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Analysis of Heavy Metals in Municipal Solid Waste: In Case of Koshe Open Dumping Site of Assela Town, Oromia Region, Ethiopia

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ABSTRACT

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 metals into the water, soil and plant material growing on the waste dump site by that contaminating them. Therefore, the purpose of this study was to identify the status of selected heavy metals in municipal solid waste 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) and institution (3.32 kg/day). For assessing heavy metal concentration in decompose municipal solid waste at the dumping site, three decomposed waste samples were collected. Heavy metals such as: Fe, Mn, Cu, Zn, Ni, Co, Cr, Pb and Cd in decomposed municipal solid waste samples were analyzed. Results showed the concentration of these heavy metals in the decomposed municipal solid waste samples were in the order of Fe>Mn>Zn>Cu>Ni>Cr>Co>Pb>Cd. The pH, EC, OC values of decomposed municipal solid waste sample where 8.3, 1.59 dS/m, and 3.33% respectively. 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.

Key words : *Assela, Dumpsite, Heavy metals, Koshe, Municipal*

Introduction

Environmental pollution by heavy metals increased due to industrial expansion and high quantities of heavy metals exist in industrialize area and finally reaches in to municipal solid waste (Adesuyi *et al.*, 2015). The continuous dumping of municipal solid 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. Apart from uptake by plant, they can also be leached into underground water sources. Ukpong *et al.* (2013), reported 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 canenter plant, animal and human tissues through inhalation, food chain and manual handling. They can interfere with cellular components. Moreover, high concentrations of heavy metals in municipal solid waste now dominate the outflow from most cities (Bergback *et al.*, 2001). This is due to 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 municipal solid waste 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 municipal solid waste management (Zennaro *et al*., 2005). The knowledge on the occurrence and distribution of heavy metals in municipal solid waste could assist policy makers and management authorities in eliminating major contaminant sources through effective modification of municipal solid waste handling, collection, treatment and disposal practices (Zhang *et al*., 2008).

The *Assela* town municipal solid waste dumping site was known by local name *Koshe*. The *Koshe* solid waste dumping site is open with non-engineered lower lying. However, there is no leachate collection and treatment system at this 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. In addition to this, some of the heavy metals are strongly absorbed by soil constituents and their mobility and bioavailability depends on soil conditions. However, in the absence of comprehensive and wide studies in line with heavy metal in solid waste disposal site in developing countries like Ethiopia. Therefore, the present study was focused on the analysis of selected heavy metals such as cadmium, chromium, copper, iron, manganese, lead, nickel and zinc at *Asella* town solid waste dumping site

Materials and Methods

The study area

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, Ethiopia at about 175 km from Addis Ababa capital city. Geographically, the town is located at 7°572N and 39°72E, 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

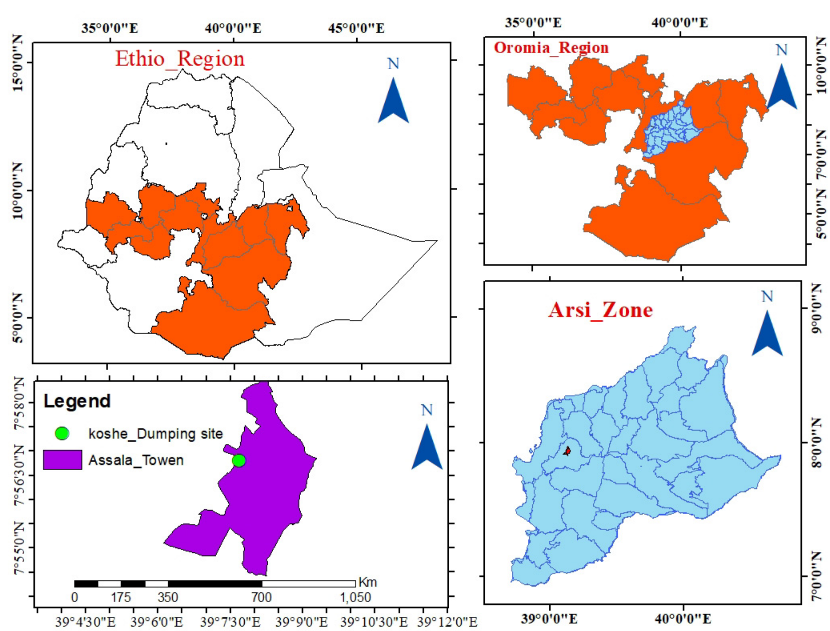

Fig. 1. Map of study area
Sources: identification of municipal solid waste

kebeles. The 2012, world population report shows a total population of 110,088 of which 55,357 were men and 54,731 were women.

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. 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 municipal solid waste management (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.

Sampling techniques for solid wastes

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. 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.

Experimental analysis

The decomposed municipal solid waste sample were analyzed for selected physicochemical properties mainly pH, EC, organic carbon (OC). The pH was measured by pH meter in suspension of 1:1 ratio of decomposed municipal solid waste sample. Ten gram of air dried decomposed municipal solid waste sample (< 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 (Tang, 1996). For determination of electrical conductivity 10 g decomposed municipal solid waste sample 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. The decomposed municipal solid waste sample organic carbon (%) was determined by the wet oxidation method as described by (Walkley and Black, 1934).

The decomposed municipal solid waste sample 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 °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 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).

Results

Sources of heavy metals in municipal solid waste at *Koshe* solid wastes dumping site

Sources of heavy metal in the study were analyzed and the results were summarized in Table 1. Accordingly, the major source of municipal solid waste were generated from three sources, they are commercial, institutional and household. Among these identified sources, commercial area showed highest quantity (5.69 kg/day) of solid waste generation rate and least one is from household (1.29 kg/day) source.

Table 1. Sources and quantities of metal dumped at Koshe solid waste dumping site per day.

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

Selected chemical properties of decomposed municipal solid waste at Koshe dumping site

The decomposed municipal solid waste sample were subjected to analysis of selected physicochemical properties such as pH, EC, organic carbon (OC) and the results were indicated in Table 2. It showed pH value is 8.3, electrical conductivity is 1.59 dS/m and organic carbon 3.33%.

Table 2. Selected physico chemical characterization of solid waste at Koshedumping site

Selected physico chemical parameters	
pH	8.3
Electrical conductivity	1.59 dS/m
Organic carbon	3.33%
Total	10.3

Heavy metals concentrations in decomposed municipal solid waste at *Koshe* site

The selected heavy metal such as Fe, Mn, Cu, Zn, Ni, Co, Cr, Pb and Cd were identified from solid waste at *Koshe* dumping site and the results were indicated in table.3. The results were revealed that the highest proportion of heavy metal such as Fe (1912.7 mg/kg) followed by Mn (1172.7 mg/kg) and Zn (468.92 mg/kg) were recorded in the study area. The least heavy metal in the municipal solid waste is Cd (4.92 mg/kg).

Discussion

The sources of metals in municipal solid wastes at the dumping site were identified and results indicated in Table 1. Major compositions of MSW at the dumping site were biodegradable 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 1). From the metal wastes dumped at the site per day about 55.24% was from commercial centers. In line with is similar study 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.

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. However, pH value of decomposed waste at the study site was slightly higher than the acceptable range. High pH value of wastes at *Koshe* (8.3) dumping site might be presence of metals. McCauley *et al.* (2009) suggested that high pH values of decomposed solid wastes might be due to presences of some of the 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.

The electrical conductivity (EC) of the decomposed municipal solid wastes was 1.59 dS/m at Koshe dumping site, as shown in Table 2. The EC of

Table 3. Heavy metals concentrations in decomposed municipal solid waste at Koshe site

S. N.	Types of Heavy Metals	Concentration (mg/kg)
1.	Fe	1912.7
2.	Mn	1172.6
3.	Cu	234.42
4.	Zn	468.92
5.	Ni	46.5
6.	Co	30.75
7.	Cr	37.74
8.	Pb	12.22
9.	Cd	4.92

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* site. This indicates the presences of more soluble mineral substances in the decompose wastes at *Koshe* site.

Organic carbon of the decomposed waste was 3.33 % at study dumping site as shown in Table 2. According to Ayolagha and Onwugbuta (2001), the presence of moderate organic carbon in compost/ soil is favorable for heavy metal chelation formation.

The concentrations of heavy metals such as Fe, Mn, Zn and Cu in decomposed municipal solid waste at *Koshe site* (Table 3) 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) from *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, 70-100 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.

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