HEAVY METAL STATUS OF MUNICIPAL SOLID WASTE AND SOIL AT KOSHE OPEN DUMPING SITE OF ASSELA TOWN ,OROMIA REGION, ETHIOPIA

MSC THESIS

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Heavy Metal Status of Municipal Solid Waste and Soil At Koshe Open Dumping Site of Assela Town ,Oromia Region, Ethiopia

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As thesis research advisors, we hereby certify that we have read and evaluated this Thesis entitled, **Heavy Metal Status of Municipal Solid Waste and Soil At Koshe Open Dumping Site of Assela Town ,Oromia Region, Ethiopia** prepared under our guidance by ***Saudi Bahmud***. We recommend that it shall be submitted to fulfill the thesis requirements for MSc Degree in Environmental Science and Management.

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DEDICATION

I dedicate this piece of work to my mother Amina Anole and brothers Sultan Bahmud

STATEMENT OF THE AUTHOR

By my signature below I declared and affirm that this thesis is my own original work where works of any other investigator has been properly recognized through citation. This thesis has been submitted in partial fulfillment of the requirements for MSc degree at Haramaya University and shall be deposited in the University library to be made available to borrow under rules of the library. I solemnly declared that this thesis had not been submitted anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author was born in December, 1992 at Robe District, Arsi Zone, Oromia Regional state of Ethiopia. He attended elementary education at Masaranje Abbu elementary school and secondary and preparatory education at Didea Robe secondary and preparatory schools respectively. After completion of preparatory school education he joined Madda Walabu University in 2012 and graduate with BSC degree in Forestry in 2014. He was employed by the Robe Woreda Agricultural Office in 2015 and worked as expert until he joined Mettu University as Graduate Assistant in 2016. After serving for one year, he joined the postgraduate program directorate of Haramaya University in October, 2017 to pursue studies leading to Master of Science Degree in Environmental Science and Managements.

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ACRONYMS AND ABBREVATIONS

AAS	Atomic Absorption Spectroscopy
CME	Canadian Ministry of the Environment
DMSW	Decomposed Municipal solid waste
DS	Dumping Site
EPA	Environmental Protection Agency
EPMC	Environmental Protection ministry of China
CS	Control Site
HM	Heavy Metal
KMSWDS	Koshe municipal Solid Waste Dumping site
MSW	Municipal Solid Waste
TMS	Tanzanian Ministry of State

TABLE OF CONTENTS

TABLE OF CONTENTS (*continued*)

LIST OF TABLES

Table **page**

LISTOF FIGURES

Figure **page**

LIST OF TABLES IN APPENDICES

Appendices Table **page**

Heavy Metal Status of Municipal Solid Waste and Soil At Koshe Open Dumping Site of Assela Town ,Oromia Region, Ethiopia

ABSTRACT

Dumping of heavy metals wastes has environmental impacts on soil and water at the nearby waste dump sites. The purposes of this study was to identify the sources and also status of selected heavy metals in municipal solid waste and soil at koshe open dumping site of Assela Town. For seven consecutive days metal wastes were manually separated from all wastes dumped at the site to identify the sources of heavy metals.Sources of the metals were categorized under three groups; household (1.29) commercial (5.69) & institution (3.32 kg/day). For assessing heavy metal concentration in decompose municipal solid waste and soil at the dumping site, three decomposed waste and soil samples were collected. Heavy metals such as: Fe, Mn, Cu, Zn, Ni, Co, Cr, Pb and Cd in waste and soil samples were analyzed using AAS. Results showed the concentration of these heavy metals in the DMSW were in the order of Fe>Mn>Zn>Cu>Ni>Cr>Co> Pb>Cd. The pH, EC, OC values of DMSW where 8.3, 1.59 dS/m, and 3.33% respectively. The textural class of the soil under the waste and the nearby site was sandy clay loam. pH, EC,OC and CEC were 6.45, 0.09 dS/m,1.27 % and 48.6 $cmolkg^{-1}$ respectively for the depth of 0- 20 cm. In soil the trend of heavy metal concentration was Fe>Mn>Cu>Zn>Cr>Ni>Co>Pb>Cd .The concentrations of the analyzed heavy metals in soil under the waste were greater than that of the control. Different sources of heavy metals are carried by waste which is then transferred to dumping site. Iron concentration was the highest across the depth followed by Mn, Cu,Zn and Cr at the dumpsite. the concentration of Fe, Mn,Zn, Cu and Ni decrease with depth while Pb and Cd, concentration increase with the depth while Cobalt and chromium concentration the remains the same across the depth at the study area. The concentrations of heavy metals were above acceptable level of different standards. Other processing and treatment of waste such as energy recovery from waste technologies need to be considered in all Ethiopian towns and cities.

Keywords: Assela, Concentration, Dumpsite, Heavy metals, Koshe, Municipal

1. INTRODUCTION

Municipal solid wastes are sources of environmental contamination through introduction of chemical substances above the threshold limit of the environment (Obasi *et al.,* 2012). Most adverse effect of solid waste on the environment are rooted from in adequate collection and recovery of recyclable waste and lack of properly design landfills (USAID, 2009; Remigos, 2010).Open dumping is the most frequently used method of municipal solid waste disposal in many middle and lower income countries(Muniafu and Otiato, 2010; Panagos *et al*., 2011).

Heavy metal pollution of the environment, even at low levels, and their resulting long-term cumulative health effects are among the leading health concerns all over the world (Oluyemi *et al.,* 2008). Open dumps are a source of various environmental and health hazards. The decomposition of organic materials produces methane, which may cause explosions and produce leachates, which pollute surface and ground water. It ruins the aesthetic quality of the land (Oyelola *et al*., 2009).Hazardous materials such as heavy metals, pesticide and hydrocarbons that are dissolved in this liquid often pollute soil and water (Adelekan and Alawode, 2011). Environmental pollution has become a serious public health concerns because it become a major sources of health risk and causes several serious disease all over the world (Briggs D, 2003).one of serious environmental pollution is heavy metals.

The effect of heavy metals on human health can even lead to death. Environmental pollution by heavy metals increased due to industrial expansion and high quantities heavy metals exist in industrialize area (Adesuyi *et al* 2015). Anikwe and Nwobodo (2001) suggested that continuous dumping of municipal waste on soil may lead to increase heavy metals in the soil and surface water that would be inimical to deep feeding plants. Solid municipal waste usually contains food waste, paper, metal scraps, glass, ceramics, ashes, etc. Over a period of time decomposition or oxidation process releases heavy metal into the water, soil and plant material growing on the waste dumpsite by that contaminating them(Ukpong, *et al.,* 2013).

Apart from uptake by plant, they can also be leached into underground water sources. Ukpong, *et al.* 2013, noted that even slow movement of heavy metals in the soil profile may result in the deterioration of ground water quality. Heavy metals are found naturally in the earth. They become concentrated as a result of anthropogenic activity and can enter plant, animal and human tissues through inhalation, diet and manual handling. They can interfere with cellular components. Cadmium, lead, chromium and arsenic appear among the 10 list of chemicals of major public concern to (WHO 2012). Some of their sources include atmospheric deposition, waste disposal, fertilizer, pesticide application, industry and nuclear waste. High concentrations of heavy metals in municipal solid waste now dominate the outflow from most cities (Bergback *et al*., 2001). This is a result of human activities like manufacturing, production of agriculture and activities of industry.

The presences of uncontrolled dumpsites in most localities in towns or cities are the result of the indiscriminate deposition of the waste prevalently waste food and putrescible materials. While MSW can be reused as organic fertilizer and soil amendment after biological transformation (Manios, 2004); the heavy metal contained in it and its products restricts beneficial use and disposal of the waste. This enhances the concern for management of MSW (Zennaro *et al*., 2005). Knowledge on the occurrence and distribution of heavy metals in MSW could assist policy makers and management authorities in eliminating major contaminant sources through effective modification of MSW handling, collection, treatment and disposal practices (Zhang *et al*. ,*2008*).

Soil represents a major sink and source of heavy metal ions, which are incorporated in the food (Oguntimehin *et al*., 2008). When food crops are grown on soil contaminated by heavy metals their soluble forms could be extracted by the plant and subsequently, consumed by humans and animals. This is particularly evident in most African rural communities that believed dumpsites traditionally considered as fertile and could be used for agricultural production. Despite the adverse effects of heavy metal accumulation, it was reported that soils amended with organic wastes have high organic matter, reduced bulk density, and increased total porosity (Anikwe, 2000).

Organic wastes also enrich the soil nitrogen increase its pH and cation exchange capacity and provide nutrient for plant development (Anikewe and Nwobodo, 2001). This is perhaps why most countries use soils from dumpsite to improve soil fertility and supply nutrients to short-duration crops including vegetables, which is very common in Sub-Saharan African countries. According to Jayaprakash *et al.* (2012) heavy metals occurrence in soil is an indication for the existence of natural or anthropogenic sources of pollution. Various types of wastes like old computer, tin cans, paints, plastics, wood preservatives, old drum in copy machine and E-waste and old battery are few examples that contribute heavy metals in the landfill. Heavy metals such as arsenic, cadmium, lead, chromium, nickel, cobalt and mercury are of concern primarily because of their ability to harm soil organisms, plants, animals and human beings (Adelekan and Abegunde, 2011). Heavy metals contamination such as lead, cadmium, copper, molybdenum, nickel and chromium has led to the following diseases: renal failure, liver cirrhosis, hair loss and chronic anemia on people (Salem *et al*., 2000); for example fractures due to cadmium, neurological effect due to lead poisoning and skin cancer due to arsenic (Jarup, 2003).

The Assela town MSW dumping site was known by local name koshe. The koshe solid waste dumping site is open with non-engineered lower lying. There is no any leachate collection and treatment system at a site. The generated leachates find paths into the surrounding environment. Heavy metals become a primary concern than other environmental pollutions because heavy metals can’t be destroyed by degradation.

Some heavy metals are strongly absorbed by soil constituents and their mobility and bioavailability depends on soil conditions .However, there is absence of comprehensive and wide studies in line with heavy metal status and soil properties near solid waste disposal site in developing countries like Ethiopia. In Ethiopia there are researches done on ground water contamination near Reppi open solid waste disposal site in Addis Ababa and on heavy metal contents and physico- chemical properties of soil around solid waste disposal site in Adama town. those researches results shows the need to conduct other study in other dumping site. There are suggestions for further studies on heavy metals content in the soil profiles closer to dumpsites (Kouame *et al.,* 2010). The present study focusing on the analysis of cadmium,chromium,copper, iron ,manganese ,lead, nickel and zinc at Asella town solid waste dumping site

1.2. General Objective

The general objective was to assess heavy metal status of municipal solid waste and soil at koshe open dumping site of assela town.

1.3. Specific Objectives

- To identify the source of heavy metals in solid waste at dumping site of Assela town
- To asses selected heavy metals concentration in the municipal solid waste at dumping sites of Assela town
- To asses selected heavy metals concentration in soil at municipal solid waste dumping sites of Assela town

2. LITERATURE REVIEW

2.1. Municipal Solid Wastes

Solid municipal waste presentative of a major crisis for rural communities because of lack of awareness of the effects of people dumping their wastes in the water canals causing water pollution as well as visual pollution (Salah and El-Haggar, 2007).Solid waste (MSW), commonly known as trash or garbage in the united state and as refuse or rubbish in Britain, is a waste type consisting of everyday items that are discarded by the public. Garbage specifically refers to food waste as in a garbage disposal ;the two are sometimes separately collected (Mamodu *et al.,* 2011*).*Though widely understood as a concept, waste garbage, rubbish, discards, definition, varying by who defines it. Engineers define MSW as materials that are discarded from residential and commercial sources (Williams, 2005) or as materials that have ceased to have value to the holder (McDougall et *al.,* 2001). Urban municipal solid waste is usually generated from small industries, human settlements and commercial activities (Singh *et a.,l* 2011).Plus to these sources of waste that finds its way to MSW is the waste from hospitals and clinics. In the many of developing countries, most of the smaller units do not have any specific technique of managing these wastes. When these wastes are mixed with MSW, they pose a threat to health and also they may have a long-term effect on the environment. Similar is true for Assela MSW dumping site that the waste collected from deferent sources of an urban area, doesn't separate by waste type, simply collected and dumped at the land filling site .Inappropriate management of solid waste areas has resulted in serious environmental and ecological health problems. Such practices contribute to widespread environmental pollution as well as the spread of diseases (Syeda *et al.*, 2014).

2.2. Categories of Municipal Solid Wastes

Municipal solid waste ,are referred to as ready to discarded or needless non-liquid substance originating from human activities ,including industrial sources and human activities(Momodu *et al.,* 2011). Municipal solid waste is unavoidable by product of human activity .By nature there is no such thing as waste because nature is capacity to “recycle ’’the elements in the ecosystem .However, urbanization and rapid population increase has generated waste, which has exceeded the earth's carrying capacity by more than 30%, has resulted in accumulation of waste in specific sites (Salah and El-Haggar, 2007).

There are basically two sources of MSWs, which are domestic and commercial sources (Momodu *et al.*, 2011). Domestic Sources, refers to general household wastes which includes food waste, rubbish, ashes and special wastes. While commercial sources are referring to waste originating from commercial activities like restaurants, shops, auto-mechanic repairs, medical facilities, schools, construction activities and other special wastes . Furthermore, wastes may be classified according their source, properties, degradability, toxicity.

Table . Classification of municipal solid waste based on point source

s/n	Classes of waste	Characteristics & possible source	Typical examples	References
1	House hold solid waste	Specific solid waste originating from domestic activity	Food items,ashe,garden waste ,clothes	NEST (1995)
2	Organic waste	Solid biodegradable waste	Leaves ,vegetables,fruits ,woods	Adamu *et al* 2014
3	Plastic waste	Usually semi degradable or non degradable	Package water bags polythenbags usedtyres ,phone casing	Botkin&Keller (1997)
4	Metal waste	Metallic waste could be toxic due to their leach ability to the environment	Grenerator ,air conditioner ,scrapcars ,plates,pots,buckets ,spoons refrigerators	Adamu *etal* (2014)
5	Glass	These are made up of broken or discarded glassware	Drug ,wine &chemical bottle containers ,ceramic plate &cups	Botkin&Keller (1997)

2.3. Effects of Municipal Solid Waste on the Environment

The environmental problems posed by solid waste ranges from health hazards, soil and water pollution, repulsive sight and offensive odor. The resultant of these is the degradation of our environmental quality (Abdus-Salam *et al.*, 2011). Solid degradable waste in synergy with environmental factors and bio-degraders or both comes with environmental impacts that limit the quality of air; soil, as well as both surface and ground water. For instance, under anaerobic condition methanogens (bacteria) can aid the release of methane gas (Amuda *et al.*, 2014), as well as CO_2 or both which degrade air quality and also aid the incidence of global warming. Besides this, other anthropogenic pollutants associated with MSWs pollutants including greenhouse gases such as: carbon dioxide, methane, oxides of sulphide, nitrogen; as well as heavymetals which includes,cadmium(Cd),Copper(Cu),Iron(Fe),Lead(Pb),Zinc(Zn),Aluminium(Al) but not limited to them and they are transported as leachate through the soil to underground water or as runoff from one ecosystem to the other during precipitation which they could be biomagnified along the food chain by terrestrial and aquatic biota thereby resulting to pollution that induce adverse effect. In a developing country like Ethiopia, high MSW stream are generated with corresponding inadequate management strategies (Angaye *et al.*2015) largely due to financial constrains (Onwughara *et al.* 2010) or weak legislation (Nkwachukwu *et al*.2016) thus resulting to the practice of open air in-situ burning which have attendant greenhouse effect that results to global warming (Amuda *et al*.,2014).

Environmental impacts of MSW on soil quality and water cannot be over emphasized although soil structure and texture determine the degree of percolation .Ogedengbe and Akinbile (2007) reported that high degree of turbidity in ground water samples from dumpsites is due to the percolation of leachate. In the review results as reported by several authors indicates that most ground water located in dumpsites are contaminated, with values exceeding regulatory limits. In the same vein, higher level of heavy metals which contaminates groundwater have also been reported (Bahnasawy*et al.,* 2011). As reported by Iwuoha *et al*. (2013), in surface water and sediment organic matters play vital regulatory role in determining heavy metal distribution. This is because they bind with heavy metals by the process of adsorption to form solution. Notwithstanding, the availability is dependent on some physicochemical factors including; temperature, pH, hardness, exposure rate etc (WHO, 2003).

2.4. Solid Waste Management Challenges

The inadequate collection, recycling or treatment and uncontrolled disposal of municipal solid waste are particularly frequent in low and middle-income countries and lead to severe health risks and environmental pollution. In such countries often more than 50% of the total municipal solid waste is organic (Christian Zurbrügg , 2017). Postconsumer waste, through its production and management, affect air quality, water quality, and public health, and it contributes to climate change (Bogner *et al.,* 2007). Improperly managed wastes affect the environment at different scale levels. Open dumping of wastes contaminates nearby water bodies with organic and inorganic pollutants. It also threatens public health by attracting disease vectors and exposing people living near the waste to the harmful products (McDougall *et al.,* 2001). Incineration of waste emits a variety of pollutants, including dioxins and furans (Tchobanoglous and Kreith, 2002); persistent organic pollutants that mix globally and harm human and ecological health. Waste management also emits a variety of greenhouse gases (GHGs); the most significant sources are landfills, which emit methane as organic waste decomposes.The Intergovernmental Panel on Climate Change estimates that waste manageme nt emits less than 5% of the global GHG emissions (and emits 9% of methane released globally), but this estimate is uncertain and variable, as waste management can act as either a net source or sink of GHGs (IPCC, 2007). Because waste poses a threat to people and the environment, provision of waste management services has often fallen to cities, which are charged with providing public goods to their citizens. Global trends in waste production increasing quantity and complexity of MSW compound the challenge, making waste management "one of the biggest challenges of the urban world" (UN-Habitat, 2010 p. 1)

2.5. Heavy Metals in Solid Waste

Heavy metals are metallic elements that have relatively high density and toxic even at low concentration (Duribe *et al.*, 2007). Heavy metals are defined as metallic elements that have a relatively high density compared to water. Any metal or metalloid that causes environmental problem which cannot be biologically degraded should be considered as a heavy metal. Heavy metals are natural components of the Earth's crust, but in many ecosystems the concentration of several HMs has reached toxic levels due to consequence of anthropogenic activities. Fifty three elements fall into the category of heavy metal till date and defined as the group of elements whose densities are higher than 5 g cm^{-3} and recognized as ubiquitous environmental contaminants in industrialized societies (Padmavathiamma and Loretta, 2007).

With the assumption that heaviness and toxicity are inter-related, heavy metals also include metalloids, such as arsenic, that are able to induce toxicity at a low level of exposure (Duffus ,2002).Up to date there has been an increasing ecological and global public health concern associated with environmental contamination by these metals . Also, human exposure has risen dramatically as a result of an exponential increase in their use in several industrial, agricultural, domestic and technological applications (Bradl,2002).Heavy metals are occurring naturally throughout the earth’s crust ,most environmental contamination and human exposure result from anthropogenic activities like mining and smelting operations , industrial production and use, and domestic and agricultural use of metals and metal-containing compounds (He ZL,2005).

Heavy metals are also considered as trace elements because of their presence in trace concentrations (ppb range to less than 10ppm) in various environmental matrices (Kabata-Pandia,2001).Heavy metals bioavailability is influenced by physical factors such as temperature phase association ,adsorption and sequestration .Also affected by chemical factors that influence speciation at thermodynamic equilibrium ,complexation kinetics ,Lipid solubility and octanol /water partition coefficient . Biological factors such as species characteristics, trophic interactions, and biochemical/physiological adaptation, also play an important role (Kabata- Pendia, 2001).In plants and animals heavy metals exert essential biochemical and physiological functions .They are important constituents of several key enzymes and play important roles in various oxidation reduction reactions(WHO/FAO/IAEA, 1996) and domestic and agricultural use of metals and metal-containing compounds (He ZL., 2005). Contamination of the environment can also occur through metal corrosion, deposition of atmosphere, soil erosion of metal ions and leaching of heavy metals, re-suspension of sediment and evaporation of metals from water resource to soil and groundwater. Natural phenomena such as weathering and volcanic eruptions have also been reported to significantly contribute to heavy metal pollution (Bradl*et al.,* 2002). The sources of the industries include metal processing in refineries ,coal burning in power plants ,petroleum combustion ,nuclear power station and high tention lines ,plastics ,textiles ,microelectronics ,wood preservation and paper processing plants (Arruti *et al.,* 2010).

2.5.1. Sources of heavy metals in solid waste

2.5.1.1. Geochemical sources

Geologically heavy metals are included in the groups of elements referred to as (trace metals) wich together constitute < 1% of the rocks in the earth's crust ;the macro elements (O, Si ,Al, Fe, Ca, Na, K, ,Mg, Ti, H ,P and S) comprise 99% of the earth's crust .The natural enrichment of metals in the soils may still give rise to harmful effect to living Organisms (Alloway and Ayres,1993).

2.5.1.2. Agriculture material

Agriculture constitutes one of the most important non-point sources of metals pollutants. The main sources are: Impurities in fertilizers: Cd, Cr, Pb, eg .Cd in the phosphatic fertilizer); Pesticides: Cu, As, Pb, Mn, Zn (eg historical Pb orchard sprays. ; Composts and manures: Cd, Cu, Ni, Pb, Zn, As ,Sewage sludge: especially: Cd, Pb, (also many other elements); Corrosion of metal objects (e.g. galvanized metal roofs and wire fences (Cd) (Alloway and Ayres,1993).

2.5.1.3. Metallurgical industries

Any heavy metals are used in specialist alloys and steel Mn, Pb, Cr, Co, Ni, Cu, Zn, Cd ,As hence both the manufacturing and disposal or recycling of these alloys in scrap metal can lead to environmental pollution of a wide range of metals (Alloway and Ayres,1993).

2.5.1.4 .Waste disposal

Many metals especially Cu, Cd, Pb and Zn are dispersed into the environment in leachates from landfills. Which pollute soils and ground waters, and in fumes from incinerators (Alloway and Ayres, (1993).

2.5.1.5. Other sources

Other significant sources of heavy metals pollution in manufacture (sometimes in use) and disposal include: Batteries Pb, Sb, Zn, Cd ;paints and pigments ,Pb, Sb, As, Mo, Cd, Si, Zn, Co. Polymer stabilizers Pb, Sn, Zn, Cd (for incineration of plastic); Printing and graphics, Pb, Zn, Cd (Alloway and Ayres,1993).

2.6. Management of Heavy Metal poisoning

Metal toxicity is unique in that the toxic agent may not be metabolized. Compounds containing metals may certainly be metabolised to hasten their excretion and the properties of metals may change, but the body cannot reduce a toxic metal to a non-toxic metal. One mechanism that may reduce the toxicity of metals is a metal carrier protein, metallothionein, which may complex with the metal, preventing it from exerting a toxic effect, and transport it to the kidney where it may be filtered and excreted (Neal and Guilarte, 2012) A common treatment for metal intoxication is the use of chelators. A chelator is a flexible molecule with two or more electronegative groups that can form stable complexes with cationic metal atoms. The complexes are then eliminated from the body. The most widely used chelator is ethylenediaminetetraacetic acid (EDTA). It has four binding positions (two nitrogen atoms and two oxygen atoms) that focus on the metal ion. It works very well on many metals, the most notable being calcium, magnesium, and lead (Neal and Guilarte, 2012) .Chelating with drugs is indicated primarily for acute poisonings by some metals, especially lead, arsenic, mercury, and iron. Though the drugs may have dangerous side effects, the risks are considered worthwhile in the face of toxicity which may be fatal or cause serious, even permanent injury (Kosnett, 2010) Approved chelating drugs include succimer, dimercaprol (BAL), edetate calcium disodium, deferoxamine, and penicillamine. They are given only for diagnosed metal toxicity because they may have serious side effects, even when their use is needed; and they are non-specific and can bind even essential “trace” metals in the body, for example copper and zinc. They can sometimes bind calcium, too. Chelation of these substances can cause symptoms related to their deficiency (Howland, 2011a).

Stabilization is one of the most effective methods of dealing with heavy metals contaminate sites. By the method of mobility of hazardous substances and contaminants is significantly reduced in the environment through physical and chemical means physical aspect involves changes in mechanical properties of materials and chemical aspect involves the change to the form and mobility of the contaminants by leaching present. The goal of stabilization is to limit migration of hazardous waste into environmental by leaching mechanisms. Solidification and stabilization seek to immobilize contain within their host medium instead of removing them through chemical or physical treatment (Korac and Buzidoru, 2007). The term solidification stabilization refers to a general category of processes to treat a wide variety of waste, including solids and liquids. Solidification is the process that encapsulates to from solid material and to restrict contaminate migration by decreasing the surface area exposed to leaching by coating a waste with low permeability materials. Stabilization refers to processes that involve chemical reaction that reduce the lean ability of waste. The physical nature of the waste may or may not be changed by this process (Gandji doust *et al.*, 2009).

Remediation is necessary for the protection and restoration of soil ecosystems contaminated by heavy metals (Wuana and Okieimen, 2011). This requires knowledge of the source of contamination, chemistry and environmental and associated health effects (risks) of heavy metals. phytoremediation can also be used to control heavy metals which are the use of plants to minimize metals pollution (EPA,1998). It has the benefits of a natural solution to the environmental problem at low cost. The reduction of Cadmium uptake by the plant be achieved through soil dressing, water management chemical cleaning of soil, use of different varieties and rootstock and phytoextraction (Arao *et al*., 2010). There should be a risk assessment in the environment. This is an effective scientific tool which enables decision makers to manage sites so contaminated in a cost-effective manner while preserving public and ecosystem (Zhao and Kaluarachchi, 2002)

2.6.1. Heavy metals and environmental pollution

The effect of heavy metals contaminate in the sedimentation benthic organisms can be either acute or chronic (cumulative) (Han *et al*., 2009). Metal concentration in soil typically ranges from less than one to as high as 100,000 mg/kg (Long *et al.,* 2002) .Heavy metals are the main group of inorganic contaminants and a considerable large area land contaminated with them due to use of sludge or municipal compost, pesticides, fertilizers, and emissions from municipal wastes incinerates, exudates, residues from metalliferous mines and smelting industries (Halim *et al., 2002*) .Irrespective of the origin of the metals in the soil, excessive levels of many metals can result in soil quality degradation, crop yield reduction, and poor quality of agricultural products, posing significant hazards to human, animal, and ecosystem health(Long, *et al.,* 2002). Therefore, it becomes essential to remove the accumulated metals Mechanisms proposed to be involved in transition metal accumulation by plants are phytoaccumulation, phytoextraction, phytovolatilization, phytodegradation, and phytostabilization(Long *et al* ., 2002) .

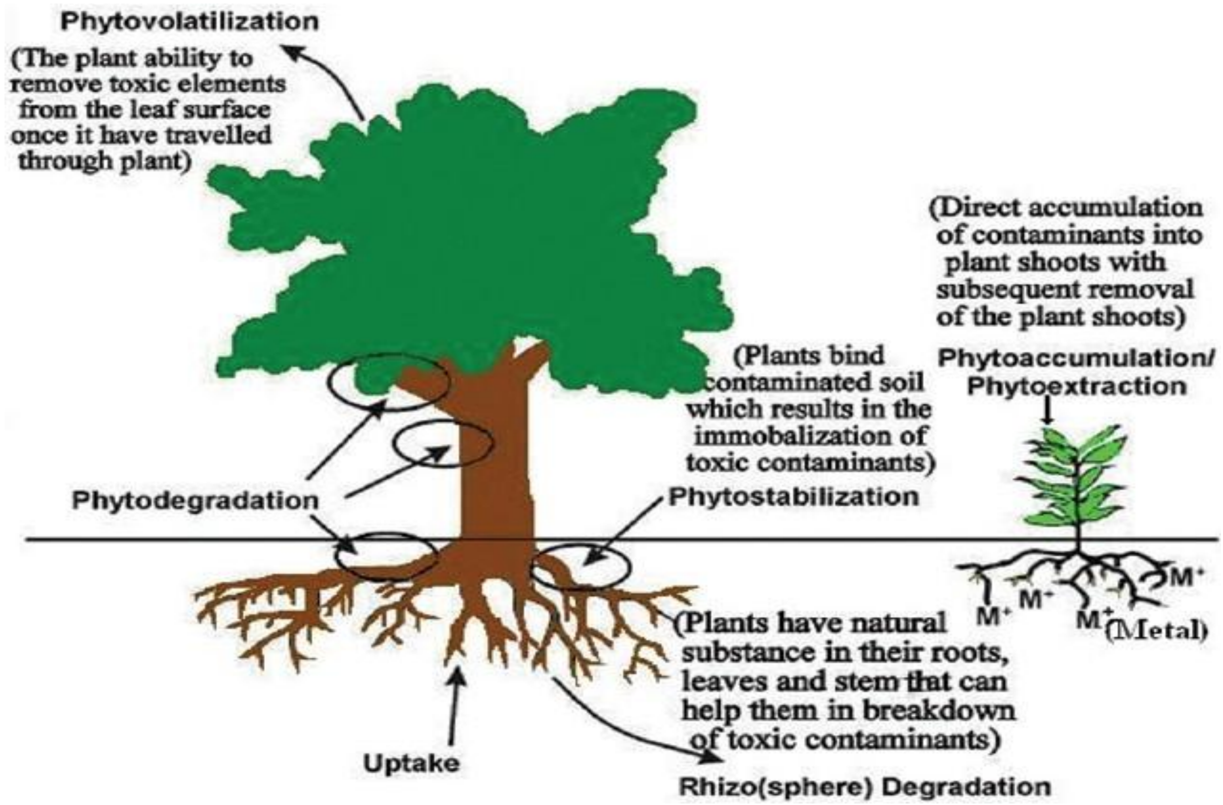

Figure .Transition mechanism in plants for metal accumulation

2.6.2. Heavy metal concentrations in soil

Domingo and Kyuma (1983) showed that the mean trace elements status of Cu, Zn, B, Mo, Co, Cr and Ni of paddy soils of Bangladesh were 27.0, 68.0, 68.0, 3.3, 58.0, 133.0 and 22.0 mg kg-1, respectively.

The permissible limit (MPL) values of the trace heavy metals in agricultural soil by different standards FAO/WHO Cd, Cr & Pb are -, 0.1 and 90-400 mg/kg respectively (FAO/WHO 1985). Indian; Cd 0.003 -0.006, Cr - & Pb 0.50 mg/kg (Awashthi and S.K , 2000) and United States; Cd 0.6, Cr 1500 & Pb 50-300 mg/kg respectively. In normal agricultural soils, total Cu content ranges between 1 and 50 mg/kg and available Cu ranges from 0.1 to 10 mg/kg (Baker, 1974). The industrial waste water, sewage water used for irrigation, quarrting sites and hazardous waste disposal on soil is the sources of soil contamination. Low concentration of these metals can interact with the soil; to cause nutrient deficiency (Gebreyesus, 2014). Heavy metals can also affect soil matrices hence metal transport. Heavy metal contamination of agricultural soil and urban can result from mining, manufacturing, and the use of synthetic products (e,g .pesticide ,paints ,batteries ,industrial waste ,and land application of industrial or domestic sludge. Contaminated soils may occur at fields that had past applications of wastewater or municipal sludge, areas in or around mining waste piles and tailings, industrial areas where chemicals may have been dumped on the ground and so on. The existence of toxic metals in soil can severely inhibit the biodegradation of organic contaminants (Maslin and Maier, 2000). The soil contaminated by heavy metals can cause adverse effect on human health, animals and soil productivity (Smith *et al.*, 1996).

Over the last many years, heavy metals have considerably damaged the soil quality and fertility in consequence of increased environmental pollution from industrial, agricultural and municipal sources (Okoronkwo *et al*., 2006). Metals cause physiological disorders in soils as absorption through root system consequently retards plant growth and deprives it of vigor (Nyle and Ray, 1999). Different metals are carried by wastes which are then transferred to plants in different ways depending on the tendency of the contaminants they end up either in water held in the soil or leached to the water in the underground. Contaminants like Cd, Cu, Ni, Pb, and Zn can alter the soil chemistry and have an impact on the organisms and plants depending on the soil for nutrition (Shaylor *et al.*, 2009). The factors that affect the bioavailability and occurrence of metals in the soil include soil pH, cat ion exchange capacity, organic matter content, soil texture and interaction among the target elements (Jung,2008).

As indicated in this literature review the concentration of heavy metals has divers' effects on soil, aquatic environment, human health and atmospheric pollution. So evaluation of the concentration of heavy metals from municipal solid waste dumps site soil and compare it with untreated site soil help to understand how much the MSW accelerate the heavy metal concentration on dumpsite soil.

2.6.3. Toxicity of heavy metals

Heavy metals are dangerous because they are tend to accumulate .Compounds accumulate is living things any time they are taken up and stored faster than they are broke down or extracted (metabolized).They can enter the water supply by industrial or consumer waste or even from acidic rain breaking down soils and releasing heavy metals into stream, rivers, lakes and ground waters (Lenntech .(2005a). Toxicity of heavy metals contributes to a variety of adverse health effects. This exit over than 20 different heavy metals toxins that have impacts on human health and each toxin will produce different behavioral physiological and cognitive changes in exposed individuals. The degree to which a system organ tissue or cell is affected by a heavy metal toxin depends on the toxin its self and the individual's degree of exposure to the toxin (Extreme health USA. (2005). Heavy metals toxicity can be listed in the order of Hg>Cd>Cu>Zn>Ni>Pb>Cr>Al>Co, also this is only appropriate as Vulnerability of species to individual metal varies. Toxicity also varies according to the environmental conditions that control the chemical speciation of metals (Gray, 1999).

2.6.4. Quantities of heavy metals in municipal solid waste

Because of their toxicities, heavy metals have been singled out for concern as environmental pollutants. In addition, and given the documented toxicity to organisms, certain metals, termed“RCRA heavy metals”, have specific groundwater limits pursuant to the U.S. Resource Conservation and Recovery Act (RCRA). These metals include arsenic (As), Barium (Ba), Cadmium (Cd), Chromium (Cd), Lead (Pb), Mercury (Hg), Selenium (Se), and Silver (Ag). Other heavy metals such as Nickel (Ni), Copper (Cu), and Zinc (Zn) are also of concern. These metals are apparently not RCRA metals because at low levels they function as nutrients and also because they have not shown human toxicity to the same degree as the RCRA metals. However, they can be toxic to other organisms and in some situations to humans as well. Several studies have provided data on quantities of heavy metals in MSW.

Table 2: below shows quantities of heavy metals estimated to be disposed per year, in some cases as directly reported and in other cases based on reported concentrations multiplied by an estimated yearly quantity of 250 million tons metric tons MSW disposed of in landfills. (Goldstein *et al.*, 2001)

Table . Heavy Metals in MSW

Metal	Estimated MSW Concentration	Metric tons/year disposed of in U.S.landfills, either as reported directly or assuming 250 million tons MSW disposed/year and concentration as in column to the left
Cadmium (Cd)	4 ppm[8]	1000
	20 ppm[9]	5000
		2700[10,11]
Copper (Cu)	77 ppm[12]	19,250
Chromium (Cr)	350 ppm[13]	87,500
Lead (Pb)	230 ppm[14]	57,500
	400 ppm[15]	100,000
		127,000[16]
Mercury (Hg)	1.5 ppm[17]	375
		400[18]
Nickel (Ni)	57 ppm[19]	14,250
Zinc (Zn)	380 ppm[20]	95,000

2.7. Effects of Heavy Metals Contamination on Human Health

Heavy metals contamination has become subject of public interest because humans have been harmed by metal concentration. Effects of humans can be observed after either a none off exposure to large non-lethal dose (acute) or after repeated exposure to lower doses (chronic) of these heavy metals, the classic example of the effect of bio concentrated oxidants are the painful and fatal. It is a disease caused by chronic cadmium poisonings and minimart disease, caused by chronic mercury poisoning (Han *et al.*,2009). Heavy metals contamination such as cadmium ,lead ,copper ,nickel molybdenum and chromium has led to the following disease renal failure ,hair loss ,liver cirrhosis and chronic anemia in people in Egypt (Salem *et al.*,2000); bone effects ,fractures in cadmium ,neurological effect in lead and skin cancer in arsenic (Jarup,2003). Living organisms needs varying amounts of heavy metals. Iron, cobalt, copper, manganese, molybdenum, and zinc are needed by humans (Lane TW and Morel FM ,2009). All metals are harmful at higher concentrations (Chronopoulos *et al.*, 1997).

Immoderate levels can be damaging to the organism. Also other heavy metals such as mercury, lead and plutonium are harmful metals that have no known very important effect on organisms, and their accumulation over time in the bodies of animals can cause serious disease. Certain elements that are normally harmful are for certain organisms or under certain conditions, important. Examples include vanadium, tungsten, and even cadmium (Singh *et al.*, 2007).

Table .The types of heavy metals and their effect on human health with their permissible limits

Pollutant	**Major source**	**Effect on human health**	**Permissible lev el(mg/l)**
Arsenic	Pesticide,fungicide ,metal smelters	Bronchitis, dermatitis, poisoning	0.02
Cadmium	Welding ,pesticide ,fertilizers',electroplatin g ,Cd&Ni batteries	Renal dysfunction ,lung disease & lung cancer ,bone defects ,blood pressure ,kidney damage ,gastro intestinal dis-order	0.06
Lead	Paint,pesticide ,smoking ,automobile emission ,mining ,burning of coal	Mental retardationin children,dev'ta l delay ,congenital paralaysis ,liver kidney ,sensor neural deafness gastro intestainal dis order,	0.1
Mangans e	Welding ,fuel addition, ferromanganese production ,	Inhalation or contact cause damage to central nerve system	0.26
Mercury	Pesticide,batteries ,paper industry	Tremors ,gingivitis ,minor psychol ogical change ,spontaneous abortion	0.01
Zinc	Refineries,brass manufacture metal plating ,plumbing	Corrosive effect on skin, cause damage to nerve membrane	15
Chromiu m	Mines ,mineral source	Damage to nerve system ,fatigue ,irritability	0.05
Copper	Mining,pesticide product ion , chemical industry	Anemia ,liver and kidney damage ,stomach and intestinal irritations	0.1

Metabolic functions disrupted by heavy meals in two ways .They collect and there by interrupt function in vital organs and glands like the heart, kidney, brain, liver, bone, etc .They displace the vital nutritional minerals from their orginal place by hindering their biological functions. However it's impossible to live in an environment free of heavy metals .there is a lot of ways by which these toxins can be introduced into the body such as consumption of foods, skin exposure, beverages and inhaled air (Singh, 2007). Plants experience oxidative stress upon exposure to heavy metals that leads to cellular damage and disturbance of ionic homeostasis. To reduce the detrimental effect of metal exposure and their accumulation ,plants have evolved detoxification mechanisms mainly based on chelation and subcelluar compartmentaliz ation .A principal class of heavy metal chelator known in plants is phytochelatins (PCs) are synthesized no translation from reduce gluthathoine (GSH) in transpeptidation reaction catalyzed by the enzyme pyhtochelatin synthase (PCS).So availability of gluthathoine is very essential for PCs synthesis in plants at least during their exposure to heavy metals (Yadav,2010).

2.8. **Technologies for Reduction Toxicity of Heavy Metals**

There are several options to reduce exposure of heavy metals; these include reduction of the sources of soil pollution, cultivation of crop plants that trans locate less amount of heavy metals to the edible portion (mainly to seeds or grains), water management practices, cooking rice with excess water and draining the gruels, some micro-organism-based remediation techniques, such as bioremediation, show potential for their ability to degrade and detoxify certain contaminants(Rafiqual *et al.*, 2013).

2.8.1. Bioremediation

Bioremediation is a defined as a process that uses micro-organism, fungi, green plants or their enzymes to return the natural environment altered by contaminants to its original condition. Bioremediation technologies can be generally classified as *in situ* or *ex situ*. *In situ* bioremediation involves treating the contaminated material at the site while *ex situ* involves the removal of the contaminated material to be treated elsewhere. Some examples of bioremediation technologies are bioventing, land farming, bioreactor, composting, bio augmentation, rhizofiltration and bio stimulation. Not all contaminants, however, are easily treated by bioremediation using microorganisms. For example, heavy metals such as Cd and Pb are not readily absorbed or captured by organisms (Meagher, 2000).

2 .8.2. Phytoremediation

Phytoremediation is considered a clean, cost-effective and non-environmentally disruptive technology, to remove heavy metals from polluted lands. However, one major disadvantage of Phytoremediation is that it requires a long-term commitment as the process is dependent on plant growth, tolerance to toxicity and bioaccumulation capacity. Sarma (2011) has reviewed the recent advances of Phytoremediation technology. Different plants have been identified for Phytoremediation of heavy metals. Chinese Brake fern (*Pterisvittata*) for As, Willow (S*alix viminalis*) for Cd, Zn and Cu, and Indian Mustard (*Brassica juncea*) and sunflower for Pb (Phil-Eze, 2010). Hyper accumulators store metals in their tissues at concentrations far exceeding those in the environment. Heavy metal contents in hyper accumulators are more or less 100 times those found in non-hyper accumulator plants grown in soil under the same conditions (Brooks, 1998).

2.9. Sources of Heavy Metal in Contaminated Soils

Heavy metals occur naturally in the soil environment from the pedogenetic processes of weathering of parent materials at levels that are regarded as trace (<1000 $mg\,kg^{-1}$) and rarely toxic. Due to the disturbance and acceleration of nature’s slowly occurring geochemical cycle of metals by man, most soils of rural and urban environments may accumulate one or more of the heavy metals above defined background values high enough to cause risks to human health, plants, animals, ecosystems, or other media (J. J. D'Amore,*et al* .,2005). The heavy metals essentially become contaminants in the soil environments because (i) their rates of generation via man-made cycles are more rapid relative to natural ones, (ii) they become transferred from mines to random environmental locations where higher potentials of direct exposure occur, (iii) the concentrations of the metals in discarded products are relatively high compared to those in the receiving environment, and (iv) the chemical form (species) in which a metal is found in the receiving environmental system may render it more bioavailable (J. J. D'Amore,*et al* .,2005).

A simple mass balance of the heavy metals in the soil can be expressed as follows:

$M_{total} = (M_p + M_a + M_f + M_{ag} + M_{ow} + M_{ip}) - (M_{cr} + M_l)$,(1) where "$M$" is the heavy metal, "$p$" is the parent material, "a" is the atmospheric deposition, "f" is the fertilizer sources, "ag" are the agrochemical sources, "ow" are the organic waste sources, "ip" are other inorganic pollutants, "cr" is crop removal, and "l" is the losses by leaching, volatilization, and so forth. It is projected that the anthropogenic emission into the atmosphere, for several heavy metals, is one-to-three orders of magnitude higher than natural fluxes (M. Kaasalainen and M. Yli-Halla, 2003)

Heavy metals in the soil from anthropogenic sources tend to be more mobile, hence bioavailable than pedogenic, or lithogenic ones. Metal-bearing solids at contaminated sites can originate from a wide variety of anthropogenic sources in the form of metal mine tailings, disposal of high metal wastes in improperly protected landfills, leaded gasoline and lead-based paints, land application of fertilizer, animal manures, biosolids (sewage sludge), compost, petrochemicals, and atmospheric deposition(N. T. Basta et al.,2005)

3. MATERIALS AND METHODS

3.1. Descriptions of Study Area

3.1.1. Location

The study was conducted at koshe solid waste dumping site of Assela town, which has been used as waste dumping site since 2001. Assela is an administrative town of Arsi Zone of Oromia Region at about 175 kilometers from Addis Ababa. Geographically, the town is located at 7°57′N and 39°7′E, with an elevation of 2,430 meters above sea level. It is one of the developing towns in South-Eastern part of Ethiopia. The town has fourteen *kebeles*. The 2012, world population (WHO) report shows a total population of 110,088 of which 55,357 were men and 54,731 were women.

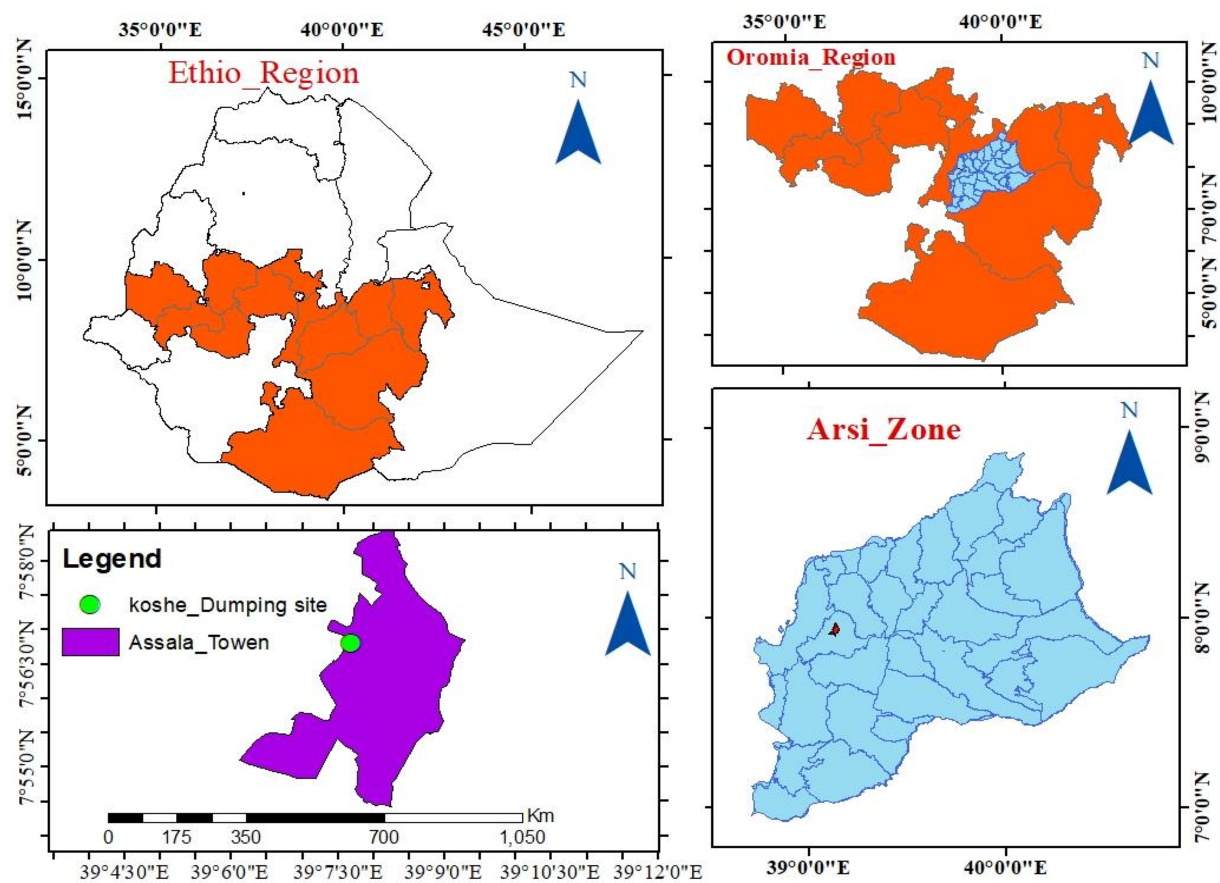

Figure .Map of Study Area

3.1.2. Climate

Assela town has mid subtropical *weather*, with minimum and maximum *temperature ranging* from 8.4 to 22.6°C, and the relative humidity *ranging* from 0.43 to 60%.The average annual temperature is 15.1 °C. Monthly temperature variation is low, due to its high elevation. The seasons are only distinguished by high rainfall intensity, in August and then decreasing to the lowest rainfall in December. Precipitation in averages is 1147 mm(Wikipedia, 2019 retrieved 26/5/2019)

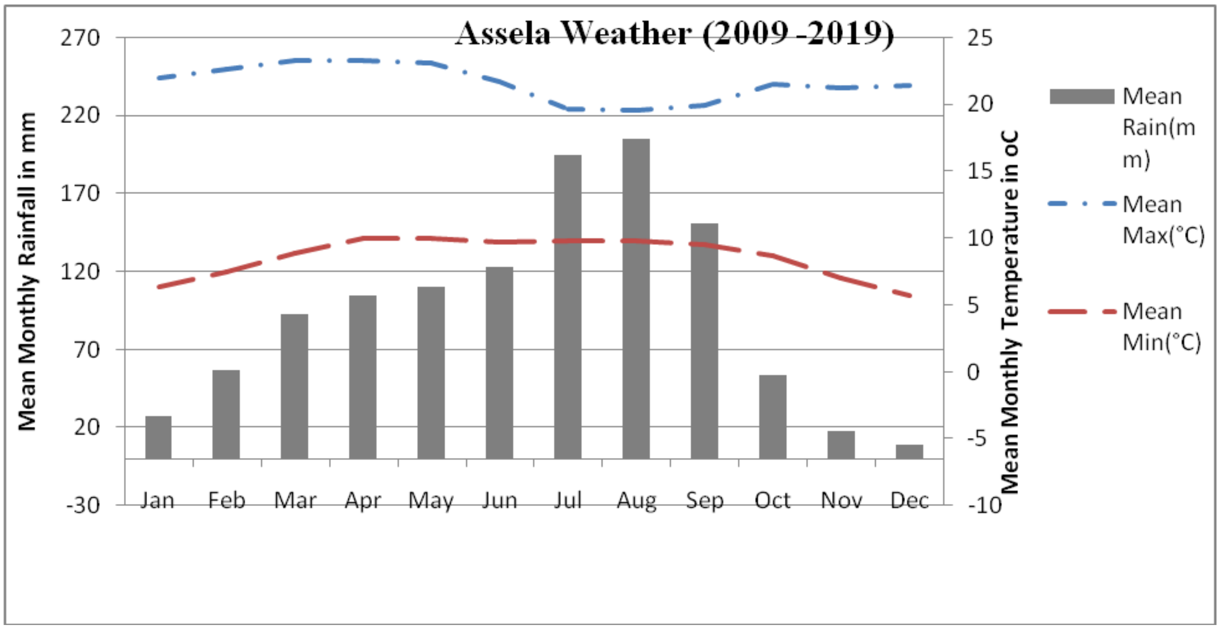

Figure .Graph of Assela Weather
Source:*Climate Data.org,altitude 2430 m.*

3.2. Sources Identification of Municipal Solid Waste

Solid wastes have been dumped by using two dump trucks, four hand-drawn carts and disposed of in open area. One micro and Small Enterprises with eight members are engaging in the solid waste collection from different sources and transporting to Koshe dumping site (Assela town administrations, 2019). To identify the sources of heavy metals in municipal solid waste at the dumping site of Assela town, the source identification of municipal solid waste method was conducted. This method involves identifications of metallic waste from trucks and carts employed for collection and transportation of MSW. As per this method, trucks and cars from the fourteen identified *kebeles* reaching the dump site was selected purposively during each day of the one-week identification period, to have a metallic waste stream. Wastes loaded on trucks and cars were classified as from commercial, institutional, and household wastes as per their places of origin. The metallic wastes were segregated manually at onsite with the help of people collecting metals from the wastes for selling to metal waste recycling industries. After separation, the weight of all metallic wastes was recorded. The mean of metallic waste were calculated by using the results of each recorded metallic waste under each group.

3.3. Sampling Techniques for Solid Wastes and Soil

3.3.1. Solid waste sampling

To assess heavy metals concentration in the decomposed municipal solid waste, from the dumping site three decomposed municipal solid waste sampling points were selected purposively. The representative solid waste samples were collected to form one composite decomposed municipal solid waste samples from the selected locations. Non-degradable materials were separated from the decomposed waste manually. The collected samples were air-dried, packaged in polyethylene bags and taken to laboratory for preparation.

3.3.2. Soil sampling

To assess concentration of heavy metals in soil at koshe dumping site, 3 soil sampling points were purposively selected from where the decomposed wastes were taken. The wastes were removed from the surface and soil samples were collected from 0-20, and 20-40 cm depth using auger. A total of 2*2 = 4 soil samples were collected from the dumping site. One composite soil sample was made from samples collected from the sampling point with respective depths. A composite of control sample with similar depths were taken from 100 m away from dumping site. The samples were packed in plastic bags and transported to laboratory.

The soil samples were air dried, mixed frequently to expose fresh surface to dryness. The samples were ground after drying and sieved through a 2 mm sieve, coarse particles greater than 2 mm size was discarded. The ground samples were stored for digestion and subsequent analyses.

3.4. Solid Waste and Soil Sample Analysis

The composite soil sample were analyzed for selected physicochemical properties mainly soil texture (sand, silt, and clay), soil pH, EC, organic carbon (OC), and cation exchange capacity (CEC) using the standard laboratory procedures.

Soil texture was determined using the Bouyoucos hydrometer method (Bouyoucos, 1962). The pH was measured by pH meter in suspension of 1:1 ratio of soil and water mixture. Ten g of air dried soil and DMSW (< 2 mm) was weighed and transferred into 100 mL beaker and 10 mL of distilled water were added. The mixture was stirred by a magnetic stirrer and the pH was measured after allowing the suspension to stand for 1 hr. at room temperature (Tan, 1996). For determination of electrical conductivity 10 g DMSW and soil were weighed into 100 mL beaker and 50 mL of Deionized water was added. Then, the mixture were stirred using an automatic stirrer for 30 minutes. Finally, the conductivity of the sample was measured from the upper part of the mixture after the suspension is settled. Cation exchange capacity (CEC) was determined after saturating soil with 1N ammonium acetate (NH4OAc) and displacing it with 1N NH_4OAc (Chapman, 1965). Soil organic carbon (%) was determined by the wet oxidation method as described by (Walkley and Black, 1934).

The solid waste and soil samples were digested with concentrated nitric (HNO_3) and perchloric ($HClO_4$) acids. 3 mL of concentrated HNO_3 were added to 0.5 -1.0 g samples. The acid sample mixture was heated to about 145°C for 1 hour. After 1 hour heating, 4 mL concentrated $HClO_4$ was added and the mixture were heat to 240^{o}C for further 1 hour. After complete digestion of all samples, the digests were allowed to cool to room temperature. The content of the digests were filtered through what man No. 42 filter paper and diluted to 50-mL volume with deionized water. The diluted digests were taken for subsequent analysis of heavy metals as described by Chen *et al.* (2009).

The selected heavy metals concentrations (Fe, Mn, Cu, Zn, Cd, Ni, Pb, Co, and Cr) were measured by Atomic Absorption Spectrophotometer model number 210VGP. The level of each heavy metal were measured at specific wavelength; Chromium (357.9nm), Lead (217nm), Zinc (324.8nm), Iron (248.3nm), Cadmium (228.8nm).

3.5. Data Analysis

Data obtained were analyzed using statistical software for Microsoft Excel and using SPSS V16.0. The relationships between different heavy metal ion concentrations in soil at the dumping site and some physicochemical soil properties were analyzed by Pearson's correlation coefficient.

4. RESULTS AND DISCUSSION

4.1. Sources of Heavy Metals in Municipal Solid Waste at Koshe Solid Wastes Dumping Site

The sources of metals in municipal solid wastes at the dumping site were identified and results indicated in Table 4. Major compositions of MSW at the dumping site were biodegrada ble and non-biodegradable. Among these, large quantities of the wastes are in the form of biodegradable (organic fractions), including fruits and vegetables, old clothes, papers, which have been generated by different social groups, institutions and commercial centers in the town. In addition to these, more quantity of metals were observed in the municipal solid waste. The main sources of metals in MSW at Koshe dump site were from households, institutions and commercial centers. Commercial centers generate the largest amount of heavy metals per day compared to other sources (Table 4).From the metal wastes dumped at the site per day; about 55.24% was from commercial centers. .The same was reported by Sapna *et al*. (2013).The possible reason for high quantity of metals in wastes from commercial centers could due to presence of more metal workshops, hotels and restaurants which expected to dump metal packing materials.

Table .Sources and quantities of metal dumped at Koshe solid wastes dumping site per day.

Sources	Quantity(kg/day)
Household	1.29
Institution	3.32
Commercial	5.69
Total	10.3

4.2. Selected Chemical Properties of Decomposed Municipal Solid Waste at koshe Dumping Site

PH: The pH value of the collected samples was analyzed and the results are indicated in table-5**.** pH values of decomposed municipal solid waste (DMSW) was moderately alkaline (8.3). pH values ranging from 6.5 to 8 is acceptable for composted products, and most common feed stocks fall within this range (TDMSW, 2013). However, pH value of decomposed waste at the study site was slightly higher than the acceptable rang suggested by TDMSW (2013).High pH value of wastes at Koshe (8.3) dumping site might be presence of other basic metals which were not included in this study. McCauley *et al*. (2009) suggested that high pH values of decomposed solid wastes might be due to presences of some of metal ions having characters to form basic ionic reactions. However, the recorded pH values for Koshe dumping site was close to the similar finding reported by Alemayehu *et al.*(2016) at Kile dumping site (8.05), in Harari City, Ethiopia.

Electrical conductivity:The EC of the decomposed municipal solid wastes was 1.59 dS/m at Koshe dumping site, as shown in Table 5. The EC of Koshe municipal solid wastes is greater than that of the EC reported by Alemayehu *et al.* (2016) at Selate(1.12 ms/cm), while its pH is also greater than that of decomposed waste at Kile and Selate. This indicates the presences of more soluble substances in the decompose wastes at Koshe site.

Organic Carbon: Organic carbon of the decomposed waste was 3.33 % at study dumping site as shown in Table 5. According to Ayolagha and Onwugbuta(2001), the presence of moderate organic carbon in compost/soil is favorable for heavy metal chelation formation.

Table .pH, electrical conductivity and Organic Carbon, of decomposed municipal solid waste.

pH	**EC**	**OC**
8.3	1.59 dS/m	3.33%

4.3. Heavy Metals Concentrations in Decomposed Municipal Solid Waste at Koshe Site

The concentrations of most heavy metals (Fe, Zn, Cu and Mn,) in decomposed municipal solid waste at Koshe site (Table 6) were relatively higher than the results reported by Hoque et al. (2014); Alemayehu *et al*. (2016). This might be due to more metallic wastes dumped at Koshe site. The presences of Cd (4.91 mg/kg) and Pb (12.22 mg/kg) in decomposed wastes at dumping site were relatively lower compared to other heavy metals. Similar findings were reported by Alemayehu *et al.***(**2016) for Harari city waste dumping sites. In addition to this, variation of heavy metals concentration also depends on summer and monsoon seasons. In line with, Hoque *et al.* (2014) reported that high concentration of heavy metals was observed in his study during summer season. The concentrations of heavy metals such as Cu, Zn, Ni, Cr, Pb ,and cadmium metals in decompose municipal solid waste did not exceed the limits when compared with Indian and USEPA standard (Anjanapriya and Lalitha ,2016).

Jalali and Khanlari (2007) pointed out that lead (Pb), cadmium (Cd), copper (Cu) and nickel (Ni) are potentially toxic to plants and animals and have been shown to accumulate in the food chain. Zinc (Zn) is necessary micronutrient for plants but at high level is phytotoxic and might reduce fertility of the land. Therefore, continuous dumping of wastes can disturb natural soil physical, chemical and biological characteristics, pollute ground water and causes hazardous impact on human health. The food crops grown on soils contaminated with heavy metals absorb the metal ions depending on their metal uptake and storage capabilities (Alexander, 2014). So the application of these municipal solid wastes as organic fertilizer to soils may be major potential source of metal pollution into farm lands. The concentration of lead in compost is 100, 150, 70-1000 and 300 mg/kg for India compost standards, German Standards, EU-Range standards and USEPA compost Standards , respectively. In decomposed MSW, the concentration of lead was 12.22 mg/kg which was below the limit standards set by those organizations. But continuous accumulation of this heavy metal might contaminate soil and ground water.

Generally, the concentrations of some of the heavy metals recorded in decomposed municipal solid wastes were below the limits but continuous dumping of these sources of wastes may be hazardous for plants, humans and animal. The use of municipal solid waste and waste water contaminated by heavy metals for irrigation for a long period of time rise the heavy metal contents of soils higher than the permissible limit. Eventually, raising the heavy metal content in soil also raises the uptake of heavy metals by plants depending upon the soil type, plant growth stages and plant species (Afzal*et al*., 2011).

Table . Comparing DMSW all given by mg/kg

Particulars	Fe	Mn	Cu	Zn	Ni	Co	Cr	Pb	Cd
Value	1172.6	1912.7	234.42	468.92	49.5	30.75	37.74	12.22	4.92
Indian	NA	NA	300	1000	50	-	50	100	5
EU-Range	NA	NA	70-600	210-4000	20-200	-	70-200	-	0.7-10
USEPA	NA	NA	1500	2800	420	-	1200	300	39
GS	NA	NA	150	500	50	-	150	150	3

Source: Legislation in different European countries and Indian regarding implementation of anaerobic digestion, 2000 and Manju*etal., 2013),*US composting council (1997).

4.4. Selected Physico-Chemical Properties of Soil at Dumping Site

Texture: Particle size distribution at 0-20cm depth in soil under the waste was 63% for sand, 26 % for clay and 11 % for silt, while it was 66 % for sand, 20 % for clay and 14 % for silt in the nearby soil which is not under the waste. Even though, there is a variation in particle size distribution, textural class of soil nearby to the dumping site and soil under the waste was sandy clay loamy. Soil not under waste had higher sand and lower clay and silt contents than the dumpsite soil. Ideriah *et al.* (2006) reported similar results for soil around a solid waste dumpsite in Port-Harcourt, Nigeria. Results reported in this study were similar to the report of Osakwe (2014). Soil texture is related to certain physical properties of soil like the capacity of water holding, permeability, plasticity, fertility, ease of tillage and overall productivity of soil.for example loamy and clay textures are suitable for irrigation purposes because they have high moisture holding capacity while loamy sands and sands have no such capacity to hold water(Brady,1996).

Soil pH: The soil pH range was in between 5.36 and 5.15 in the control, which is not under waste for 0-20 and 20-40 cm depth respectively. Moreover soil pH of dumping site where 6.45 and 5.44 for 0-20 and 20-40 cm depth respectively. The pH values indicate moderate acidic soil for the control site and slightly acidic for soil under waste. Soil under the waste might have low heavy metal solubility and mobility as compared to the nearby soil. Soil with lower pH values has increased heavy metal concentration in the soil solution (Odu*et al*., 2005). Akan *et al*. (2013) also indicates low pH enhances solubility and mobility of heavy metals. Heavy metal mobility decreases with increasing soil pH; hence the sites with low pH had relatively high concentration of selected heavy metals. The recorded pH of soil from dumping area is less than the values of similar studies by Hunachew and Sandip (2011) in Addis Ababa and in Harari city by Alemayehu *et al. (*2016*).* Lower pH of soil from the dumping sites could be attributed to that Assela town is less industrialized, more humid area and less populated than Addis Ababa and Harari cities

pH affects the mobility of heavy metals in soil. It showed that pH of the soil is correlated with accessibility of nutrients to the plant (Gray *et al*., 1998). Subsequently as pH reduces the solubility of metallic element in the soil increases and they become more easily accessible to plants (Oliver ,.1998 ;Salam and Helmke,1998).The solubility of heavy-metal ions in soil can mainly be influenced by many factors such as soil pH, moisture, temperature etc (TDMSW, 2013).

Electrical conductivity (**EC)**: EC is the ability of a material to conduct (transmit) an electrical current and it is commonly expressed in units of millisiemens per meter (ms/m).Inherent factors affecting EC include soil minerals, climate and soil texture, salts originate from the disintegration of minerals and rocks. The recorded results for soil from koshe dumping site showed that EC increased as pH decreased. This indicates the effect of pH on soil electrical conductivity. Mohd-Aizat*et-al. (*2014) identified that pH and soil moisture content affect the solubility of salts, which also affect electrical conductivity of the soil. Thus, moderate soil will have high amount of soluble salt. The lower soil pH indicates larger number of hydrogen ions in the soil. Hydrogen ions can appear in varying amount in the soil environment which can affect the level of electrical conductivity. Higher amount of hydrogen ions in the soil will show a higher rate of electrical conductivity. Hence, low soil pH due to large number of hydrogen ions in the soil may encourage soil electrical conductivity (Bruckner, 2012).

Soil organic carbon: The presence of organic carbon raises exchange capacity of the soil which retains nutrients assimilated by plants. Total organic carbon in the soils under investigation in this study was1.04 and 0.23 for control site at 0-20 and 20-40 cm while organic carbon of dump site soil were 1.27 and 0.78 with respective depth as indicated in Table 7 .Soil organic carbon was decreased from 1.27 to 0.78 as depths increased from 0-20cm and 20-40cm depth for dump site soil while also soil organic carbon decreased from 1.04 to 0.23 with respective depth for control site.

This observation was supported by Oyedele *et al*. (2008) who reported that dump sites had significantly higher pH regime and soil organic matter as compared to the control. (Ayolagha and Onwugbuta (2001) also demonstrated that organic matter greater than 2.0% or organic carbon greater than 1.2% create great conducive medium for heavy metal chelation formation.

Soil Cation exchange capacity: The cation exchange capacity is the amount of exchangeable cation per unit weight of dry soil that plays an important role in soil fertility. It depends especially on the pH, clay and on the soil organic matter content. Results of this study revealed that soils from the control had lower values of CEC of 45.8 and 46 cmol kg^{-1} at 0-20 and 20-40cm depth respectively while dump site had 48.6 and 52.2 cmol kg^{-1} CEC with respective depth. Although the clay content at the dumpsite was greater than that at the control site and pH value of dump site to some-extent higher than control site. So the higher organic matter in the dump field might result in higher soil CEC. Higher CEC makes nutrients to be available to plants and take up nutrients more easily (Aydinalp and Marinova, 2003).

Table . pH, electrical conductivity, organic carbon, cation exchange capacity, and textural properties of soil at Koshe solid waste dumping site.

	Dumping site		control site	
	0-20	20-40	0-20	20-40
pH	6.45	5.44	5.36	5.15
EC(dS/m)	0.09	0.25	2.49	2.56
OC%	1.27	0.78	1.04	0.23
CECcmol kg^{-1}	48.6	52.2	45.8	46
Sand%	63	59	66	64
Clay%	26	28	20	23
Silt%	11	13	14	13
textural class	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam

4.5. Heavy Metals Concentration in Soil

The evaluation of dumpsite soils for the concentration of toxic elements and micronutrients are essential for healthy crop production. Soil at the dumpsite was evidently **c**ontaminated by some of heavy metals relative to the control sites as indicated in Fig.5. The waste load from refuse dump soils were found to be slightly higher than the control area (100 m from the dumpsite) with the exception of Mn, which was found in less than the control site in all the soils depths. These results are collaborated by Al-Turki and Helal (2004) and Ren *et al.* (2005) who reported that lead and cadmium are anthropogenic metals, and without external interference, are normally not abundant in upper layer soils. Iron had highest concentration across the depths followed by Mn, Cu, Zn and Ni at dump site. The concentration of Fe, Mn, Cu, Zn and Ni, decreased with depths, while Pb and Cd concentrations increased with depth in dumpsite while cobalt and chromium concentration were remains the same across the depth fig 4. Some heavy metal concentrations at dumping site were equal to the concentration at the control site this may due to some peoples collect those heavy metals from the dumping site and sells for their daily life to metal recycle industries .

Lead (Pb): Lead is a non- degradable and toxic element (Arsalan.,*et al* 2004).The concentrations of Pb was10.56and 9.46 mg/kg in the soil samples from the controlsite at 0-20 and 20-40cm depth and 1.11 & 10.56 mg/kg in the dumpsite th respective depth. These values were lower than the maximum tolerable levels proposed for agricultural soil, 90-400 mg/kg set by NEPCA (2010). This is in agreement with the results obtained from similar study by Umoh and Etim (2013) for soils from dumpsites within Ikot-Ekpene in Akwa-Ibom State, Nigeria. Lead concentrations in soil at KMSWD site were also lower than the report of Hunachew and Sandip (2011) for MSW of Addis Ababa.Concentrations of lead in soil from control area at 0-20 cm were lower than in soils from waste dumping areas. This indicates continuous dumping of MSW increased hazardous heavy metal concentration at dumping area compared to control area. Higher concentration of lead at dumping area could be attributed to the decomposition of lead containing wastes like disposal of Pb batteries, dry cell batteries chemicals for photograph processing, Pb-based paints,and pipes. Therefore the concentration of lead found at Koshe municipal solid waste dumping site might be harmful for plants, ground water pollution and human health.

Iron (Fe): Iron was found to be the dominant metals as compared with other heavy metals in the study areas soil. Iron is essential element for almost all living organisms participating in wide variety of metabolic process, including DNA synthesis, oxygen transport, and electron transport. It is known that adequate iron in a diet is very important for decreasing the incidence of anemia. According to; WHO the standard and accepted level for iron in soil were 50 mg/kg. Concentration of iron at study site was 12172 and 12000 mg/kg in soil at dumping site at 0-20 and 20-40cm depth respectively while its concentration was 12103.77 and 11603.77 mg/kg in soil of control site at 0-20 and 20-40 cm depth respectively (appendix Table 5). Which is much far above the accepted range of iron in soil. At both sites high concentration of iron were recorded.

This might be the effect of Dumping site age, climate of the area, soil properties and decomposition of waste as a result of temperature, moisture and rainfall amount. Comparing the recorded values at dumpsites to control sites, slightly higher concentration of iron at dumpsites could be attributed to the decomposition of iron containing wastes. Steel scraps are the main sources of iron in the MSW (Chu *et al.*, 1994). Iron concentrations in soil of both sites were greater than world health organization standards but less than guideline for metal above standard level 50000 mg/kg (Antoniadis, v.1998). It's should be properly monitored to maintain its concentration in the accepted range to avoid health effects caused by the excess amount of it.

Zinc (Zn): zinc deficiency in the diet may be more detrimental to human health than too much zinc in the diet .Concentration of zinc in soils of dumping site were 211.57and 154.69 mg/kg while at control site 182.44 and 178.27 mg/kg at 0-20 and 20-40 cm depth respectively for both sites. Its concentrations in soil at both sites were below the maximum accepted standards 300 mg/kg suggested by Odukoya *et al.* (2000) but above the limit standards suggested WHO**.**

Chromium (Cr): The concentrations of Cr in the control soil was 37.74 and 75.47 mg/kg while concentrations of Cr in dump site was 56.6 and 56.6 mg/kg at 0-20and 20-40cm depth respectively. The second depth value75.47 mg/kg which was slightly higher, as compared to the Dump (56.60 mg/kg), but are still higher than the critical permissible level which is 50 mg/kg for soil recommended for agriculture by MAFF (1992), and EC (1986) but less than the standard limit of heavy metal in agricultural soil of Canada, china and Tanzania 250,150-300 and 100mg/kg respectively. This is less difference from the finding of Asmamaw *et al*. (2016) which revealed 16.98 ppm Cr concentration at Adama Town .Sources of Cr in the soils could be due to waste consisting of lead-chromium batteries, colored polythene bags, discarded plastic materials and empty paint containers (Jung et al., 2006).So chromium is toxic in high concentration to both plant and animals .It causes perforation bronchogenic carcinoma, skin disorder and liver damage.

Cadmium (Cd): The Cadmium concentration at both depth of control site were 2.45 mg/kg while cadmium concentration of dump site were 2.45 and 2.68 mg/kg at 0-20 and 20-40 cm depth respectively. The concentrations of Cd in soils at both sites were lower compared to other heavy metals concentration. This result was closely similar with study at Addis Ababa MSW dumping site2.41mg/kg *(*Hunachew and Sandip, 2011). Its accepted range in soil as stated by Ebong *et al*. (2008) is (0.01-300) mg/kg the result obtained showed that the cadmium level at dump site and control site were both fall under accepted range of metal in the soil. Cadmium uptake is high in acids soil. Cadmium has no beneficial effects in humans, and there is no known homeostasis mechanism for it (Vieira *et al*., 2011).Generally it's considered as the most toxic to animals and humans; the adverse human health effects associated with exposure to it, even at low concentration. At extreme levels it causes an illness called tai-itai disease characterized by brittle bones and intense pain (Connel and Miller,2011).

Nickel (Ni): Nickel is widely used in consumer products like buttons, zips, coins ,dental braces artificial joints, jeweler, batteries, hair sprayer *etc*. The nickel concentration at control site were 44.82 and 56.6 mg/kg while the dumping site concentration were 54.25and 51.89 mg/kg at 0-20 & 20-40cm depth respectively for both sites. Nickel concentrations in soils at both sites were also higher compared to similar study at Addis Ababa MSW dumping sites (3-46 mg/kg) reported by Hunachew and Sandip (2011).These might be difference in the sources of Ni wastes generated from Asella and for Asella town there is only one dumping site in a town as compared to Addis Ababa. In excessive amount become mildy toxic .short term over exposure can cause some health problem ,but long term exposure can lead to decrease of body weight liver damage and skin irritation.

Manganese (Mn): The inadequacy of manganese in the human body can produce severe skeletal and reproductive abnormalities in mammals more doses of manganese produce adverse effect primarily on the brain and lungs. The concentrations of manganese at dump site were lower than concentration of control site as indicated in Appendix table 6. The concentrations of manganese decrease across the depth at both sites. This result is supported by similar finding by Alemayehu *et al.* (2016) in Harari city. His result was also revealed that control site concentration of Mn was higher than dump site. Mn appear naturally in greater than 100 minerals with background levels in soil ranging from 40 to 900 mg/kg, with an estimated mean value concentration background of 330 mg/kg. Manganese is released to the environment from industrial emissions, fossil fuel combustion, and erosion of manganese containing soils (Thomas, 2008).This might be cause for the results.

Copper (Cu): It is known that Cu is an essential element, in addition it may be toxic to both humans and animals when its concentration exceeds the safe limits and its concentration in some human tissues such as thyroid can be changed depending on the tissue state. The natural range of concentration of copper in soil is (2-100) mg/kg (Ebong *et al*., 2008).Concentration of copper in soils of dumping site were 214.91and 197.74 mg/kg while at control site 134.43 and 165.38 mg/kg at 0-20 and 20-40 cm depth respectively for both sites. According to these authors concentrations of copper in soil at both sites were above the accepted standard range. According to Dara 1993 the high concentration of copper at the dump site might be attributed to biodegradable waste introducing metallic copper into the soil. WHO 1984 states that the injection of copper can lead to sever muscular irritation, nausea, vomiting, diarrhea, and other dangerous health effect.

Cobalt (Co): The concentrations of cobalt at dump site were higher than concentration of control site as indicated in appendix table 6. The concentrations of cobalt in soil at both sites were above the accepted standard range of Dutch 9mg/kg and Austria 50mg/kg.

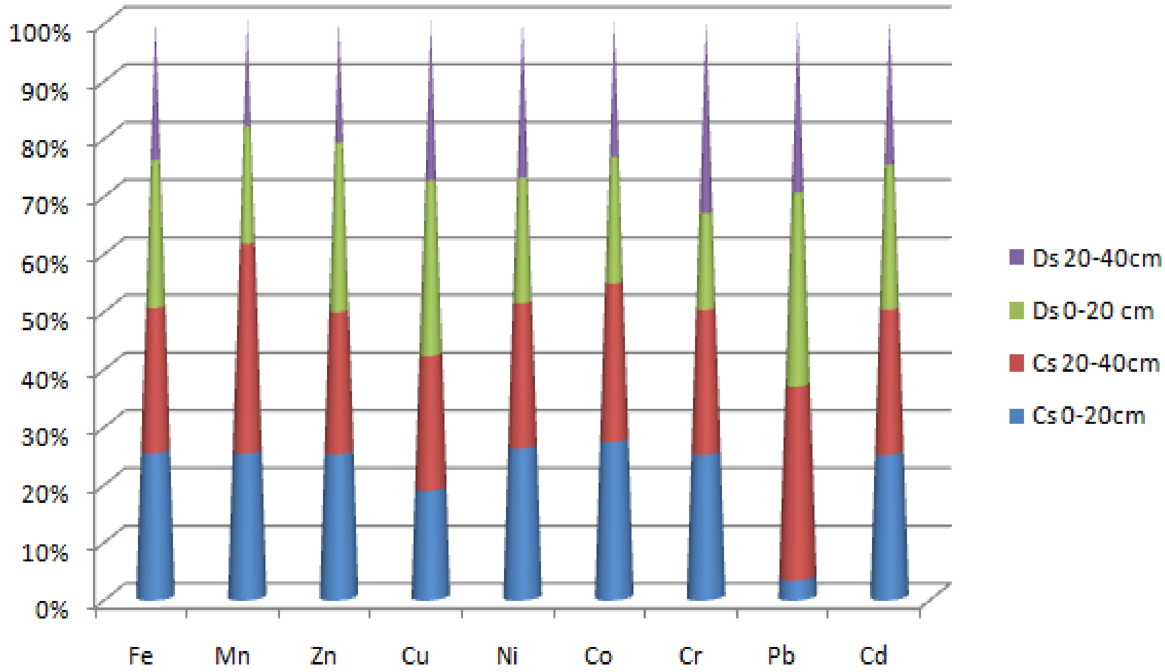

Figure .Heavy metal concentration at Koshe Dumping Site

4.6. Inter-Metal and soil physicochemical properties Correlation

The relationships between different heavy metal ion concentrations in soil at the dumping site and some physic-chemical soil properties were analyzed by Pearson's correlation coefficient.pH significantly correlated with Mn (r = 0.987)at significant level of 0.05%. , but positively correlated with EC, %sand , %OC , Fe ,Zn and Pb while CEC, Clay ,Cu, Ni, Co ,Cr ,Cd and show negative correlation with Mn .this indicate that pH positively correlate with those element but not significant at a significant level of 0.05%,there is other factor that influence pH .i.e temperature ,rainfall ,moisture. Clay significantly correlated with Mn and Co at significant level of 0.05% with (r = 0.950 & 0.968) respectively. Organic carbon significantly correlated with iron at $p < .05$ with (r = 0.983) .but iron positively correlated with some other parameters but not significant at significant level of 0.05%.Cupper is significantly correlated with Co, at $p <.05$ (r= 0.976).Cobalt correlated least significantly with pH and all other heavy metals. Cadmium negatively and least significantly correlated with all other heavy metal ions and pH.

Table . Inter-metal and soil physico- chemical properties correlation analysis

	PH	EC	OC	CEC	sand	clay	Fe	Mn	CU	Zn
PH	1									
EC	.664	1								
OC	.246	-.540	1							
CEC	-.690	-.845	.198	1						
Sand	.818	.751	.058	-.963*	1					
Clay	-.907	-.887	.094	.914	-.938	1				
Fe	.248	-.559	.983*	.302	-.039	.135	1			
Mn	.987*	.774	.087	-.749	.838	-.950*	.089	1		
CU	-.851	-.915	.286	.708	-.706	.908	.254	-.921	1	
Zn	.152	-.118	.533	-.432	.518	-.195	.371	.077	.233	1
Ni	-.825	-.254	-.479	.161	-.363	.526	-.564	-.764	.615	.142
Pb	.311	.571	-.573	-.053	-.021	-.322	-.438	.407	-.687	-.866
Co	-.855	-.955*	.284	.845	-.830	.968*	.291	-.926	.976*	.046
Cr	-.711	.021	-.739	.027	-.277	.350	-.802	-.604	.354	-.073
Cd	-.517	-.537	-.075	.904	-.906	.714	.079	-.529	.367	-.773

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

5. SUMMARY AND CONCLUSION

The inadequate collection, recycling or treatment and uncontrolled disposal of municipal solid waste are particularly frequent in low and middle-income countries and lead to severe health risks and environmental pollution. The presences of uncontrolled dumpsites in most towns or cities are the result of the indiscriminate deposition of the waste prevalently waste food and putrescible materials. While MSW can be reused as organic fertilizer or for soil amendment after biological transformation the heavy metal contained in it and its products restricts beneficial use and disposal of the waste. This enhances the concern for management of Municipal solid waste.

Heavy metal pollution of the environment, even at low levels, and their resulting long-term cumulative health effects are among the leading health concerns all over the world (Oluyemi et al., 2008). Open dumps are a source of various environmental and health hazards. The decomposition of organic materials produces methane, which may cause explosions and produce leachates, which pollute surface and ground water. At current, waste management of Assela Town is simply a linear system of collection and disposal without any source segregation, creating health and environmental hazards. There is an urgent need to develop a comprehensive MSW management system. The study was conducted to identify sources and to evaluate concentrations of selected heavy metal at waste dumpsite soil and decomposed municipal solid waste at Assela municipal dumping site Area , Ethiopia.

Koshe land filling site of Assela town is non-engineered low lying open dumps. So all the leachates generated find their paths into the surrounding environment. Atomic absorption spectrophotometer was used to determine the concentrations of each heavy metal in waste and soil under waste and in the nearby soil. The collected data were analyzed using statistical software for Microsoft Excel and SPSS V16.0 for Window. The heavy metal concentrations in decompose solid waste were all above the WHO acceptable limit. Based on their concentration, the heavy metal components in the DMSW were found in the following order: Fe>Mn> Zn > Cu > Ni > Co > Cr >Pb>Cd at koshe dump site. The recorded concentrations of heavy metals found in KDMSW were low when compared with the results reported by other investigators. The recorded concentrations of heavy metals found in soil were high when compared with WHO standard limit except Lead concentrations.

Heavy metal concentrations in the Koshe dump site of Assela town may not appear to pose very serious environmental problems at the moment.However, accumulation of these metals may later pose a threat to human health and environment. Uncontrolled burning of solid waste was practiced at dumping site. Burning of solid waste constitutes serious environmental pollution, adversely affecting solid waste workers and collectors.

It can be conclude that the compost and soils from the land fill site revealed contaminations by heavy metals .since the dump site is only one in town, its unsustainable approach to handling waste. Using phytoremediation technology to the contaminated soil might be important in the site. Other waste processing and treatment initiatives such as waste to energy conversion technologies need to be considered to minimize the impact of those heavy metals on the environment. The commercial and institutions sector should build concrete before they dispose the waste to the site because their wastes have more heavy metals.

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7. APPENDICES

Appendix Table. Assela Weather (2009 -2019)

	Jan	Eb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Max(°C)	22	22.6	23.3	23.3	23.1	21.7	19.7	19.6	19.9	21.5	21.2	21.4
Mean Min(°C)	6.4	7.5	8.9	10	10	9.7	9.8	9.8	9.5	8.7	7	5.7
Mean Rain(mm)	27	57	93	105	110	123	195	205	51	54	18	9

AppendixTable Source of MSW

Household	single-and multi-family home
Commercial	Offices, wholesale &retails ,restaurant, hotels ,market center
Institutional	Schools, Colleges , hospitals, clinics, prison

AppendixTable World Health Organization (WHO), Food and Agricultural Organization

Chemical element	Maximum permissible limit in level in soil(µg⁄g)
As	20
Cd	3
Co	50
Cr	100
Cu	100
Fe	50000
Mn	2000
Ni	50
Pb	100
Sn	10
Zn	300

Source (FAO) and Ewers U, Standard Guidelines in Europe as shown in Table below: source (Chiroma, 2014)

Appendix Table . Range of trace metal concentration in the soil accepted by WHO (mg/kg).

METAL	**RANGE**
Aluminium (Al)	6 – 3500
Chromium (Cr)	0.002 – 0.2
Nickel (Ni)	0.1 – 5
Arsenic (As)	0.009 – 1.5
Cadmium (Cd)	0.02 – 0.5
Lead (Pb)	0.3 – 10
Lithium (Li) <	0.01 – 143
Copper (Cu)	1 – 12
Zinc (Zn)	12 – 60
Mercury (Hg)	0.001 – 0.04

Source: (Akaeze , 2001)

Appendix Table 5. List of table in appendix .Comparison of Metals in Soil Samples with Different Standards (mg/kg)

Element	DS 0-20cm	20-40cm	Cs 0-20 cm	20-40cm	Dutch	Canada	Tanzania	WHO	chi
Fe	12172.78	12000	12103	11603.77	NA	NA	NA	50	NA
Mn	959.6	877.9	1723	1159.5	NA	NA	NA	2	NA
Cu	214.91	197.74	134.43	165.38	36	150	200	1 – 12	50-20
Zn	211.57	154.69	182.44	178.27	140	500	150	12 – 60	200-30
Ni	54.25	51.89	44.82	56.6	35	100	100	0.1 – 5	40-60
Co	32.91	32.91	26.33	28.52	9	-	-	0.05	-
Cr	56.6	56.6	37.74	75.47	100	250	100	0.002 – 0.2	150-30
Pb	1.12	10.56	10.56	9.48	85	200	200	0.3- 10	80
Cd	2.25	2.68	2.25	2.25	0.8	20	1	0.02 – 0.5	0.3-0.

Source (CME2009, EPMC20014, TMS2007,van Lynden *et al.*, 2004, Chiroma *et al., 2014*,Maleki *et al.*,*2014)*