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Original Research

Analysis of Selected Physicochemical Parameters of Soils Used for Cultivation of Garlic (*Allium sativum* L.)

Wodaje Addis* and Alemayehu Abebaw

Department of Chemistry, Ambo University, Post Box No: 19, Ambo, Ethiopia

Abstract

Assessment of some selected physicochemical parameters in soil samples collected from four agricultural areas of East Gojjam Zone (Debre Markos, Dejen, Bichena and Debre Werk), Ethiopia was studied. The soil characterization was carried out for parameters like moisture content (MC), pH, electrical conductivity (EC), organic carbon (OC), organic matter (OM), cation exchange capacity (CEC), potassium, sodium, calcium and magnesium. Na and K in the soil samples were analyzed using flame photometer, Ca and Mg were analyzed by atomic absorption spectrophotometer while conventional analytical methods were employed for the determination of the rest of the physicochemical parameters. The results obtained revealed that the concentrations of physicochemical parameters in the soil samples were in the range of; 7.35-11.01% for MC, 6.53-7.64 for pH, 0.09-0.34 mS/cm for EC, 1.25-3.44% for OC, 2.16-5.93% for OM, 30.75-41.83 cmol/kg for CEC, 845-1014 mg/kg for Na, 1980-6065 mg/kg for K, 952–2118 mg/kg for Ca and1751–4288 mg/kg for Mg. pH was found to vary from neutrality to slightly alkaline. The values of EC indicated that all samples of the soils are non-saline. Statistical test of significance using ANOVA revealed that there were no significant differences ($P>0.05$) between the values of physicochemical parameters in the soil samples obtained from all the sampling sites. Correlation analysis was also employed to examine the relationship between the various parameters in the soil samples. The soil studied can be considered as good sources of essential nutrients and this information will help farmers to solve the problems related to soil nutrients, amount of which fertilizers to be used to increase the yield of crops.

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***Corresponding Author:**
Wodaje Addis

E-mail:
wedajeaddis@yahoo.com

INTRODUCTION

Soil acts as a thin layer of earth's crust which serves as a natural medium for the growth of plants and it is the unconsolidated mineral matter influenced by genetic and environmental factors (Manimegalai and Sukanya, 2014). It is a natural body consisting of layers (soil horizons) of mineral constituents of variable thicknesses, which differ from the parent materials in their morphological, physical, chemical and biological properties (Sumithra *et al*., 2013; Manimegalai and Sukanya, 2014). Soil is one of the important and valuable resources of the nature. It is composed of particles of broken rock that have been altered by chemical and mechanical processes that include weathering and erosion. All living things are directly and indirectly dependent on soil for day to day needs and 95 % of the human food is derived from the earth. Soil has complex function which is beneficial to human and other living organism. It acts as a filter, buffer storage, transformation system and thus protects the global ecosystem against the adverse effects of environmental pollutants (Sumithra *et al*., 2013).

The study of soil physicochemical parameters is important to agricultural chemists for plants growth and soil management. The physicochemical properties such as moisture content, specific gravity, nitrogen as a fertilizer required for the growth of plant. Potassium is used for flowering purpose; it is also required for building of protein, photosynthesis, fruit quality and reduction of diseases. Calcium is an essential part of plant cell wall, which provides normal transport and retention of other elements (Chaudhari, 2013).

Soil is one of the most significant ecological factors, on which plants depend for their nutrients, water and mineral supply (Shaikh and Bhosle, 2013). Soil testing is the only way to determine the available nutrient status in soil and the only way we can develop specific fertilizer recommendations. Results of physical and chemical tests provide information about the capacity of soil to supply mineral nutrients (Ganorkar and Chinchmalatpure, 2013). Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agricultural production. Nitrogen, phosphorous, potassium and sulphur are important soil elements that control its fertility and yields of crops (Singh and Mishra, 2012).

East Gojjam Zone is famous for garlic. So it is an important district of the Amhara Regional State. Garlic (*Allium sativum* L.) is the most widely used bulb crop next to onion in Ethiopia. It contributes significant nutritional value to the human diet (Diriba *et al*., 2013). Garlic has been used throughout recorded history for both culinary and medicinal purposes (http://www.uni-graz.at/~katzer/engl/Alli_sat.html). The productivity of agricultural soil depends largely on its physicochemical properties. The soil condition is important because it is a universal medium for plant growth, which supplies essential nutrients to the plants. In Ethiopia now a day, large number of fertilizers are used instead of manures due to this the crop productivity increases speedily but the quality of the soil decreases. So it is essential to analyze the physicochemical characteristics of soil because as with the increasing use of chemical fertilizer to the soil, it is difficult to control the adverse effect of the chemicals fertilizer to the soil, plants, animals and human beings. The information on the physicochemical parameters of soil on the study area is scarce. Therefore, the present study was under taken to know the physicochemical parameters of soils used for cultivation of garlic in East Gojjam Zone, Ethiopia and an attempt was also made to correlate nutrient contents of the soils with other soil properties.

MATERIALS AND METHODS

The Study Area

The study was conducted in selected sites of four different agricultural locations of East Gojjam Zone of the Amhara Regional State, Ethiopia namely: Debre Markos, Dejen, Bichena and Debre Werk. The study areas are located in between 230-300 km north of Addis Ababa, the capital city of Ethiopia. Debre Markos lies between latitude 10°20′N and longitude 37°43′E, and elevation 2,446 m. Dejen lies between latitude 10°10′N and longitude 38°8′E, and elevation between 2421 and 2490 m, Bichena lies between latitude 10°24'47"N and longitude 38°11'26" E, and elevation 2,476 m. Debre Werk lies between latitude 10°40'11"N and longitude 38°10'12"E, and elevation 2,489 m (Figure 1).

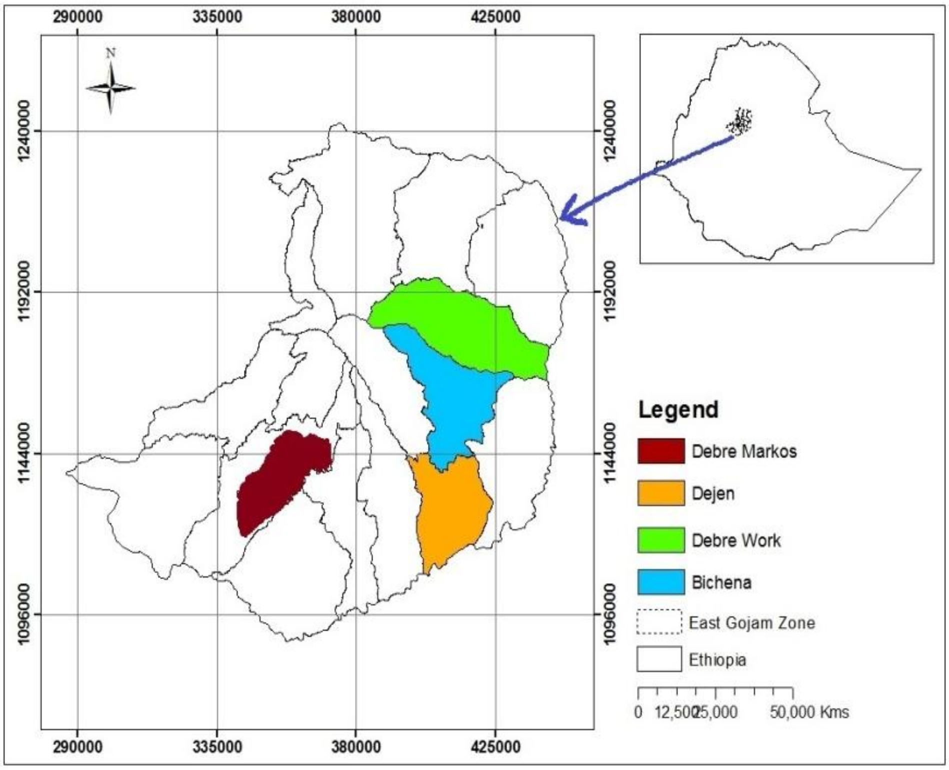

Figure 1: Map of the study area

Sample Collection

Top soil samples were collected at a depth of 0–20 cm using soil auger from four agricultural areas that used for cultivation of garlic in February, 2014. From each four main site, five sub-sites were taken for the purpose of random sampling. Five soil samples were randomly collected from the five sub-sites in each four agricultural areas and pooled together to obtain a composite sample. Finally, four soil bulk samples one from each stated areas were transferred in to polyethylene bags and transported to Ambo University laboratory for further analysis.

Sample Preparation

The soil samples were air dried for a period of one week, ground with a clean porcelain mortar and pestle and passed through a 2.0 mm sieve. The soil samples were kept in polythene packets for further analysis.

Calibration Standard and Spiking Standard Preparation

For calibration of the flame atomic absorption spectrophotometer (FAAS) and flame photometer a series of five calibration standard solutions were prepared by serial dilution from 1000 ppm stock standard solutions. For the spiking process, 100 ml of a mixture of standard solution containing 100 mg/L of each Na and K; 50 mg/L of Ca and Mg was prepared.

Determination of Some Physicochemical Parameters of the Soil Samples

Soil samples were analyzed for the following physicochemical parameters: moisture content, pH, electrical conductivity, organic carbon, organic matter and cation exchange capacity.

Moisture Content

Soil moisture content was determined by oven drying method (Jackson, 1967). 10 g of composite soil sample was taken. The samples were oven dried at 105°C for 24 hrs. Dry weight of the sample was taken till it showed its constant weight. The loss in weight corresponds to the amount of water present in the soil sample. The formula below was used to calculate the percentage of moisture content in each of the soil samples (Joel and Amajuoyi, 2009).

$$\text{Moisture content (MC) (\%)} = \frac{\text{Loss in weight on drying (g)}}{\text{Initial sample weight (g)}} \text{ x } 100$$

The corresponding moisture correction factor (mcf) for analytical results or the multiplication factor for the amount of sample to be weighted in for analysis is calculated as:

$$\text{Moisture correction factor (mcf)} = \frac{100 + \%\,\text{moisture}}{100}$$

pH

The pH of the soil samples was measured in water suspension (1:2.5) as described by (Jackson, 1967). Air dried soil of 20 g was taken in a beaker and to this 50 ml of water was added. The mixture was stirred with glass rod for 10 min and was allowed to stand for 30 min. The pH meter (ELMETRON, CPI-501, Poland) was calibrated using standard buffer solution of pH 4.0, 7.0 and 10.0. Then electrode of the pH meter was inserted in to the supernatant solution and the pH reading was taken.

Electrical Conductivity

The electrical conductivity (EC) of the soil samples was determined as described by (Jackson, 1967). Air dried soil of 20 g was taken in a beaker and to this 50 ml of water was added. The mixture was stirred with glass rod for 10 min and was allowed to stand for 30 minutes without any disturbances. The soil was allowed to settle down and the EC value was measured inserting electrical conductivity meter (SCHOTT handylab LF11, Germany) in to the supernatant solution.

Organic Carbon and Organic Matter

The organic carbon content of the soil samples were determined by the method of Walkey and Black (1934). 1 g finely ground soil sample was passed through 0.5 mm sieve without loss was taken into 500 ml conical flask, to which 10 ml of 1 N potassium dichromate and 20 ml conc. H_2SO_4 were added with measuring cylinder. The contents were shaken for a minute and allowed to stand for 30 min. Then 200 ml distilled water, 10 ml orthophosphoric acid and 1 ml diphenylamine indicator were added. The solution was titrated against 0.5 N ferrous ammonium sulfate till the colour flashes from blue-violet to green. The blank titration was carried at the beginning without soil. The results were calculated by the following formulas:

$$\text{Organic carbon \%} = \mathrm{N} \text{ x} \frac{(\mathrm{V_1} - \mathrm{V_2})}{\mathrm{S}} \text{ x } 0.39 \text{ x mcf}$$

Where: N = Normality of ferrous ammonium sulfate (FAS)
V_1 = Volume of 0.5 N FAS required to neutralize 10 ml of 1 N $K_2Cr_2O_7$ i.e. blank reading (ml).
V_2 = Volume of 0.5 N FAS needed for titration of soil sample (ml)
S = Weight of air-dry sample (g)
0.39 = 0.003 x 100% x 1.31 (0.003 is the milliequivalent weight of carbon in g). It is assumed that only 77% of the organic matter is oxidized and a fraction of 100/77 = 1.31

Organic matter (%) = Organic carbon (%) x 1.724

1.724 = average content of carbon in soil organic matter is equal to 58%

Cation Exchange Capacity

Cation exchange capacity (CEC) was determined by the method described by Raman and Sathiyanarayanan (2009). 1.3 g of soil was taken in the centrifuge tube. 11 ml of 1 N sodium acetate solution was added into the centrifuge tube. It was shaken well and centrifuged. The supernatant liquid was decanted. 11 ml of isopropyl alcohol was added into the centrifuge tube. The centrifuge tube was shaken well and centrifuged. The supernatant liquid was decanted. 11 ml of 1 N ammonium acetate solution was added into the centrifuge tube. The centrifuge tube was shaken well and centrifuged. The supernatant liquid was poured into the 100 ml flask. The solution in the 100 ml standard measuring flask was made up to 100 ml. The flame photometer was calibrated with standard sodium solution. The prepared solution was injected into the instrument and the reading was taken (Raman and Sathiyanarayanan, 2009). CEC value was then determined by the formula (Herk, 2012).

$$\text{CEC, cmol}_{(+)}\ \text{kg}^{-1}\ \text{soil} = \frac{\text{10*Na concentration in meq L}^{-1}}{\text{Mass of sample (g)}}$$

Determination of Metal Concentrations

0.5 g each of the air-dried, ground and sieved soil samples was accurately weighted into a digestion tube. 6 ml aqua regia and 1.5 ml H_2O_2 were measured and added into the digestive tube and swirled gently to mix the sample property. The digestion tubes were then placed on digestive furnace (Model: KDN-20C, China) and heated at a temperature of 180°C for 3 hrs. All the digests were cooled and filtered through Whatman No.42 filter paper in to 50 ml volumetric flask. Lanthanum chloride solution (1%) was added to the filtrate and the flask containing the filtrate was made up to the mark with double distilled water. Each sample was digested in replicates of five and transferred to acid washed stoppered glass bottle, labeled and kept for metal analysis. The concentrations of Ca and Mg in the filtrate were determined by using flame atomic absorption spectrophotometer (Model: AA-320N, Shanghai, China) and Na and K was determined by flame photometer (ELICO, CL-378, India). Final concentration of the element in soil samples was calculated as:

$$\text{Concentration of the element in soil (mg/kg)} = \frac{Conc.\ (\text{mg/L}) \text{ x } V(\text{ml})}{W(\text{g})}$$

Where: *Conc.* is the concentration of the element obtained in mg/L, *V* is the final volume of the digested solution (50 ml) and *W* is the weight of the soil sample (0.5 g).

Method Validation and Quality Control for Metal Analysis

In order to validate the analytical method, the following method validation parameters such analysis and determination of continuous calibration standard, limit of detection, limit of quantification, precision and accuracy studies through the analysis of method blank, laboratory control sample, matrix spike and matrix spike duplicate analyses were carried out.

Continuing Calibration Standards

Continuing calibration standards (CCS) was used to verify calibration accuracy during every analytical run. The CCS is prepared from midpoint of initial calibration standard that is 4 mg/L for Na and K, 0.5 mg/L for Mg and 8 mg/L for Ca were prepared separately. CCS was verified after every ten measurements for each analyte.

Limit of Detection

Limit of detection (LOD) is the minimum concentration of analyte that can be detected but not necessarily quantified with an acceptable uncertainty (Prichard and Barwick, 2007). LOD for each metal was determined from analysis of seven replicates of method blanks which were digested in the same digestion procedure as the actual samples. LOD was calculated as three times the standard deviation of the blank.

Limit of Quantification

Limit of quantification (LOQ) is the lowest concentration of analyte that can be determined with an acceptable level of uncertainty (Prichard and Barwick, 2007). LOQ was obtained from triplicate analysis of seven method blanks which were digested in the same digestion procedure as the actual samples. LOQ was calculated as ten times the standard deviation of the blank.

Precision and Accuracy

Precision and accuracy of the analytical method was assessed by repeatability and recovery studies of matrix spike (MS), matrix spike duplicate (MSD) and laboratory control samples (LCS). Recovery study was performed by spiking five replicate soil samples with a known concentration of metal standard solution (mid-range calibration concentration). The spiked samples were then subjected to the same digestion procedure like the actual sample. Precision was expressed as relative standard deviation (RSD) of the five replicate results. The relative standard deviations of the sample were obtained as RSD = (standard deviation/mean value) x 100. Accuracy is expressed as matrix spike recovery and the percent recovery results were calculated by the following equation (Javed *et al*., 2010).

$$\%\text{Recovery} = \frac{\text{conc. in spiked sample} - \text{conc. in un spiked sample}}{\text{actual spike conc.}} \times 100$$

Analysis of Matrix Spike and Matrix Spike Duplicate

Matrix spike (MS) and matrix spike duplicate (MSD) samples are two aliquots of the same environmental sample to which known quantities of the method analytes are added in the laboratory (USEPA, 2001). Both MS and MSD were prepared by spiking 0.5 g of each soil samples with 2 ml of a mixture of spiking standards so that the spike level were 4 mg/L of each Na and K; 2 mg/L of Ca and Mg. They were all carried through the same digestion and analysis steps as the unspiked sample. The relative percent differences (RPD) between the MS and MSD results were calculated using the following equation (USEPA, 2001).

$$\text{RPD} = \frac{\text{MS sample result} - \text{MSD sample result}}{(\text{MS sample result} + \text{MSD sample result})/2} \times 100$$

Calibration Blank and Method Blank

A calibration blank (2% HNO_3) was prepared to determine the background signal and establish the baseline of an instrument. For the method blank, 0.5 g Li_2CO_3 was used as a matrix and prepared using the same digestion procedure described for the soil samples but with no added sample.

Laboratory Control Samples (LCS)

For the soil sample, five replicates of 0.5 g lithium carbonate (method blank) spiked with 2 ml of a mixture of standards so that the spike level were 4 mg/L of each Na and K; 2 mg/L of Ca and Mg were prepared and digested like the sample including exposure to all glassware, digestion media, apparatus, solvents, and reagents that are used with soil samples. The percent LCS recoveries for each metal was calculated using the following equation (USEPA, 2010).

$$\%R = \frac{\text{LCS}}{\text{S}} \times 100$$

Where: %R = percent recovery, LCS = Laboratory Control Sample Result, S = amount of spike added.

Statistical Analysis

One-way analysis of variance (ANOVA) was used to evaluate the significant differences in the mean values of physicochemical parameters among groups of soils. Pearson’s correlation analysis was also applied to test the correlation between physicochemical parameters of soil samples. A probability level of $P<0.05$ was considered statistically significant. All statistical analyses were done by SPSS version 16.0 software for windows. Data were expressed as mean±standard deviation (SD) of five replicate experiments.

RESULTS AND DISCUSSION

Detection Limit, Precision and Accuracy

Table 1 presents the results of the limits of detection (LOD), limits of quantification (LOQ), recovery and RSD of the metals analyzed. As can be seen from the table, the LOD is < 0.510 and the LOQ is < 1.698 for the metals analyzed. These shows that both the LOD and LOQ were low enough to detect the levels of metals of interest. The percentage recovery for the studied metals ranges from 93–97%, which were within the acceptable range of 80–120% for metal analysis (Harvey, 2000). The RSD values ranges from 3.09−8.96%, which were within the acceptable range (<10%). Both the recovery and RSD shows that the method possesses the required accuracy and precision of the analytical method.

Table 1: Limit of detection (LOD), limit of quantification (LOQ), accuracy (%R) and precision (%RSD) of soil matrix spike sample for the determination of metals

Metal	LOD (µg/g)	LOQ (µg/g)	Recovery (%)	RSD (%)
Na	0.405	1.349	97 ± 6.48	6.68
K	0.510	1.698	94 ± 8.43	8.96
Ca	0.283	0.942	95 ± 5.30	5.58
Mg	0.109	0.363	93 ± 2.87	3.09

Matrix Spike and Matrix Spike Duplicate Results

The relative percent difference (RPD) values were calculated from the matrix spike and matrix spike duplicate result to measure the precision. As it can be seen from Table 2, the relative percent difference between matrix spike and matrix spike duplicate ranged from 0.82 to 5.04 which were in the acceptable limits ≤ 10%. This showed that the overall analytical process was less affected by matrix specific variability and the data generated was in the acceptable quality range. These results indicate that the proposed method was precise.

Table 2: Relative percent difference (RPD) results of matrix spike and matrix spike duplicate analysis

Element	Na	K	Ca	Mg
RPD	0.82	1.13	5.04	4.00

Contamination Control

Method blanks were run to identify and correct systematic errors due to impurities in the reagents and contamination in the glassware and instrumentation. The analysis results revealed that there were no readings above the method detection limits of the metals. Hence, it can be concluded that the analytical method was free of overall laboratory contamination.

Calibration Control/Continuing Calibration Standard

Analysis of metal standard solution of mid-point calibration curves after every 10 sample and at the end of sample run shows that each analyte falls ± 10% of the expected value. This indicates that the sample analysis is within the control limits.

Laboratory Control Samples Results

LCS recoveries and RSD were calculated for each analyte. The corresponding results are summarized in Table 3. The percent recovery values of LCS results lied in the range of 91.22% to 94% and the RSD values ranged from 2.95 to 7.14%. All the values were found under the recommended control limits 80–120% for LCS recovery (Harvey, 2000) and ≤ 10% RSD. These results showed that the analytical method possesses the required precision and accuracy.

Table 3: Recovery and precision test results for the laboratory control samples.

Element	Amount Added (µg/g)	Conc. in Spiked Sample[a] (µg/g)	Recovery[a] (%)	RSD (%)
Na	400	370.64±0.92	92.56±3.81	4.12
K	400	365.16±0.74	91.22±6.51	7.14
Ca	200	186.45±0.28	93.07±2.75	2.95
Mg	200	188.00±1.13	94.00±5.14	5.47

[a]Mean ± SD, n = 5

Physicochemical Characteristics of the Soils

The results of the determination of some selected physicochemical parameters of the soils are shown in Table 4 and Figure 2.

Moisture Content

The moisture content (MC) which is directly proportional to the water holding capacity of the soil ranged from 7.35 to 11.01 % (Table 4). Soil collected from Bichena site has relatively higher moisture content than the other studied sites. Statistical test of significance using ANOVA revealed significant differences ($p < 0.05$) between the values of moisture content in the soil samples obtained from the four areas.

pH

Soil pH is a measure of hydrogen ion activity in the soil solution. It expresses the acidity and alkalinity of the soil and is a primary factor in plant growth. It is a very important property of soil as it determines the availability of nutrients, microbial activity and physical condition of soil. Soil pH values in the four areas ranges from 6.53 to 7.64 % (Table 4). The lower pH observed was in Dejen soil sample and the higher pH in Debre Werk soil sample. The soils studied from the farmlands were neutral except Debre Werk soil which is slightly alkaline. Statistical test of significance using ANOVA revealed significant differences ($p < 0.05$) between the values of pH in the soil samples obtained from the four areas. Odoemelan and Ajunwa (2008) studies have shown that the application of biosolids such as animal manure and compost on acid soils increases the soil pH appreciably.

Electrical Conductivity

Electrical conductivity (EC) expresses ion contents of solution which determine the current carrying capacity thus giving a clear idea of the soluble salts present in the soil. Electrical conductivity value ranges from 0.09 to 0.34 mS/cm (Table 4). The electrical conductivity of Dejen soil is high as compared to the other sites which may due to excess use of fertilizer like P and K. Electrical conductivity is used to estimate the soluble salt concentrations in soil and is commonly used as a measure of salinity. Soil with EC below 0.4 mS/cm are considered marginally or non-saline while soils above 0.8 mS/cm are considered severely saline (Wagh *et al*., 2013). The soils under analysis were found non-saline. Statistical test of significance using ANOVA revealed significant differences ($P<0.05$) between the values of EC in the soil samples obtained from the four sites. The difference in the electrical conductivity values could be attributed to differences in the soluble salt content of the soils.

Organic Carbon and Organic Matter

Organic matter plays an important role in supplying nutrients and water and provides good physical conditions to the plants. From Table 4, we can observe that the organic carbon (OC) ranges from 1.25 to 3.44%, while the organic matter (OM) ranges from 2.16 to 5.93%. Statistical test of significance using ANOVA revealed there was no significant differences ($p > 0.05$) between the values of OC and OM in the soil samples obtained from Dejen and Debre Werk areas. Odoemelam and Ajunwa (2008) reported soil OM content of < 2.0 % as low; 2.1- 3.0 % as medium and > 3.1% as high. Following this classification the agricultural soil investigated had medium OM for Debre Markos and Bichena soils, and high OM in Dejen and Debre Werk soils. The higher levels of OM present could be attributed to the application of animal manure.

Cation Exchange Capacity

Cation exchange capacity (CEC) is a measure of the quantity of readily exchangeable cations neutralizing negative charge in the soil. Cation exchange capacity is an important measure of the soil's ability to retain and to supply nutrients. The cation exchange values of the studied soils ranged from 30.75 to 41.83 cmol/kg. The lower CEC is observed in Debre Markos soil and the higher is in Debre Werk soil (Table 4). Statistical test of significance using ANOVA revealed there was no significant differences ($P>0.05$) between the values of CEC in the soil samples obtained from Debre Markos and Dejen areas.

Sodium (Na)

The results obtained revealed that highest concentration of sodium in the soil studied was found in Debre Werk soil 1014 mg/kg, followed by Debre Markos soil 868 mg/Kg, Bichena soil 855 mg/Kg and Dejen soil 845 mg/Kg (Table 4). The sodium content of water is very important to decide its quality for irrigation; salts ultimately affect the soil quality and plant growth (Mahajan and Billore, 2014).

Potassium (K)

The concentration levels of potassium in the selected soil samples were 1980, 5060, 3540 and 6065 mg/kg in sample sites of Debre Markos, Dejen, Bichena, and Debre Werk, respectively (Table 4). Potassium plays a key role in a vast majority of physiological process, vital to plant growth from protein synthesis to maintenance of plant-water balance. Potassium is a very soluble cation in solution, yet its mobility in soil is very slow. The K ions, on being absorbed by the colloids displaces other ions such as Ca, Mg or Na. Soils ability to absorb and hold K is of great importance as it serves to decrease leaching and provides more continuous supply of available K (Sumithra *et al*., 2013).

Calcium (Ca)

Calcium in soil results from passage through deposit of lime stones, gypsum etc. It plays a pre-dominant role in the composition of cell wall and protoplasm. It has been associated with carbohydrates and various organic acids (Mahajan and Billore, 2014). As can be seen from Table 4, the highest concentration of calcium was found in Bichena soil 2118 mg/Kg, followed by Debre Werk soil 1793 mg/kg, Debre Markos soil 1670 mg/kg and Dejen soil 952 mg/kg.

Magnesium (Mg)

Magnesium is a water-soluble cation and it is necessary for chlorophyll pigment in green plants (Mahajan and Billore, 2014). In case of magnesium there were varied levels in concentration for all the samples ranging from 1751 to 4288 mg/kg with sample site, Dejen and Bichena having the lowest and highest Mg values respectively. The values of Mg in Debre Markos and Debre Werk soil were 3293 and 3917 mg/kg respectively (Table 4).

Correlation Analysis

The relationships between the concentrations of different physicochemical parameters were analyzed by Pearson's correlation coefficient and the results are shown in Table 5.

The high correlation coefficient (near +1 or -1) means a good relation between two variables, and its

Table 4: Results of physicochemical parameters of the soils (mean ± SD, n = 5)

Parameters	Sites			
	Debre Markos	Dejen	Bichena	Debre Werk
MC (%)	7.35 ± 0.18^{a}	9.22 ± 0.13^{b}	11.01 ± 0.29^{c}	7.95 ± 0.20^{d}
pH (H_2O)	7.13 ± 0.04^{a}	6.53 ± 0.08^{b}	7.41 ± 0.06^{c}	7.64 ± 0.04^{d}
EC (mS/cm)	0.09 ± 0.01^{a}	0.34 ± 0.06^{b}	0.11 ± 0.01^{c}	0.14 ± 0.01^{d}
OC (%)	1.25 ± 0.11^{a}	3.42 ± 0.14^{b}	1.71 ± 0.05^{c}	3.44 ± 0.12^{b}
OM (%)	2.16 ± 0.18^{a}	5.89 ± 0.24^{b}	2.95 ± 0.08^{c}	5.93 ± 0.21^{b}
CEC (cmol/kg)	30.75 ± 0.06^{a}	31.14 ± 0.09^{a}	37.49 ± 0.09^{b}	41.83 ± 0.07^{c}
Na (mg/kg)	868 ± 45.49	845 ± 11.18	855 ± 50.25	1014 ± 18.16
K (mg/kg)	1980 ± 50.99	5060 ± 15.81	3540 ± 51.48	6065 ± 37.42
Ca (mg/kg)	1670 ± 43.15	952 ± 30.09	2118 ± 34.65	1793 ± 41.78
Mg (mg/kg)	3293 ± 74.02	1751 ± 35.42	4288 ± 38.98	3917 ± 90.23

Mean values in the same column with different alphabets are significantly different ($P<0.05$).
MC=Moisture content; EC=Electrical Conductivity; OC= Organic Carbon; OM= organic carbon; CEC=Cation Exchange Capacity.

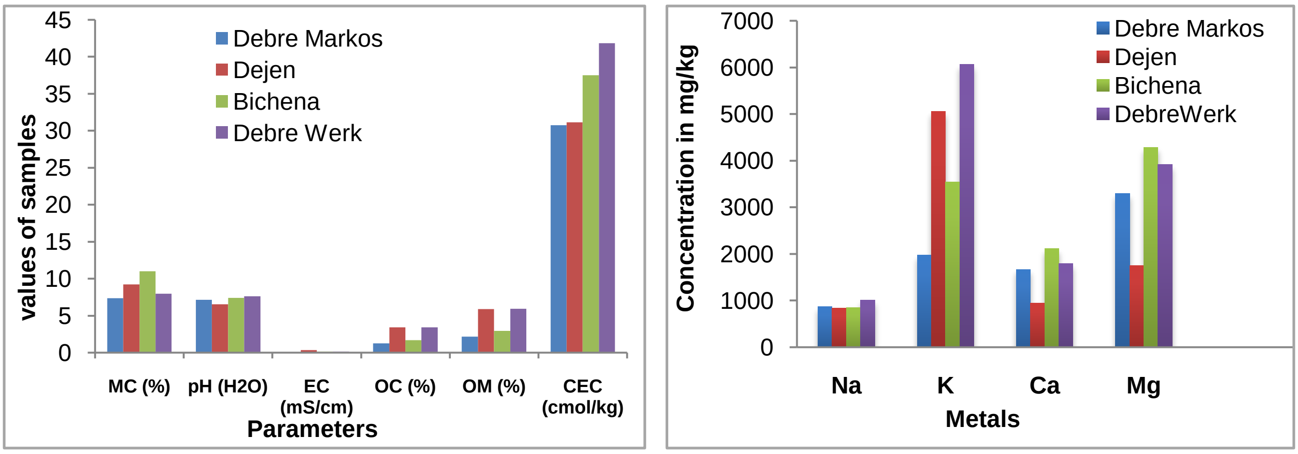

Figure 2: Comparative study of mean concentrations of physicochemical parameters (n = 5)

Table 5: Pearson's correlation coefficients between soil physicochemical parameters

	MC	pH	EC	OC	OM	CEC	Na	K	Ca	Mg
MC	1									
pH	-0.042	1								
EC	0.088	-0.807**	1							
OC	-0.036	-0.160	0.683*	1						
OM	-0.036	-0.161	0.683*	1.000**	1					
CEC	0.333	0.330	-0.147	0.104	0.103	1				
Na	-0.092	0.684*	-0.278	0.479	0.478	0.294	1			
K	0.033	0.102	0.486	0.950**	0.950**	0.236	0.605*	1		
Ca	0.147	0.852**	-0.896**	-0.561	-0.561	0.230	0.237	-0.288	1	
Mg	0.105	0.933**	-0.883**	-0.417	-0.418	0.287	0.409	-0.136	0.979**	1

*Correlation is significant at the 0.05 level (2-tailed) **Correlation is significant at the 0.01 level (2-tailed).

Concentration around zero means no relationship between them, it can be strongly correlated, if r>0.7, whereas r values between 0.5 to 0.7 shows moderate correlation between two different parameters (Rakesh and Raju, 2013). From Table 5, we can observe that strong positive correlation were noticed for the parameters between OC with (OM and K), OM with K, pH with (Ca and Mg) and Ca with Mg. This strong positive correlation shows that the parameters are closely associated, thus suggesting their common origin. Moderate positive correlations were observed between EC with (OC and OM), pH with Na, and Na with K. A strong negative correlation was found between EC with (pH, Mg and Ca). There was also moderately negative correlation between Ca with (OC and OM). The other correlations are week.

CONCLUSIONS

The physicochemical characteristics of soil used for cultivation of garlic in East Gojjam Zone, Ethiopia were analysed. The results indicate that the soil pH is neutral to slightly alkaline and it is one of the major factors affecting mobility/solubility of metals in soil environment. Electrical conductivity values of the soils were non-saline, while the soils have an appreciable organic matter level and cation exchange capacity. The physicochemical study of parameters is important to agricultural chemists for plants growth and soil management. These studies give information about nature of soil, nutrient status of soil; according to this information farmer arrange the amount of which fertilizers and nutrients needed to soil for increase the percentage yield of crops. It is concluded that the physicochemical analysis of soil samples under study shows different concentration of various parameters at different sites. Results of analysis of variance (ANOVA) showed that variation between physicochemical parameters were statistically significant ($p < 0.05$). In future, further study should be done to investigate the levels of heavy metals and other soil physicochemical parameters of the soils in the study area.

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REFRENCES

Chaudhari, K.G. (2013). Studies of the physicochemical parameters of soil samples. *Advances in Applied Science Research* 4(6): 246-248.

Diriba, S.G., Kebede, W., Nigussie, D.R., Getachew, T. and Sharma, J.J. (2013). Postharvest quality and shelf life of garlic bulb as influenced by storage season, soil type and different compound fertilizers. *Journal of Postharvest Technology* 1(1): 69-83.

Ganorkar, R.P. and Chinchmalatpure, P.G. (2013). Physicochemical assessment of soil in Rajura Bazar in Amravati district of Maharastra (India). *International Journal of Chemical, Environmental and Pharmaceutical Research* 4(2&3): 46-49.

Harvey, D. (2000). Modern analytical chemistry. Depauw University, United States of America: McGraw-Hill.

Herk, A.V. (2012). Physicochemical parameters in soil and vegetable samples from Gongulon agricultural site, Maiduguri, Borno State, Nigeria. *International Journal of Chemistry* 1(1): 21–36.

Jackson, M. L. (1967). Soil chemical analysis. New Delhi: Prentice Hall of India, Pvt. Ltd. pp. 205–498.

Javed, I., William, A.C., Shelly, L.C. and Chandra. S.T. (2010). Metals determination in biodiesel (B100) by ICP-OES with microwave assisted acid digestion. *The Open Analytical Chemistry Journal* 4: 18-26.

Joel, O.F. and Amajuoyi, C.A. (2009). Determination of selected physicochemical parameters and heavy metals in a drillin cutting dump site at Ezeogwu-Owaza, Nigeria. *Journal of Applied Sciences and Environmental Management* 13(2): 27-31.

Katzer, G. (2005). Spice Pages: Garlic (*Allium sativum*). Available from: http://www.uni-graz.at/~katzer/engl/Alli_sat .html. (Accessed on October 10, 2013).

Mahajan, S. and Billore, D. (2014). Assessment of physicochemical characteristics of the soil of Nagchoon pond Khandwa, MP, India. *Research Journal of Chemical Sciences* 4(1): 26-30.

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

Odoemelam, S.A. and Ajunwa, O. (2008). Heavy metal status and physicochemical properties of agricultural soil amended by short term application of animal manure. *Current World Environment* 3(1): 21-26.

Prichard, E. and Barwick, V. (2007). Quality assurance in analytical chemistry. New York: John Wiley and Sons.

Rakesh, S.M. and Raju, N.S. (2013). Correlation of heavy metal contamination with Soil properties of industrial areas of Mysore, Karnataka, India by cluster analysis. *International Research Journal of Environment Sciences* 2(10): 22–27.

Raman, N., Sathiyanarayanan, D. (2009). Physicochemical characteristics of soil and influence of cation exchange capacity of soil in and around Chennai. *Rasayan Journal of Chemistry* 2(4): 875-885.

Shaikh, P.R. and Bhosle, B. (2013). Heavy metal contamination in soils near Siddheshwar Dam Maharashtra, India. *Research Journal of Chemical Sciences* 3(1): 6–9.

Singh, R.P. and Mishra, S.K. (2012). Available macronutrients (N, P, K and S) in the soils of Chiraigaon block of district Varanasi in relation to soil characteristics. *Indian Journal of Scientific Research* 3(1): 97-100.

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

USEPA, (2001). Method 200.9, Trace elements in water, solids, and biosolids by stabilized temperature graphite furnace atomic absorption Spectrometry, revision 3.0, EPA-821-R-01-011. Washington, DC.

USEPA, (2010). National functional guidelines for inorganic superfund: Data Review. USEPA-540-R10-011, Washington, DC.

Wagh, G.S., Chavhan, D.M. and Sayyed, M.G. (2013). Physicochemical analysis of soils from Eastern Part of Pune city**.** *Universal Journal of Environmental Research and Technology* 3(1): 93-99.

Walkey, A. and Black, I.A. (1934). An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* 37: 29-38.