsurface layer of the grazing land, whereas the lowest (20.37 cmol (+)/ kg) was observed at surface layer of the cultivated land (Table. 5).

It is a general truth that both clay and colloidal OM have the ability to absorb and hold positively charged ions. Thus, soils containing high clay and OM contents have high CEC. Therefore, the CEC under the grazing and cultivated lands increased from the overlying to the underlying soil layer (Table .5), which might be attributed to the increase in clay and OM contents with depth, respectively. [114] the top soils having CEC of > 25, 15-25 cmol(+) kg-1,5-15 cmol(+) kg-1 and < 5 cmol(+) kg -1are classified as high, medium, low and very low, respectively. Based on the above ratings, the surface soils of the grazing and the cultivated lands qualify for medium status of CEC. The result of this study indicated that the CEC of the grazing land was significantly higher than the cultivated land use types. This reveals that changing of land from grazing to crop land without proper management aggravates soil fertility reduction.

4.2.8. Micronutrients (Fe, Mn, Zn and Cu)

The contents of available micronutrients (Fe, Mn, Zn and Cu) were affected by land use, soil depth and the interaction of land use by soil depth (Table. 6). Considering the main effects of land use, the highest contents of Fe (16.14 mg/kg), Mn (19.96 mg/kg), Zn (1.13 mg/kg) and Cu (0.31 mg/kg) were recorded under the grazing land (Table. 6), while the lowest (6.43, 0.13 and 0.19 mg/kg) contents of Fe, Zn and Cu were observed under the cultivated land, respectively, and Mn content was lowest (5.41 mg/kg) on the grazing land.

Table 6. Interaction effect of land use and soil depth on available micronutrients of soils of Sito kebele.

Land use type	Fe(mg/kg)		Mn (mg/kg)		Zn(mg/kg)		Cu(mg/kg)	
	Soil depth(cm)		Soil depth(cm)		Soildepth(cm)		Soil depth(cm)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Grazing	16.14	10.33	19.96	5.41	1.13	0.45	0.31	0.12
Cultivated	13.34	6.43	12.16	7.97	0.25	0.13	0.32	0.19
LSD(0.05)	0.27		0.053			0.012		0.01
SEM	0.123		0.027			0.028		0.003

Main effect means within a column are not significantly different from each other at P ≤ 0.05 With regards to the interaction effects of land use by soil depth, the highest contents of available Fe (16.14 mg/kg), Zn (1.13 mg/kg) and Cu (0.31 mg/kg) were observed at the surface (0-20 cm) layer of the grazing land while the highest (19.96 mg/kg) of available Mn was at the surface layer of the cultivated land (Table. 6). On the other hand, the lowest interaction mean values of available Fe (10.33 mg/kg), Mn (12.16 mg/kg), Zn (0.25 mg/kg) and Cu (0.19 mg/kg) contents were recorded at the subsoil layer of the cultivated land. The lowest available micronutrients under the cultivated land compared to the grazed land use might be due to crop harvest, OM degradation, and sheet and rill erosions that were aggravated by continuous cultivation with very low input of farming system. [115] indicated that the critical or threshold levels of available Fe and Mn for crop production are 2.5-4.5 mg/kg and 1-50 mg/kg, respectively. Therefore, the results observed in this study revealed that the average mean values of available Fe and Mn were in adequate range for the production of most crop plants.

5. SUMMARY AND CONCLUSIONS

5.1. Summary

The continuous and intensive cultivation of soils with very low inputs have been practiced in the study area over thousands of years as elsewhere in the country. Population pressure has also led to cultivation of marginal lands and steep slopes. The results of this study are evidences of significant changes in the quality of the soils in the study area following the frequent cultivation that lead to soil erosion and thereby declining soil fertility. The attributes of the soils under the cultivated lands showed overall change towards the direction of loss of their fertility compared to the soils attributes of the adjacent grazing land soils. The decreased values of the soil organic matter on the cultivated fields would indicate higher N and organic carbon losses from the agro ecosystem compared to the grazing system. The higher OM values in the grazing indicate low activities of N-losing processes, which is due to the relatively closed nutrient cycling and minimal disturbance in the grazing system. The extensive uses of agricultural lands have resulted in soil degradation and loss of environmental quality. Soils profoundly responded to these changes and successions of land use through their physical and chemical properties. Bulk density increased from 1.20 g cm^{-3} in grazed soils to 1.31 g cm^{-3} in cultivated land soils. Clay fractions increased from 29.05% in the grazing lands to 33.15% in the soils of the cultivated land .Soil pH-H_2O decreased from 5.86 to 4.9 in grazed to the cultivated land soils. The soil of the cultivated land was moderately acidic, the amount of exchangeable basic cations decrease and resulting in limitation of growth of most crop plants and ultimately to decline in crop yields and productivity.

5.2. CONCLUSIONS

The results showed that with changing grazed land to cultivation land, physicochemical properties of soil are subjected to degradation and erosion. Degradation and subsequent cultivation of soils had the negative effects on measured soil properties. Management practices that increase OC, TN, P ava and potassium in the system should be included, when the land is continuously cultivated. These variations of soil physicochemical properties between land use types indicate the risk to the sustainable crop production in the area. Therefore, to maintain sustainable agricultural production on the Sito Kebele, there should be integrated soil management, improvement in the management of the soil resources, incorporation of crop residues, compost, animal dung, crop rotation, improved practices such as chemical and organic fertilizers, improved fallows, enhanced crop variety and livestock techniques would be important in improving soil fertility as well as other physicochemical characteristics of the soils.

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7. Appendices

7.1Aappendix i. Tables

Appendix Table 1. Ratings of soil ph for 1:2.5 soil to water ratio suspension (Foth and Ellis, 1997).

No	**P^H**	**Rating**
1	< 4.5	Very strongly acidic
2	4.6 – 5.2	Strongly acidic
3	5.3 – 5.9	Moderately acidic
4	6.0 – 6.6	Slightly acidic
5	6.7 – 7.3	Neutral
6	7.4 – 8.0	Moderately alkaline
7	>8	Strongly alkaline

Appendix Table 2. Ratings of OM (Berhanu, 1980), Total Nitrogen (Berhanu, 1980), CEC (Landon, 1991), Av. P (Bray II (1954)).

SOM%	TN %	CEC (cmol(+)/Kg	Ava.P (cmol(+)/Kg)	EA (cmol(+)/Kg	Rating
> 20	> 0.3	>40	>20	> 15	Very high
10-20	0.225 -0.3	26-40	15-20	8-15	High
4 -10	0.125 -0.225	13-25	10-15	4-8	Medium
2-4	0.05-0.125	6-12	5-10	2-4	low
< 2	< 0.05	< 6	<5	< 2	Very low

Appendix Table 3. Ratings of exchangeable bases (FAO, 2006a; Landon, 1991).

Exchangeable bases (cmol(+)/Kg)	**Rating**

Ca	Mg	K	Na	
>20	>8	> 1.2	> 2	Very high
10-20	3-8	0.6-1.2	0.7-2	High
5-10	1-3	0.3-0.6	0.3-0.7	Medium
2-5	0.3-1	0.2-0.3	0.1-0.3	Low
<2	< 0.3	< 0.2	< 0.2	Very low

Appendix Table 4. Ratings of Micronutrients (FAO, 2006a, Landon, 1991).

Micronutrients (cmol(+)/Kg)				**Rating**
Fe	Zn	Cu	Mn	
30.0	3.0	0.6	30.0	Very high
20.0	2.0	0.4	20.0	High
7.0	1.0	0.3	3.0	Medium
5.0	0.8	0.2	1.0	Low
3.0	<0.4	<0.1	<0.6	Very low

Appendix Table 5.Mean values of soil physical properties as affected by land use and soil

Soil properties	Surface(0-20cm)			Subsurface(20-40cm)		
	GRL	CUL	MEAN	GRL	CUL	MEAN
Sand(%)	60.0	59.0	59.5	48.0	43.0	45.5
Silt(%)	18.3	21.7	20	25.6	30.0	25.7
Clay(%)	21.7	19.3	20.5	26.4	27.0	27.8
BD(%)	1.20	1.31	1.26	1.26	1.27	1.27
PD(%)	2.42	2.37	2.39	2.18	2.21	2.19
TP(%)	50.0	45.0	47.5	42.2	42.6	42.4

Appendix Table 6. Mean values of soil chemical properties as affected by land use and soil depth.

Soil properties	Surface((0-20cm)			Subsurface(20-40cm)		
	GRL	CUL	MEAN	GRL	CUL	MEAN
P^H (H_2O)	5.86	5.26	5.56	5.65	4.9	5.28
P^H (kcl)	4.76	4.32	4.54	4.51	4.21	4.36
EC(dS/m)	0.18	0.07	0.13	0.036	0.04	0.04
Ex.acidity	0.213	0.43	0.32	0.21	0.4	0.31
OM (%)	7.2	4.3	5.73	4.5	4.7	4.6
Total.N (%)	0.36	0.21	0.29	0.23	0.26	0.25
Av.P(mg/Kg)	3.24	3.23	3.24	2.14	2.38	2.26
Ca(cmol(+)/Kg)	4.09	3.99	4.04	2.40	4.14	3.27
Mg(cmol(+)/Kg	1.07	1.02	1.05	0.39	0.27	0.33
K(cmol(+)/Kg	1.08	0.65	0.87	0.87	1.04	0.96
Na(cmol(+)/Kg	0.32	0.23	0.28	0.36	0.19	0.28
Fe(mg/Kg)	36.31	21.9	29.11	17.17	10.07	13.62
Mn(mg/Kg)	37.18	42.14	39.66	14.72	8.46	11.59
Zn(mg/Kg)	1.13	0.16	0.65	0.45	0.13	0.29
Cu(mg/Kg)	1.75	0.28	1.02	0.48	0.19	0.34

7. 2 Appendix II. Figures

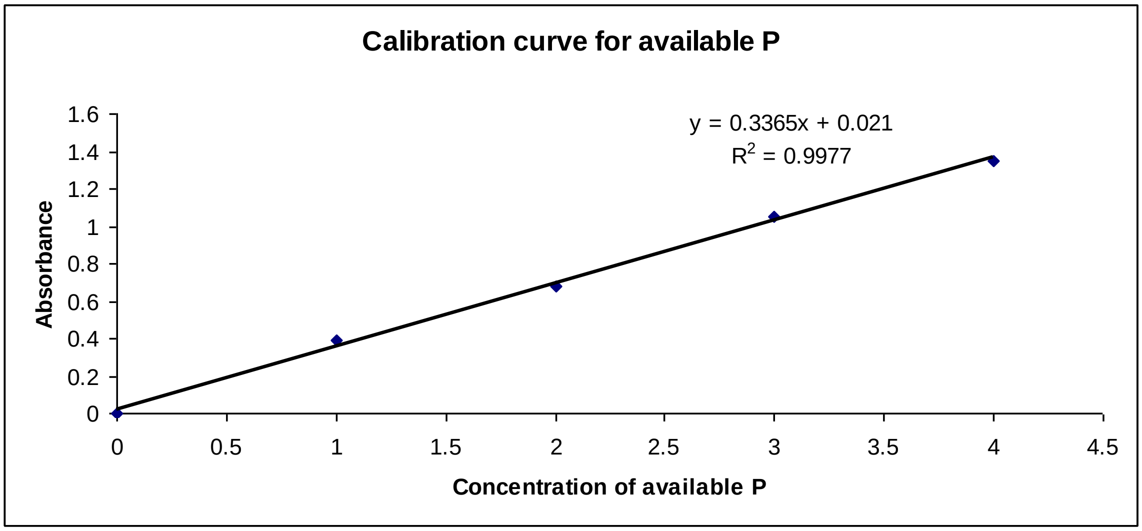

Figure 1. Calibration curve for absorbance versus concentration of available P.

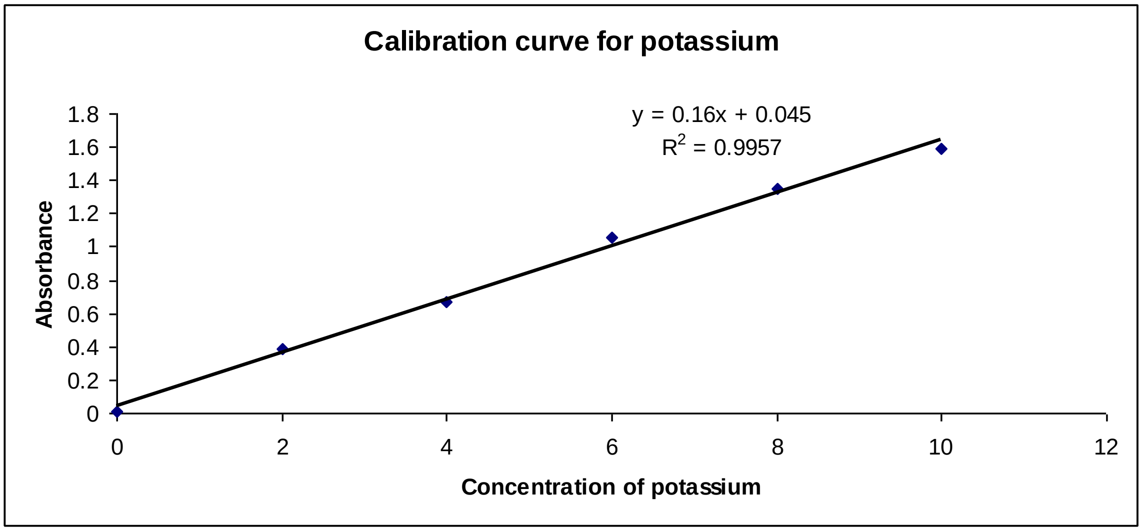

Figure 2. Calibration curve for absorbance versus concentration of potassium.

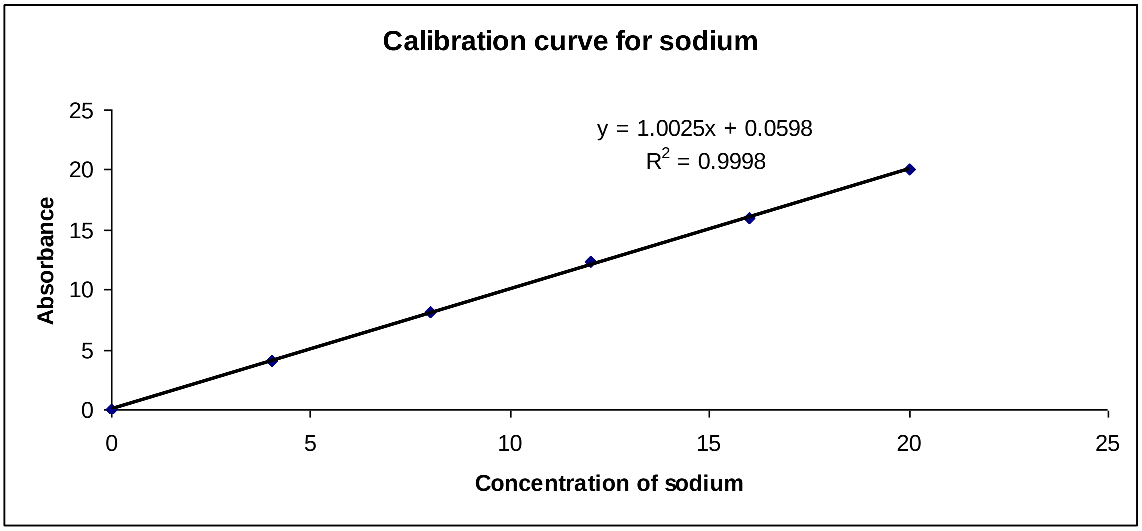

Figure 3. Calibration curve for absorbance versus concentration of sodium.

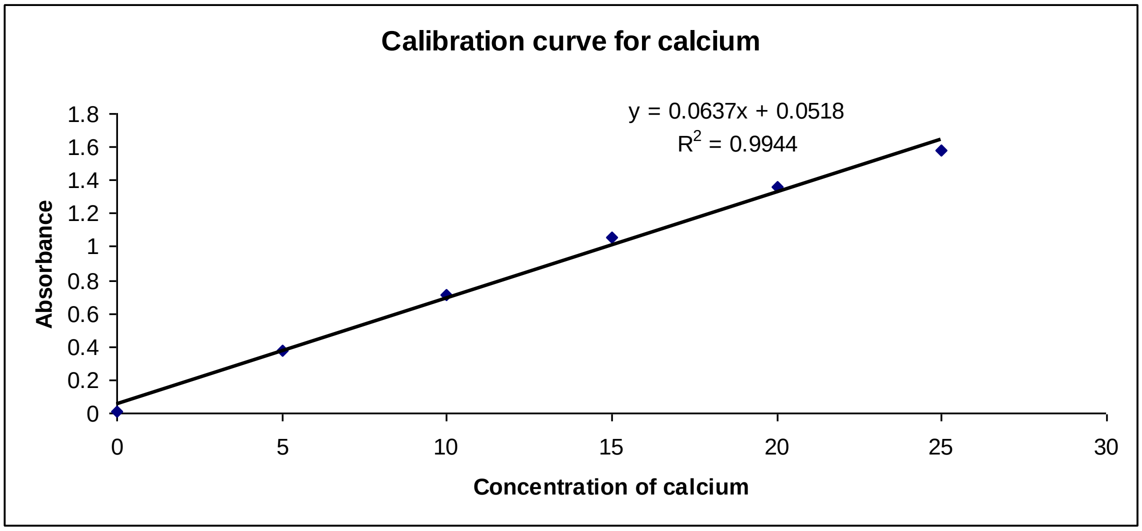

Figure 4. Calibration curve for absorbance versus concentration of calcium.

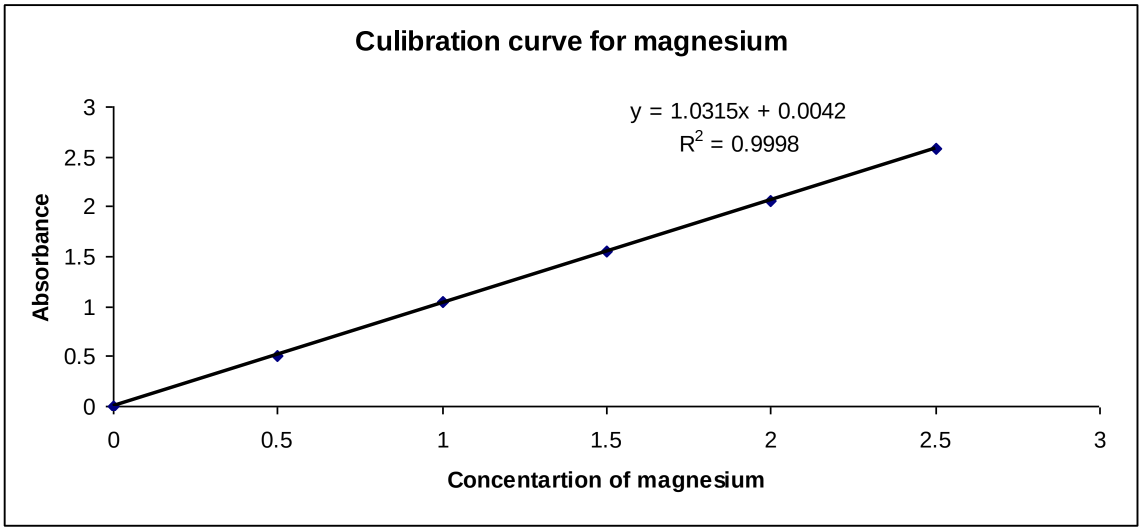

Figure 5.Calibration curve for absorbance versus concentration of magnesium.

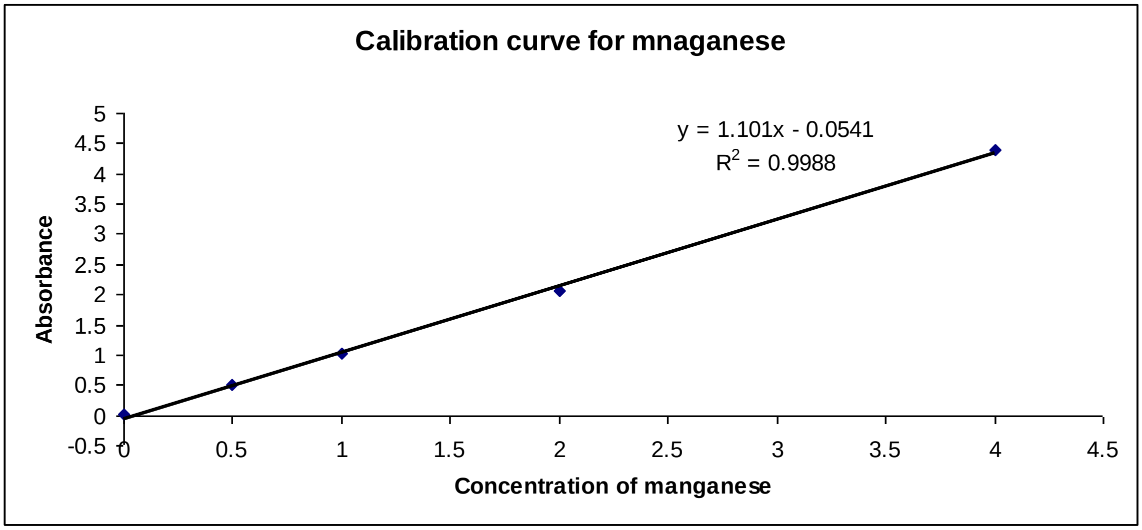

Figure 6. Calibration curve for absorbance versus concentration of manganese.

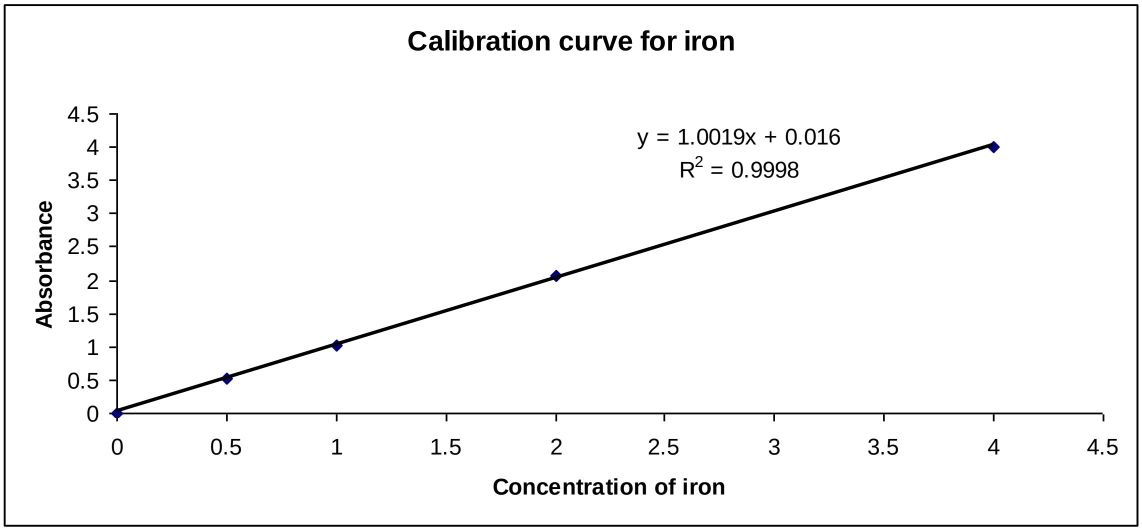

Figure 7.Calibration curve for absorbance versus concentration of iron.

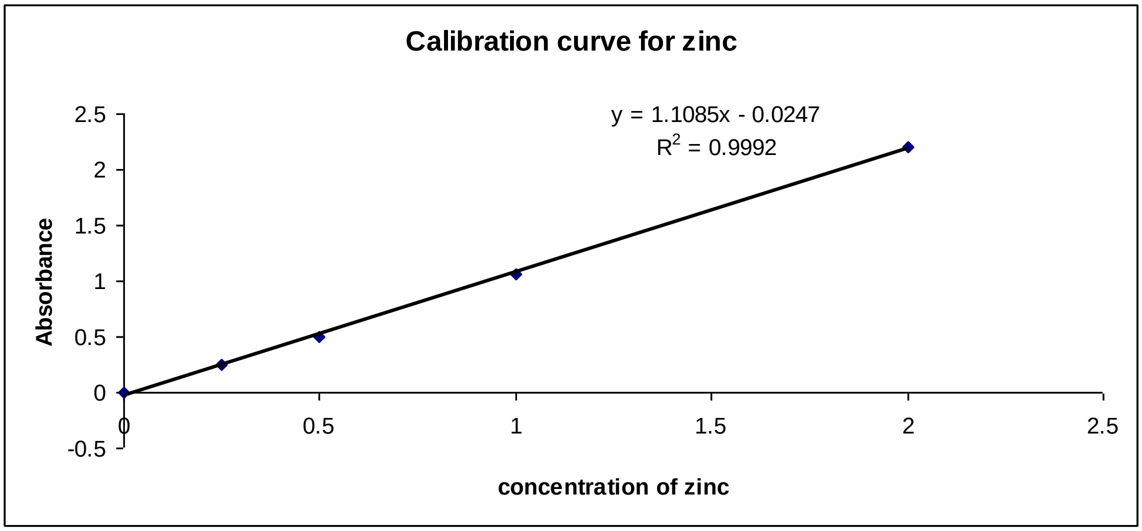

Figure 8. Calibration curve for absorbance versus concentration of zinc.

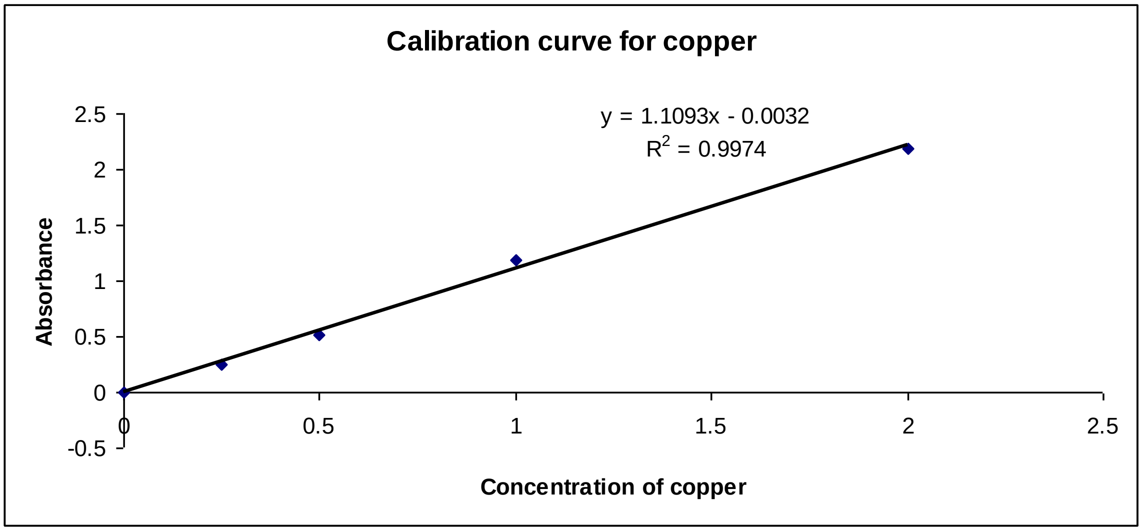

Figure 9. Calibration curve for absorbance versus concentration of copper.