DEBRE BERHAN UNIVERSITY

PHYSICO-CHEMICAL CHARACTERIZATION OF BIO-SOLID WASTE OF DEBRE BERHAN UNIVERSITY FOR AGRICULTURAL LAND USE

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A thesis submitted to the School of Graduate Studies, of Debre Berhan University, College of Natural and Computational Sciences, Department of chemistry, in partial Fulfillment of the Requirements for the degree of Masters of Science in chemistry

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APPROVAL SHEET FOR SUBMITTING FINAL THESIS

As members of the Board of Examining of the Final MSc. thesis open defense, we certify that we have read and evaluated the thesis prepared by Tamirat Belay under the title “physico-chemical characterization of bio-solid waste of Debre Berhan university for land ” and recommend that the thesis be accepted as fulfilling the thesis requirement for the Degree of Master of Science in chemistry.

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Certification of the Final Thesis I hereby certify that all the correction and recommendation suggested by the board of examiners are incorporated into the final thesis entitled physico-chemical characterization of bio-solid waste of Debre Berhan University for agricultural land use

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DECLARATION

This is to certify that this thesis entitled “physico-chemical characterization of bio-solid waste of Debre Berhan University for agricultural land use” is accepted in partial fulfillment of the requirements for the award of MSc Degree in chemistry by the school of graduate studies of Debre Berhan University through the college of natural and computational sciences, done by Tamirat Belay is genuine work carried out by him under my guidance. The matter embodied in this thesis work has not been submitted earlier for award of any degree. The assistance and helped received during the course of this investigation have been duly acknowledged. Therefore, I recommend that it can be accepted as fulfilling the research thesis requirements.

Kifle Zeleke(phD) ____________________ _____________

Advisor Signature Date

STATEMENT OF THE AUTHOR

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BIOGRAPHICAL SKETCH

The author was born on October 7 /1983 in Arsi Zone of Oromia region.He attended his elementary education in Jawi Chafeko primary school and his Secondary education in Halila secondary school and his preparatory school, in kula preparatory school. He then joined Woliata Sodo University in 2006 in E.C and received his degree MSc in Chemistry in 2006 E.C Since 2007, he has been teaching Chemistry in Amgna Gesgar preparatory school from 2007to 2011 in Amigna Gesgar district. From 2012 until now he has been teaching chemistry in Tulu Dimtu Primary school in Adis Ababa.

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Abstract

The term bio-solid was introduced in the early 1990 to designate the solid semi-solid or liquid materials generated from the treatment of domestic sewage that has been sufficiently processed to be safely land applied. The physic-chemical properties bio-solid waste of Debre Berhan were 1.54 mS/cm, 3.32%, 35.8%, 5.93, 11.27%, and 61.72% for sample, A for, EC, TN%, OC, pH, C:N, OM, 1.67mS/cm, 3.13%, 11.27%, 5.63, 60.79%, 35.26%.For EC, TN%, C:N%, pH, OM, OC. For sample B and 5.62, 26.44%, 2.36mS/cm, 3.13%, 8.45%, 45.56%. For PH, OC%, EC, TN% and OM respectively for sample C. In general the study revealed that the bio-solid waste has high OM, OC, TN, C: N, and low EC and P low concentration of heavy metals of (Pb, Cu, Ni, Zn, Cd) that meets the ceiling concentration limit of Rule 503 that was set by US EPA for using the bio-solid waste for land use as a fertilizers and high concentration of heavy metals of (As, Hg). In addition to this, the bio-solid waste has high concentration of primary nutrients of potassium, nitrogen and phosphorus. However the low pH of the bio-solid waste indicates that, the bio-solid is slightly acidic and application of it on the land needs further treatment or it is better to use it on the less acidic soil.

ACRONYMS AND ABBREVIATIONS

ADW : Air dry weight

C/N : Carbon to Nitrogen ratio

CFR : Code of federal regulations

Cpc : cycles per second

Cv : coefficient of variation

E.C : electrical conductivity

ICP-OES: Inductively coupled plasma optical emission spectroscopy

N : Normality

NSSS : National sewage sludge survey

O.C : Organic carbon

O.M : Organic matter

PCBs : Poly chlorinated bi phenyl

pH : power of hydrogen

S : Volume of $FeSO_4$ used for blank titration

SD : Standard deviation

T : Volume of $FeSO_4$ used for sample titration

TKN : total kjeldhal nitrogen

US EP A : united States of America Environmental protection agency

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CHAPTER ONE

1 INTRODUCTION

1.1 Background of the study

The term bio-solid was introduced in the early 1990s to designate the solid, semi-solid or liquid materials generated from the treatment of domestic sewage sludge that has been sufficiently processed to be safely land-applied. Bio-solids contain organic carbon (C) , nitrogen(N) , phosphorus (P) ,potassium (K), sulphur (S) ,calcium (Ca) ,magnesium (Mg) ,and micro elements necessary for plants and soil fauna to live.

Nutrient contents in bio-solids depend on the untreated water source, chemicals used for purification, and types of unit operation used [3].

Sewage sludge refers to the solids separated during the treatment of the municipal waste water. According to united to States Environment Protection Agency (US EPA),bio-solids refers to treated sewage sludge that meets the EPA Pollutant and Pathogen requirement for land application and surface disposal [7].

The sewage sludge produced at different treatment plants and during different seasons varies in physicochemical properties. As a result, knowledge of the chemical composition of each kind of sewage sludge is necessary before it is used for land application. The characteristics of sewage sludge depends not only the nature of the waste water, but also on the processes by which the waste water is processed. Sewage sludge is generally composed of organic compounds, macronutrients, and a wide range of micro nutrients, nonessential trace metals, organic micro pollutant, and micro-organism [12, 27] Waste from different house hold industries also contributes heavy metals to waste water and, therefore, ultimately to sewage sludge [26].

The chemical properties of sludge soil mixtures not only depend on the properties of soil or sludge or sludge application rates, but also on soil (pH) and how this components interact [10]. Application of bio-solids on agriculture and degraded lands is one of the most promising alternatives of disposal because it offers the possibility of recycling plant.

Nutrients and organic matter [26]. This practice may also contributed to soil sequestration, reducing green-house gas emissions [6, 30].

However bio-solids may contain undesirable hazardous substances such as potentially toxic trace elements ranging from less than 1 to over 1000 mg kg^{-1} polychlorinated biphenyl (PCBs), poly cyclic aromatic hydrocarbons (PAHs), and dioxin [1].

The most common management option for bio-solids are land application, land fill disposal and incineration. Land application is an attractive option for bio-solids management [32] as it is a cheap and easy solution with the added benefit that bio-solids typically contain high concentrations of nitrogen, phosphorus and small quantities of other nutrients. However, land application has met much opposition in recent years for several reasons.

Municipal bio-solids are composed of waste streams from residential, commercial and industrial sources which the concern of potential chemicals, solvents and pharmaceuticals being included in the bio-solid [2]. has shown that there also concerns about the presence of pathogens (fecal coliforms salmonellae) that can contaminate the land, concentration of which have been found to increase over time even after destruction method have been applied and sample indicate no measurable pathogens[8].Indicated that high concentrations of heavy metals in bio-solids are also of concern, as they can contaminate and reduce the productivity of land used for disposal by reducing the bacterial diversity within the soil [19].

Determination of bio-solid quality based is based on trace element (pollutant) concentration and pathogen and vector attraction reduction. The part 503 rule prohibits land application of sewage sludge whose pollutant concentrations exceed certain limits for nine trace elements: As, Cd, Cu, Pb, Hg, Mo, Ni, Se and Zn, such material should not be applied to land and are not considered bio-solids. Waste Sludge, exceeding the ceiling concentration limit for even one of the regulated pollutant is not classified as bio-solids and hence, cannot be land applied. Bio-solids meeting pollutant concentration limit are subject to fewer requirement than bio- solids meeting ceiling concentration limits. Results of the U.S. EPA's 1990 National sewage sludge survey (NSSS) [31] demonstrated that the mean concentration of the nine regulated pollutants are considerably lower than the most stringent part 503 pollutant limits.

In 1987, the U.S. EPA established pretreatment specification (40 CFR Part 403) that requires industries to limit the concentrations of certain pollutants, including trace elements and organic chemicals, in waste water discharged to a treatment facility. An improvement in the quality of bio-solids over the years has largely been due to pretreatment and pollution prevention programs [24].

Part 503 does not regulate organic chemical in bio-solids because the chemical of potential concern have banned or restricted for use in the United State; are no longer manufactured in the United States; are present at lower concentrations based on data from the U.S EPA's 1990 NSSS[31]. The National Research council concluded, in their review of the science up on which the part 503 Rules was based that additional testing of certain organic compounds should be conducted [21]. These include poly-brominated biphenyl ether, nonyl phenols, pharmaceuticals, and other potential carcinogenic and endocrine-path way disrupting personal care product. Restriction will be imposed for agricultural use if testing of these organic compounds verifies that bio-solids contain level that could cause harm stringent as the federal regulation [29].. Individual states may impose may impose additional regulations that are at least as stringent as the federal regulation [29].

1.2 Statement of the problem

The main reason that reinforce the researchers to do this research are the following

To increase the use of bio-solid waste for agriculture rather than discarding some were.

The discharged bio-solid inform of solid can be the host for disease.

The discharged sludge can inter into water bodies and can harm organism in water bodies.

To analyze the odors of bio-solid waste wether it cause disease to human being.

it has been incinerated, land filled and drained into water bodies in the form of sewage. This study to characterize the physical as well as chemical properties of bio-solid waste of Debre Berhan University in which the macro nutrient and micro nutrient of bio-solid are specified. When the use of bio-solid waste practice increases, result in decrease in the cost for fertilizer as well as decrease in waste borne disease specially those on land filled waste.

Consequently the country demands more research, innovation and practical solution to ensure the sustainable development on the use of bio-solid waste on agricultural land.

1.3 Objectives of the study

1.3.1 General objective

- The general objective of this study is to characterize the physico-chemical properties of bio-solid waste obtained from Debre Berhan University for agricultural land use.

1.3.2 Specific Objectives

The specific objectives of this study are:

- To determine the physical and chemical properties of bio-solid waste obtained from Debre Berhan University.
- To determine the concentration of macro and heavy metals of the bio-solid waste
- To determine the total nitrogen content of bio-solid waste.
- To determine the total organic carbon content of bio-solid waste.
- To determine the organic matter content of bio-solid waste.
- To determine the pH of bio-solid waste.
- To determine the EC of bio-solid waste.
- To determine the C:N of bio-solid waste.

1. 4 Significance of the study

The study of physicochemical characterizations of bio-solid waste for land use plays crucial role for using the solid as fertilizer. Before bio-solid waste is used on land, its macro and micro nutrient should be determined. This study determines the physical properties of bio-solid waste, such as electrical conductivity, pH and moisture content as well as chemical properties such as determination of some metals and non- metals in bio-solid waste.

The university itself is also body that is going to benefit from the output of the study, since the university is the host of a of conglomerates research out of diverse profession with multitude of research works that could contribute a lot for learning and problem solving. Therefore, University as a home of knowledge can benefit in both theoretical and practical perspectives.

1.5 SCOPE OF THE STUDY

The study of physic-chemical characterization of bio solid waste takes long time for this reason, this study focused only on physicochemical characterization of bio-solid waste obtained from Debre Berhan University for agricultural land use and the studies only reveals properties like pH, EC TKN, OC, OM, macro nutrient and heavy metals concentration.

CHAPTER 2

2.1 LITRATURE REVIEW

Bio-solids is referred to as sewage sludge or domestic wastewater residuals is an insoluble biological solid residue or organic waste resulting from different sewage treatment processes [25, 26, 27 ,28] in wastewater treatment plants worldwide [18]. Bio-solids can be described as a heterogeneous matrix abundant in organic matter and soluble nutrients, which characteristically may contain potentially harmful constituents like pathogens, heavy metals and organic pollutants which can strictly limit their safe environmental disposal or agricultural usage [4]. However, addition of organic matter due to long-term application of bio-solids improves physic-chemical properties of soils [16].

Presence of the major components of bio-solids i.e. organic matter and beneficial plant nutrients especially N and P, make it a good soil ameliorating agent [14]. However, physicochemical nature/characteristics of bio-solids may show not only seasonal and treatment process induced variations but also on the nature of wastewater, hence prior to their land application for agronomic purposes bio-solid need to be analyzed chemically. Physicochemical properties of the soil for example aggregate stability, bulk density, porosity and water retention may be altered/ improved due to land application of sludge, thereby affecting the plant nutrient balance [32]. A prime reason for heavy metal contamination in bio-solids is unplanned or mismanaged urban sewerage system that leads to mixing of sewage with industrial waste water [9] and also from commercial sources, storm water runoff from city roads etc. Toxic substances like several organic micro-pollutants such as pesticides, insecticides, disinfectants, pharmaceuticals, detergents, personal care products, steroid [17] and various other inorganic salts are present in wastewater and finally in the processed bio-solids.

Organic amendment like bio-solids are known to improve the physical properties of soil such as increasing the water holding capacity, forming stable organic heavy metal complexes and reducing metal availability in contaminated soil [13]. Approximately, half of the solid fraction of bio-solids is composed of organic matter which has a significant effect on physical properties of soil such as increasing the retention and movement of water, improving soil porosity and soil aggregation [11]. Bio-solids being a rich source of organic matter can help in altering the physicochemical properties of soil there by reducing bio-availability of metals to plants due to the ability of metals to form stable metal-organic complexes [22].

Soil pH is an important consideration when it comes to abundance of trace metals in bio-solids [27].There is a strong relation between their sorption onto soils and soil properties. Generally lower pH values lead to increased heavy metals bioavailability for plant uptake; hence pH of bio solids is an important factor to determine potential of metal toxicity in plants [15]. The characteristics of sludge play an important role when considering the ultimate disposal of the processed sludge, especially in their use for land application. Sludge characteristics can be broken down in three categories: (i) physical, (ii) chemical and (iii) biological.

The important physical characteristics are the solid content and the organic matter content. The total solids content affects the method of land application. Liquid or low-solids sewage sludge will generally be injected into soil to prevent vectors and provide better aesthetics. On the contrary dewatered or semisolid bio-solids are usually spread on the surface and subsequently plowed into the soil [5]. The organic matter is an important constituent of bio-solids and its use for land application enhances the organic content of soils. In sandy soils the organic matter increases the water-holding capacity, soil aggregation and other soil physical properties. It reduces the soil bulk density and increases the cation exchange capacity (a very important property for supplying plant nutrients). The positive effect of organic matter on the soil physical properties enhances the plant root environment. Therefore, plants are better able to withstand drought conditions, extract water, and utilize nutrients [5].

Chemical properties affect plant growth as well as the soil's chemical and physical properties. The important chemical characteristics are: (i) pH, (ii) soluble salts, (iii) plant nutrients (macro and micro), (iv) essential and non-essential trace elements to humans and animals and (v) organic chemicals. A detailed list of heavy metals, trace elements, priority pollutants and organic chemicals can be found in Epstein [5]. The pH of most bio-solids (whether liquid, semisolid, or solid) is generally in the range of 7–8, unless lime is added during the wastewater treatment process [23]. Plant nutrients are among the most important chemical characteristics of bio-solids, the major plant nutrients are nitrogen (N), phosphorus (P) and potassium (K). Other macronutrients are calcium (Ca), magnesium (Mg), and sulfur (S). The micronutrients essential to plant growth are boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni) and zinc (Zn). It has been recognized for centuries that sewage sludge contains plant nutrients. Pretreatment, which is aiming to reduce the eventual amount of sludge production, is typically done by the application of external forces and agents in order to destruct sludge solids [20].Pretreatment is mostly used for biological sludge, even though it has application for mixed sludge as well. Applied forces lead to rupture of the cell membrane of bacteria in biological sludge resulting in release of organic substances outside the cell [32]. Hence, sludge disintegration achieves solubilization and conversion of slowly biodegradable, particulate organic materials to low molecular weight, readily biodegradable compounds ending up producing much less sludge after stabilization such as digestion.

CHAPTER 3

3 MATERIALS AND METHODS

3.1 Bio-solid sample collection.

The source of bio-solid sample was Debre Berhan University which is located in the Ahmara regional state in the northern part of Ethiopia. Bio-solid sample was taken from which it was kept from three sacks in room randomly and was kept in plastic bag as soon as it was taken. After it was sampled ,for further physicochemical analysis the solid waste was air dried and ground with mortar and pestle followed by sieving through <2mm sieve stainless steel and again stored in plastic bag.

3.2 Material and apparatus

3.2.1 Chemicals and Reagents

For different purpose of this study the chemical that were used includes, concentrated sulfuric acid and 0.1N (concH_2S0_4 and 0.1N H_2S0_4), 69%v/v nitric acid (HNO_3) concentrated hydrochloric acid (HCl), (30%w/v) hydrogen peroxide (H_2O_2), phosphoric acid (H_3PO_4), sodium sulfate (Na_2SO_4) copper sulfate ($CuSO_4$), ferrous sulfate ($FeSO_4$), potassium dichromate ($K_2Cr_2O_7$), distilled water, aqua-regia, buffer solution of pH 4,7 and 9.2 respectively, boric acid (B $(OH)_3$), sodium hydroxide (NaOH), ferroin and combination of methyl red and ethylene blue indicators.

3.2.2. Apparatus and Instruments

The following apparatus and instruments were used for the studies. Mortar and pestle for sample size reduction, electronic balance for measuring the masses of some solid chemicals and ground sample, 10ml graduated cylinder for measuring liquid volume, test tube for holding the sample, 100ml and 1000ml volumetric flask for preparation of standard solution pipet for transferring relatively small amounts of liquids, drying oven for drying the bio-solid waste, hot plate for heating purpose, 250ml conical flask for titration, block digester for digesting sample in kjeldahl flask, pH meter for pH measurement, ICP-OES instrument for determination of the concentration of some heavy metals in bio-solid waste sample, E.C meter, semi micro kjeldahl distillation unit for distillation of the digested sample in kjeldahl flask Erlenmeyer flask for neutralization of sulphuric acid and , fume cupboard to keep harmful chemicals,

3.3. Experimental Methods and Procedures

3.3.1. Experimental Site

All of the experimental works which includes all parameters of physicochemical characterization of bio-solid waste like pH, total nitrogen, organic carbon electrical conductivity, determination of heavy, and moisture content were done in Bishoftu town in eastern showa zone in Oromia regional state in cooperative horticultural institute laboratory.

3.3.2 Sample preparation for heavy metal determination with ICP- OES

From each of air dried, ground and sieved bio-solid waste 1.25g of each sample was weighed and placed in three 100ml conical flask which was labeled A, B and C rinsed with distilled water. To each conical flask 20ml of aqua-regia was added and placed on a hot plate until the sample solution is dried. The dried sample was allowed to cool and to each cooled sample 5ml of 30%v/v of H_2O_2 was again added and placed on a hot plate and allowed to dry. Finally, the dried sample was allowed to cool and to it 10ml of distilled water was added to wash the wall of the flask and 5ml of 34.5%v/v of HCl was added to each dried and cooled sample followed by filtration with a filter paper of watchman NO 42 into poly vinyl bottle. The filtrate was filled by distilled water up to 50ml of poly vinyl bottle which was standard solution for analysis

3.3.3 Sample preparation for determination of total N by kjeldahl method.

1g of air dried bio-solid waste which was ground and sieved was measured with electronic balance from each samples was placed in three kjeldahl flask labeled A, B and C respectively To each kjeldahl flask with a sample half spatula of a catalyst mixture (100g of Na_2SO_4 and 10g of $CuSO_4$) and 10ml of concentrated sulfuric acid were added and mixed. Then after, the three samples including the blank were placed on the top of block digester and digested for 3hours up to temperature of 370oC when the mixture turns to white or pale yellow, they are allowed to cool and 25ml of distilled water was added to each digested samples. Finally, each of the cooled sample was taken in to semi micro kjeldahl distillation unit one after the other and to each of the distillate in erlenymer flask, 25ml of boric acid, 10ml of distilled water and 2 drops of phenolphthalein indicator were added followed by titrating with 0.1N H_2SO_4.

The reaction that was takes place during determination of total nitrogen by means of kjeldhal methods follow the three major steps. Digestion, distillation and titration. In each of the three steps the following reactions were happened consequently.

Step 1 digestions of bio-solid waste.

$CHNO+H_2SO_4 \longrightarrow (NH_4)_2SO_4+CO_2+H_2O$

Organic nitrogen samples

Step 2 distillation of digested bio-solid waste

$(NH_4)_2SO_4+2NaOH \longrightarrow 2NH_3$ (gas)$+NaSO_4+2H_2O$

Step 3 Nitrogen determinations by direct titration

Boric acid was used as receiving solutions and the chemical reaction is given be

$NH_3+B(OH)\,3NH_4^+:H_2\text{-}B\text{-}O_3^-+B(OH)_3$

$2NH_4H_2\text{-}B\text{-}O_3^-+H_2SO_4 \longrightarrow (NH^+{}_4)_2+2B\,(OH)_3$

Calculation for nitrogen determination

$$\text{Nitrogen\%} = \frac{(\text{ml standard acid} - \text{mlblank}) * \text{N of acid} * 1.400}{\text{Weight of sample in gram}}$$

3.3.4 Measuring the pH of the bio-solid waste.

10g of bio-solid waste sample was measured by electronic balance from each sample and placed in three bottle by adding 25ml of distilled water followed by shaking for 30 minutes and allowed for 1 hour until it form suspension. The pH meter was calibrated with a buffer solution of a pH 47 and 9 respectively. Then after, the electrode was inserted in the suspension in the bottle and read the value one after the other by washing with distilled water.

3.3.5 Determination of organic carbon

0.5g of bio-solid waste which was air dried, ground and sieved was measured by electronic balance from three samples were placed in three 250ml conical flask rinsed with distilled water. To each sample 10ml of 1N $K_2Cr_2O_7$ and 20ml concentrated sulfuric acid (H_2SO_4) were added through swirling the flask until the sample and the reagents were mixed. A thermometer was inserted and the mixture was heated on a hot plate. To each cooled sample in a conical flask again 200ml of distilled water and 3 or 4 drops of ferroin indicator were added followed by titrating with 0.4N$FeSO_4$ until the color changed from purple blue- green to reddish- grey.

Calculations

From the equations:

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

1mL of 1N Dichromate solutions is equivalent to 3mg of carbon.

Where the quality and normality of the acid/dichromate mixture used are stated in the method, the percentage is determined from the following:

$$\text{Organic carbon (\%)} = \frac{0.003g*N*10mL*\left(1-\frac{T}{S}\right)*100}{ADW}$$

Where:

N = Normality of $K_2Cr_2O_7$ solution

T = Volume of $FeSO_4$ in sample titrations (mL)

S = Volume of $FeSO_4$ used for blank titrations (mL)

ADW = air dry weight

3.6.6 Measuring the EC of the bio-solid waste.

10g of bio-solid waste sample was measured by electronic balance from each sample and placed in three bottle by adding 25ml of distilled water followed by shaking for 30 minutes and allowed for 1 hour until it form suspension. Then after, the EC measuring electrode was inserted in suspension solution of the sample in the bottle and read the value one after the other by washing with distilled water.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 PHYSICO-CHEMICAL PROPERTIES OF BIO-SOLID WASTE

The physicochemical characterization of the bio-solid waste was first investigated to evaluate its potential for agricultural land use. The main physical and chemical properties of the bio-solid samples were present in table1.2 and 3For sample A, B and C respectively.

Table1: some of chemical and physical properties of bio-solid waste of sample A.

Sample Type	Bio-solid waste properties	Mean Value
A	pH	5.93
	OC (%)	35.8
	EC mS/cm	1.54
	TN (%)	3.32
	C:N (%)	11.27
	OM (%)	61.72

Table 2: some of chemical and physical properties of bio-solid waste of sample B.

Sample Type	Bio-solid waste properties	Mean Value
	pH	*5.63*

B	OC (%)	35.26
	EC (mS/cm)	1.67
	TN (%)	3.13
	C:N (%)	11.27
	OM (%)	60.79

Table 3: Some physical and chemical properties of bio-solid waste of sample C.

Sample type Bio-solid	Bio-solid waste properties	Mean value
C	pH	5.62
	OC(%)	26.44
	EC mS/cm	2.36
	TN(%)	3.13
	OM(%)	45.58
	C:N(%)	8.45

4.1 .1 THE ORGANIC CARBON CONTENT OF BIO-SOLID WASTE

The total mean percentage of organic carbon (OC) content of bio-solid samples was 35.80, 35.26, and 26.44% respectively. The organic carbon(O.C) obtained in this study was quite high and the content of O C in the samples make it a potential soil fertilizer which can significantly increase the supplement of essential nutrient to crops enriching the soil physical properties and boosting the organic matter in the soil and overall contributing an increase in crop production.

4.1.2 ORGANIC MATTER CONTENT OF BIO-SOLID WASTE

Based on the mean results of organic carbon and Bemmelen factor (1.724) the organic matter (OM) of the three samples was found to be 61.72%, 60.79% and 45.58%. The total mean percentage of organic matter of sample A and B of this study were achieved Taiwan recommended regulation for specification of organic matter content (dry weight) >50% for utilizing sludge as a material resource sustainable.

4.1.3 THE CARBON TO NITROGEN RATIO (C/N) OF BIO-SOLID WASTE.

The C/N ratio is one of the most important chemical characteristics of bio solid for microorganism. Carbon is the building block of life and source of energy, while nitrogen is necessary as protein, genetic material and cell structure. The C/N results obtained in this study for three bio solid samples that were labeled, A B and C was 10.78, 11.27 and 8.45% respectively. The result is found in the line with the allowable range of C/N of the fertilizer value of bio solid waste for agricultural use set by the environmental qualification authority less than 35%. The C/N ratio ranged from 11 to 20.45 implicates that the bio solid waste would support plant species diversity and growth. Therefore, we can conclude that C/N ratio of bio solid waste obtained in this study can support the plant species diversity and growth.

4.1.4 THE TOTAL KJELDHAL NITROGEN OF BIO-SOLID WASTE

Nitrogen is main macro nutrient element and presence of it in high amount stimulates shoot growth and root growth. Because nitrogen is needed to make chlorophyll. Besides the genetic protein and cell wall needed by all cells. The total kjeldhal nitrogen (TKN) contents in bio solid waste in the three samples that were labeled A, B and C was 3.32, 3.13 and 3.13% respectively. The TKN result obtained in this bio solid waste normally existed in the range of nitrogen concentration used by most plants average from 2-4%. The result of TKN of the bio solid waste samples is high in all samples in this study.

4.1.5 CONCENTRATION MACRO NUTRIENT OF BIO-SOLD WASTE

The determination of primary and secondary macro nutrient excluding nitrogen which was determined by means of kjeldhal method was determined by ICP-OES. The mean concentration of those elements were found to be 2442.76, 1108.04, 20161.77, 4615.61 and 23475.97mg/Kg respectively for sample A for magnesium(Mg), Potassium(K), Calcium (Ca), Phosphorus(p) and sulfur (S) consequently. For sample B, the mean concentration of macro elements were 2765.89, 31143.93, 34354.80, 4571.18 and 23509.33mg/Kg for magnesium(Mg), Potassium(K), Calcium(Ca) Phosphorus(p) and sulfur (S) consequently. And 2352.43, 1176.26, 17572.03, 3767.21, 36469.17mg/Kg for sample C for magnesium (Mg), Potassium (K), Calcium (Ca) Phosphorus (p) and sulfur (S) consequently. The mean concentration and SD of primary macro nutrient were presented in table4

Table4: Concentration of primary macro nutrients of the bio-solid waste samples.

Sample type	Macro nutrient elements	Concentration in mg/Kg		cv
		Mean	Mean±SD	
A	P	4615.61	4615.61±83.02	1.78
	K	1108.04	1108.04±5.17	0.46
B	P	4571.18	4571.18±21.96	0.48
	K	1143.93	1143.93±14.71	1.23
C	P	3767.21	3767.21±66.46	1.76
	K	1176.26	1176.26±27.25	2.32

4.1.6 THE pH of BIO-SOLID WASTE.

The determination of the pH of the bio-solid waste of the three samples was found slightly acidic and it was found that the pH values of the bio-solid wastes were 5.93, 5.63 and 5.62 for sample A, B and C respectively. Based on the result of the pH value it is found that the bio-solid waste is slightly acidic. Based US EPA guidance, soil treated with bio-solid waste must be maintained at a pH 6.5 or higher to reduce metal up take by crops. The federal regulation does not require a minimum pH of soil to apply bio-solid waste on it. In general the bio-solids waste obtained from

Debre Berhan university need liming in order to increase its pH value during sewage sludge treatment process.

4.1.7 HEAVY METAL CONCENTRATION OF BIO-SOLID WASTE

The heavy metal analysis was carried out with the objective of identifying potential toxicity as a result of application of bio-solid waste to agriculture. It is known that heavy metals such as cadmium (Cd), mercury (Hg), and lead (Pb) carry a high level of toxicity to human and animals while being less toxic to plants. By contrast Zink (Zn), nickel (Ni) and copper (Cu) are more damaging to plants when they are found in higher concentration.

Heavy metals such as molybdenum (Mo) and selenium (Se) can also cause toxicities in animals and humans. However, they are often present at low concentrations in solid waste and do not therefore limit the rate of bio-solid application to agricultural land. Higher concentration of heavy metals is known to affect soil biological and microbial population and they can reduce or entirely inhibit soil fertility. The concentrations of eight heavy present in the bio-solid samples taken from Debre Berhan University were analyzed by the ICP-OES.

In this study the concentration of seven heavy metals were determined for the three bio-solid samples and the result of concentration of heavy metals in this study was standardized with the rule 503 (Title 40 of the code of federal regulation [CFR])which establish standard that must be met if bio-solids are to be land applied. The regulation limit the concentration of nine heavy metals .However this study only reveals the concentration of seven heavy metals (Pb, Zn, Cu, Ni, Hg, As and Cd). The mean concentration of arsenic (As), cadmium (Cd), copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni) and Zink (Zn) were, 177.49, 36.99, 106.59, 603.19, 94.13 49.97 and 774.40 for sample A, 233.52, 50.88, 119.15, 788.55, 119.28, 66.00 and 905.33 for sample B and 202.40, 43.64, 96.51, 677.92, 98.39, 53.36 and 743.47mg/Kg for sample C respectively. In general, the mean concentration of five heavy metals of three bio-solid waste samples meets the ceiling concentration limit and only the concentration of Arsenic (As) and Mercury (Hg) were above the ceiling concentration limit. Hence the bio-solid waste is low in concentration of heavy metals and can be applied on land as fertilizer. The concentration of heavy metals of bio- waste taken from Debre Berhan University was presented in table 5, 6and 7.solid bio-

Table 5: Concentration of heavy metals of sample A.

Sample type	Heavy metals	Concentration in mg/Kg		cv (%)
		Mean	Mean±SD	
A	Zn	774.40	774.40±36.06	0.50
	Pb	603.19	603.19±6.63	1.10
	Cu	106.59	106.59±1.09	1.02
	Cd	36.99	36.99±0.48	1.30
	As	177.49	177.49±3.99	2.25
	Hg	94.13	94.13±3.90	4.14
	Ni	49.97	49.97±0.81	1.62

Table 6 :CONCETRATION OF HEAVY METALS OF SAMPLEB

Sample type	Heavy metals	Concentration in mg/Kg		Cv (%)
		Mean	Mean±SD	
B	Zn	905.33	905.33±54.60	6.03
	Pb	788.55	788.55±100.93	12.80
	Cu	119.15	119.15±1.01	0.85
	Cd	50.88	50.88±0.56	1.10
	As	233.52	233.52±7.55	3.23

	Hg	119.28	119.28±0.60	0.50
	Ni	66 .00	66.00±1.05	1.59

Table 7: Concentration of heavy metals of sample C.

Sample type	Heavy metals	Concentration in mg/Kg		CV(%)
		Mean	Mean±SD	
C	Zn	743.47	743.47±55.09	7.40
	Pb	677.92	677.92±17.73	2.62
	Cu	96.51	96.51±1.40	1.45
	Cd	43.64	43.64±1.24	2.84
	As	202.40	202.40±1.82	0.899
	Hg	98.39	98.39±1.59	1.62
	Ni	53.36	53.36±1.16	2.17

CHAPTER FIVE 5

5.1 CONCLUSION

Characterization of the bio-solid revealed that the existence of important primary nutrient like nitrogen, phosphorus, potassium, and secondary nutrients such as calcium magnesium and sulfur. In general the characterized bio-solid waste obtained from Debre Berhan University contains low heavy metal concentration that meet the allowed EPA ceiling standard for using the bio-solid waste as fertilizer, high organic carbon (OC), and organic matter (OM), low electrical conductivity (EC), that meets the salinity value of 3mS/cm, and slightly acidic pH value that needs further treatment to achieve the limit before introduced into agricultural application. Therefore a cost effective user should develop the use of bio-solid waste in the place of inorganic fertilizer.

5.2 Recommendation

From this study the total nitrogen, the organic carbon content, organic matter content, the macro nutrient like potassium and phosphorus of the bio-solid waste was so high and the heavy metals concentration was low except for arsenic (As), and mercury (Hg) whose concentration were above ceiling concentration limit set by US EPA. In contrast the pH of the sludge was slightly acid. Therefore for using the solid waste on land application as fertilizer, it is recommended that the sludge of this solid waste, need liming in order to decrease its acidity or should be applied on high pH soil. For further investigation the researcher recommend that the study of physic – chemical characterization of the sludge had better done more in detail in order to characterize it.

Hence, the awareness of using the solid waste through replacing in organic fertilizers should be practiced.

6 References

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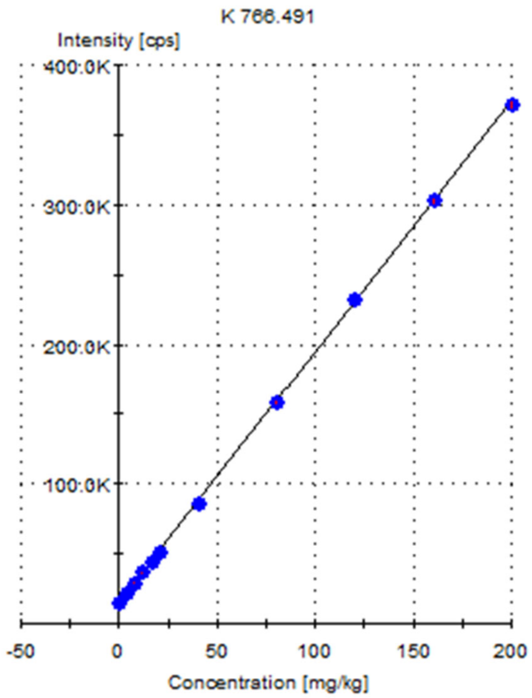
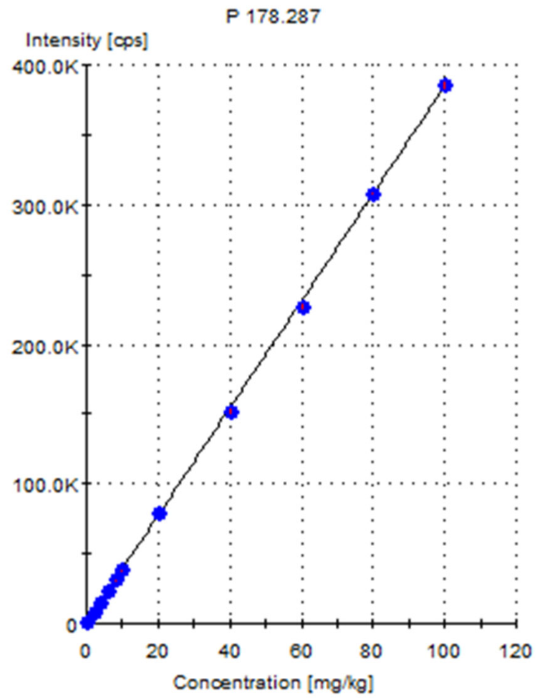
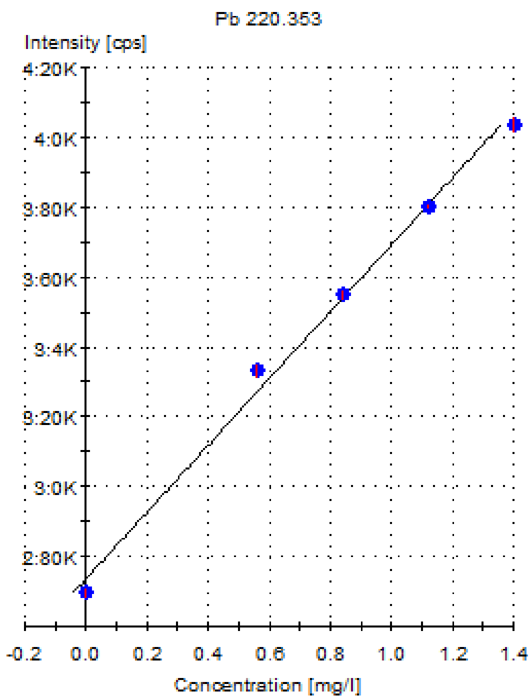
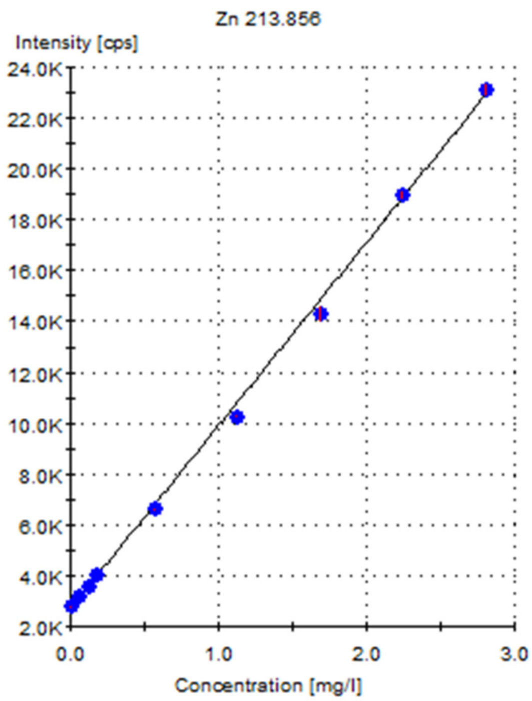
7 APPENDIXES

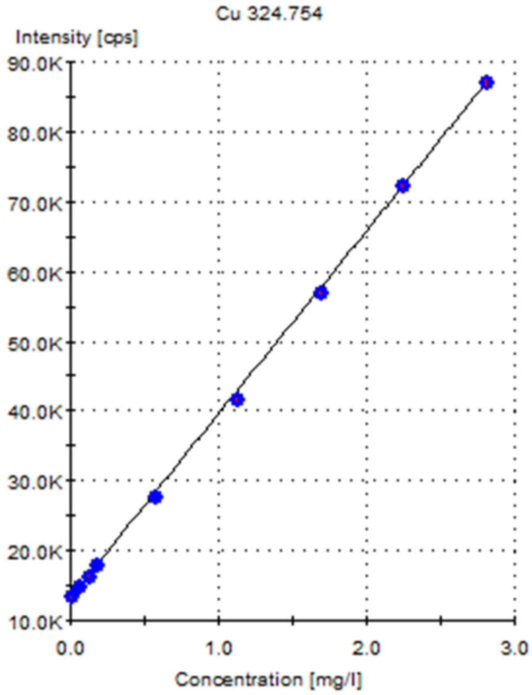
7.1 Regression graph of some heavy and micro nutrient graph

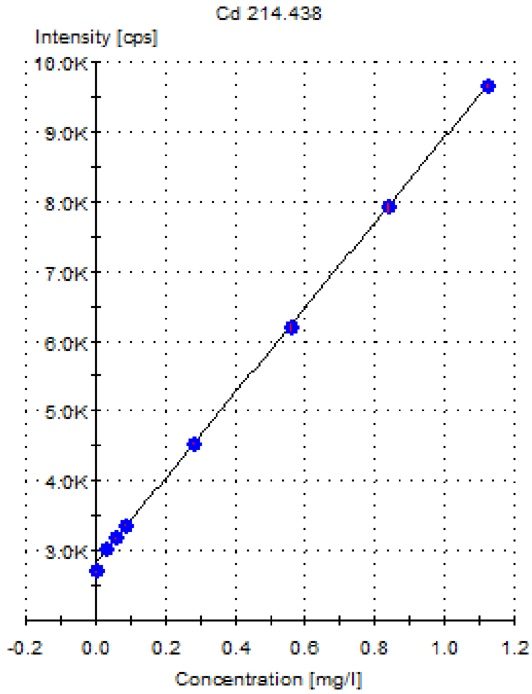

K 766.491
Intensity [cps]
400.0K
300.0K
200.0K
100.0K
-50
0
50
100
150
200
Concentration [mg/kg]

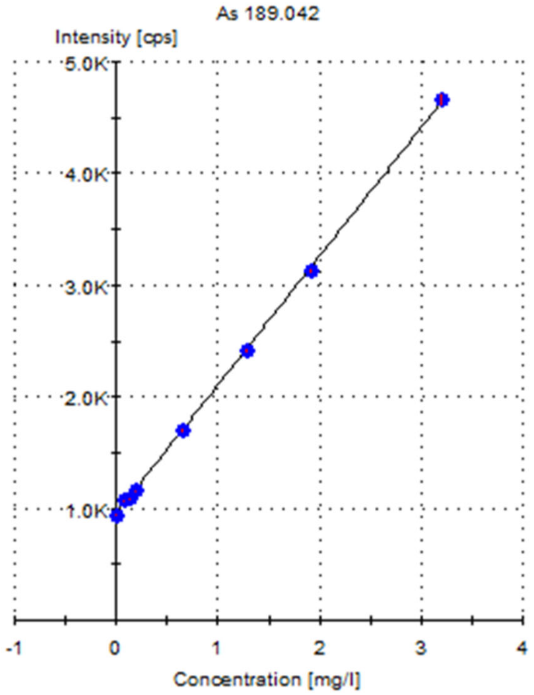

P 178.287
Intensity [cps]
400.0K
300.0K
200.0K
100.0K
0
0
20
40
60
80
100
120
Concentration [mg/kg]

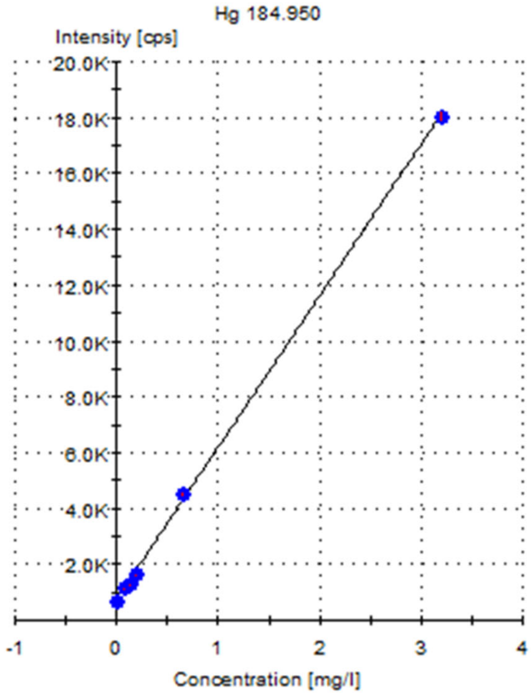

Pb 220.353
Intensity [cps]
4.20K
4.0K
3.80K
3.60K
3.4K
3.20K
3.0K
2.80K
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Concentration [mg/l]

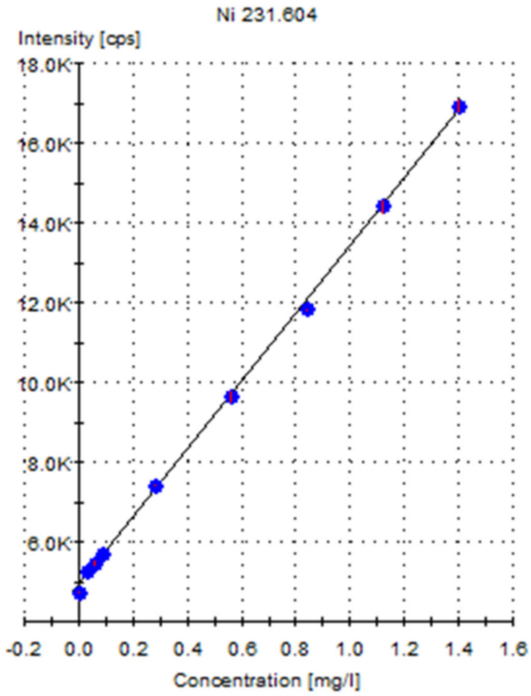

Zn 213.856
Intensity [cps]
24.0K
22.0K
20.0K
18.0K
16.0K
14.0K
12.0K
10.0K
8.0K
6.0K
4.0K
2.0K
0.0
1.0
2.0
3.0
Concentration [mg/l]


Cu 324.754
Intensity [cps]
90.0K
80.0K
70.0K
60.0K
50.0K
40.0K
30.0K
20.0K
10.0K
0.0
1.0
2.0
3.0
Concentration [mg/l]


Cd 214.438
Intensity [cps]
10.0K
9.0K
8.0K
7.0K
6.0K
5.0K
4.0K
3.0K
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Concentration [mg/l]


As 189.042
Intensity [cps]
5.0K
4.0K
3.0K
2.0K
1.0K
-1
0
1
2
3
4
Concentration [mg/l]


Hg 184.950
Intensity [cps]
20.0K
18.0K
16.0K
14.0K
12.0K
10.0K
8.0K
6.0K
4.0K
2.0K
-1
0
1
2
3
4
Concentration [mg/l]


Ni 231.604
Intensity [cps]
18.0K
16.0K
14.0K
12.0K
10.0K
8.0K
6.0K
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Concentration [mg/l]