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HEAVY METAL POLLUTION OF SOIL AND ITS PHYSICOCHEMICAL PROPERTIES AT ADAMA CITY SOLID WASTE DISPOSAL SITE, EASTERN ETHIOPIA

BY

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Heavy Metal Pollution of Soil and Its Physicochemical Properties at Adama City Solid Waste Disposal Site

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Abstract

The uncontrolled disposal of solid waste causes different adverse environmental impact. One of the serious problem is the leaching or migration of heavy metals to the nearest environment compartment. The aim of this study to analysis the heavy metal contents, extent of pollution and physicochemical properties of soil nearby solid waste disposal site. The sampling location was selected by transect from nearby disposal site toward gully erosion. The depth-specific soil samples were taken at the depth of 5-20cm and 20-30cm. Stainless steel materials were used to collect soil sample. The air dried soil samples sieved to pass 2mm and subsample of <2mm were used for pH, EC, CEC, soil porosity and heavy metals concentration analysis. The pH of soil near Qobbo Luxo and Jogo Dedo disposal site had slightly basic and basic respectively. In both disposal sites low CEC and EC were alayzed. Vertical distribution of indicate that Cd, Cr and Pb are increase but Cd and Pb are not in fixed pattern in Qobbo Luxo disposal site. Regarding to Jogo Dedo disposal site Cr and Pb are increases but Cd is in decreasing pattern. The soil is unpolluted to moderately polluted for all three heavy metals in Qobbo Luxo site based on geo accumulation indices classes but Jogo Dedo site shows unpolluted to moderately polluted by Cr and Pb but moderately polluted to Cd. Generally, soil nearby disposal sites indicates contamination of soil by heavy metal. This result alarm for the environmental risk of having heavy metals through food chain and possibly leaching to water sources. The possible recommendation remedial action should take place and installation of leachate collection as well as establishing of buffer zone necessary.

Key words: Solid waste; Heavy metals; Geo-accumulation index;Soil; Adama

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Abbreviation

ASTM; American Society for Testing and Materials

CEC; Cation Exchange Capacity

EDTA; Ethylene Diamine Tetra Acetic Acid

ETAAS; Electro Thermal Atomic Absorption Spectrometry

EC; Electrical Conductivity

EU; European Union

MCL's; Maximum Contaminant Levels

MSW; Municipal Solid Waste

NSS; New Soil Sample

OSS; Old Soil Sample

QC; Quality Control

SWM; Solid Waste Management

TCLP; Toxicity Characteristic Leaching Procedure

UNDP; United Nation Development Programme

UNICEF; United Nation International Children Fund

USEPA; United State Environmental Protection Authority

WHC; water holding capacity

1. INTRODUCTION

1.1. Background of the Study

Environmental contamination by heavy metals and organic pollutants is a phenomenon of global importance with high concentration. There is a risk they enter the food chain and cause health problems to plants, animals and humans (Panagos *et al*., 2011). The physical and chemical characteristics of the soil system influence the transformation, retention, and movement of pollutants through the soil. The properties also influence the rate of migration and form of the chemical found in leachate migrating from the waste (USEPA, 1989). Some Metals tend to be relatively strongly adsorbed by soil constituents. Their mobility and bioavailability depend on the soil condition but some metals Cr and Zn which tend to be less strongly sorbed than Pb and Cu can be leached down soil profile (Alloway, 1990).

According to Caeiro *et al*., (2005) pollution index is a powerful tool for processing, analyzing, and conveying raw environmental information to decision makers, managers, technicians, and the public. Single indices are indicators used to calculate only one metal contamination, which include contamination factor, ecological risk factor, enrichment factor, and index of geo-accumulation (Qingjie *et al*., 2008)

The environmental degradation caused by indiscriminate disposal of waste can be expressed by the contamination of surface and ground water through leachate, soil contamination through direct waste contact or leachate (Visvanathan and Glawe, 2006). The typical municipal solid waste stream will contain general wastes (organics and recyclables), special wastes (household hazardous, medical, and industrial waste), and construction and demolition debris (Salvato *et al*., 2003). The sustainability of the land filling system has become a global challenge due to increased environmental concerns. Municipal waste dumping sites have been recognized as a major source of environmental toxicants that including heavy metals. (Kimani, 2007). The pollution of land by disposal of solid waste is neglegibel in Ethiopia. The assessment of degree of soil pollution nearby solid waste disposal sites are vital to regulates bio accumulative effects of heavy metals through food chain as well as the leachability to water sources.

1.2. Statement of the Problem

Open dumping is the most common method of Municipal Solid Waste disposal in many middle and lower-income countries and such practices must be brought to an end. It is also possible that no proper sitting or site investigation and no engineering design are done for the site that cause different environmental problem (Kuria *et al.*, 2008).

Heavy metals present a serious problem for the environment. Once introduced into the soil, they may persist there for hundreds and even thousands of years. This is why soil polluted with heavy metals require special methods of utilization and maximum limit was established.The criterion for determination of origin of the metals (geochemical or anthropogenic) was the percentage of available portion in the total content (Panagos *et al.*, 2011)

Most adverse environmental impacts from solid waste management are rooted in inadequate collection and recovery of recyclable wastes, as well as codisposal of hazardous wastes (USAID, 2009). These impacts are also due to inappropriate sitting, design, operation, or maintenance of dumps and landfills. According to Kuria *et al.*, (2008) lack of proper sitting and improper MSW disposal can cause or pose environmental risk. The leachate may form and infiltrate into the subsoil from solid waste disposal site. In the case that concentrated leachate, which may be enriched with toxic metals and organic compounds, intrudes the subsoil and reaches the water table, the risk of groundwater contamination is imminent (Zaporozec, 2002).

According to Bidhendi *et al.*, (Jayaprakash *et al.*, 2012) indicate that heavy metals, are among the most common environmental pollutants and their occurrence indicates the existence of natural or anthropogenic sources. The leachate determines its own fate in the surrounding environment and therefore presents a risk to human health and the environment as it escapes. These risks are depending on the age of the dump as well as the type of waste disposed within the dump (Priddle, 2005).

Research have been done on the contamination ground water around open solid waste site in developing countries. This is supported by the research conducted by Zawdie (2007) in Ethiopia, trace metals composition of leachate, well and spring water sample 300m around Addis Ababa Reppi disposal site. The study which has been done in the same dumpsite show that at the outlet of stream near dumpsite existed 99.48%, 95.4% and 93.9% increment in the concentration of Cr, Cd and Pb respectively along the stream. The growing concerns of health and environmental risk in the landfill area are now becoming more serious as different incompatible land uses are surrounding the site (Beyene and Banerjee, 2011).

Study was conducted in Cote D'ivoire by Kouame *et al.*, (2010) suggest that further studies, including analysis of soil in closer profiles of dumpsite are necessary to elucidate the extent and mechanism of metal transport. There is lack of comprehensive study as well as little or no monitoring of the extent of leachate infiltration and its movement into soil at waste disposal facilities in developing countries including Ethiopia. Hence, the extent of short and long term contamination of groundwater and soil are unknown in different parts of the count. Therefore, continued attention is needed to heavy metal pollution around open solid waste disposal site in soil and water sources are necessary. As far as my knowledge there is no study conducted heavy metals soil pollution at Adama city solid disposal site. The present study analysis Cadmium, Chromium and Lead concentration, geoaccumulation index (I_{geo}) and physicochemical properties of soil nearby Adam city administration solid waste disposal site.

1.3. Significance of the Study

The uncontrolled manner in which solid waste is disposed of at most open dumpsites creates serious health problems to humans, animals, and environmental degradation. This inadequate waste disposal translates into economic and other welfare losses especially in developing countries.

The finding of this study showed the degree of soil pollution by heavy metal and its physicochemical characteristics around Adama city solid waste disposal sites. The quality of soil intended for agricultural crop production is a great concern as it should be free from substances harmful to human health. The findings of this study were important for site remediation and selection of appropriate land fill design. The result also used to take action to protect food and water sources from toxic substances which can accumulate in the soil as well as leached to ground water. It will be also used as reference for other researchers.

2. LITERATURE REVIEW

2.1. Physico-chemical Properties of Soil

The soil of Akouedo landfill is a reducer medium with a pH ranging from 7.24 and 8.70. This abundance of organic matter is the consequences of the presence at the landfill of biodegradable domestic solid and of high microbial activity for the mineralization of nitrogen and carbon forms. Heavy metals have a heterogonous spatial distribution and decreased gradually toward downstream to landfill (Kouame *et al*., 2010).

According to the soil in the vicinity of Ampar Tenang site were characterized by acidic pH. There was no change in pH with depth except for the downs lope soil samples, which showed a slight decrease from the surface to a depth of 70 cm and then pH remained unchanged. The Ampar Tenang site samples are characterized by a cation exchange capacity of 14.32 meq/100g (Bahaa-Eldin *et al.,* 2008).

The pH range along transects at the East-West road dumpsite was between 4.3 and 6.8 with a mean of 4.88. The pH ranges for transect and profile soils at the Kaduna/Afam street dumpsite were 5.4 and 7.9 with a mean of 6.6 ± 0.73 and 5.2 and 6.4 with a mean of 5.74 ± 0.36 respectively. At the East-West dumpsite, the highest pH of 6.8 was obtained at the topsoil of the 0m (waste dump) whereas the lowest obtained at the same spot but at the 20-30cm depth. At the Kaduna/Afam street dumpsite, while the pH tended to remain unchanged with depth. The pH values of the study sites were mostly slightly acidic. The neutral pH of 7.0 to 7.9 was consistent for some stations at Kaduna/Afam street dump site (Ideriah *et al*., 2010).

The pH of along depths indicated that the soils were slightly acidic. It ranges from 5.3 to 6.2 indicating only moderate soil acidity. There is slight differences throughout the depth in all dump sites (Adelekan and Alawode, 2011).

The study at Addis Ababa reppi dumpsite slightly basic, 8.17±0.95 in the dumps site and 7.37±0.37 in the grazing land. The EC at dump site are range from 0.2ms/cm-7ms/cm but in grazing land 0.6 ms/cm-7.1ms/cm. The Effective Cation Exchange Capacity (ECEC) was 64.34 mol kg^{-1} (Beyene and Banerjee, 2011).

According to Abdus-Salam (2009) the description of dumpsite locations and year of existence is presented in Table 1. The dumps age between 2 and 21 years. The more active sites exhibit neutral to slightly basic pH while old or inactive sites exhibit, slightly acidic pH.

Figure 1: The dumpsites locations, years of existence and pH as well as comparative extractions of Cd and Pb with Dilute and concentrated HNO_3 on dumpsite-soil samples

	Dumpsites	pH (1:1soil-H_2Osuspension)	Years of Existence	Concentration (g/kg)			
				Cd		Pb	
				Dilute	Conc	Dilute	Conc
1	Sango Shooting Range	7.4	1985 (21)	0.02	0.02	3.2	7.65
2	NSITF, Asa-Dam	6.1	1990 (16)	0.01	0.01	2.5	7.5
3	Atoto Warehouse	5.4	1985 (21)	0.01	0.01	1.06	6.11
4	Gerewu, Hajj Camp Road	7.1	2004 (2)	0.05	0.06	2.91	5.31
5	Asa-Dam KWHA	6.8	1985 (21)	0.01	0.01	1.76	4.52
6	Ita-Amoh	7.7	1985 (21)	0.01	0.01	2.43	3.9
7	Oko-Olowo	7.6	1999 (7)	0.02	0.02	2.51	3.92
8	Airport Near NASFAT	6.9	1998 (8)	0.01	0.01	0.98	2.15

Source: (Abdus-Salam, 2009)

At Egbeada site, differences were found in an elevation of pH from 4.86 at the control site to 7.07 at the 0-15cm horizon of the dump site indicating a favourable condition of acidity which supports the growing of certain crops at the dump site. At Aladinma, pH was also raised from 4.25-6.05; but at Nekede dump site, pH decreased from 6.94-6.03 at the 0-15cm horizon indicating that the presence of the dump increased acidity of the soil (Ubuoh *et al.*, 2012). The soil cation exchange capacities for the three dumps were found to have increased above the control sites at all three horizons (Ubuoh *et al.*, 2012).

Figure 2: Variation of Soil Quality in in the three dump Site

Dump Sites	Depth of soil (cm)	pH	ECEC meq/100g
Egbeada	0-15	7.07	34.076
	15-30	7.59	49.497
	30-45	7.66	13.019
Aladinma	0-15	6.05	15.124
	15-30	6.38	10.317
	30-45	6.24	8.259
Nekede	0-15	6.03	15.013
	15-30	6.33	28.199
	30-45	6.53	15.46

Source: (Ubuoh *et al*., 2012)

The Variations in Physicochemical Properties of soils in the Derived Savannah of Southern Nigeria showed that the mean pH value for each profile, all the soils were acidic. The pH of the horizons of Ita gunmodi profiles range 5.6-6.0. The pH of the soil horizons of Apomu series range 6.0-7.7, with an average value of 6.5. The pH values for the horizons of Odeyinka profile ranged between 6.4-7.1 (Nwachoko *et al*., 2009).

2.2. Heavy Metal Concentration

The environment is degraded in a number of ways. Soil is contaminated by being in contact with solid waste and leachate. In a study on a dumpsite in Kariba in Zimbabwe, trace metal concentrations were determined in soil samples collected from the area during 1996 and 1997 (Remigios, 2010). Leachates also contaminate both ground and surface water. During floods, water mixed with leachate may flow out of the dumpsites and get into nearby ponds, streams, and rivers. The Nairobi River for example, passes through the Dandora Municipal Dumping site, and some of the waste from the site finds its way into the river (Kimani, 2007)

The study was conducted at soil in Reppi dump site in Addis Ababa ranges from 70-157ppm for Cr, 58-852ppm for Pb and 0.56-5.9ppm for Cd. In the same study at the grazing land nearby dump site had a concentration of Cr ranges 46-513ppm, Cd range 0.5-6.82ppm and Pb range 67 and 371ppm. The leachate from the reppi dump site were recoreded to the maximum of 57.84mg/l, 1543.2mg/l and 455.2mg/l for Cd, Cr and Pb respectively (Beyene and Banerjee, 2011).

Figure 3: The average values of the amounts of total heavy metals concentration (μg m-3) in the soils collected at different sites downwind old municipal solid waste dumpsite (MSW) in Abis

No	Site description	Heavy metals concentration (μgm^{-3})				
		Cd	Cu	Ni	Cr	Zn
1	Close to dump site	4.90	95.20	11.80	10.20	110.00
2	200 m, east the dumpsite	4.20	82.00	9.30	9.10	95.00
3	500 m, east the dumpsite	3.85	73.8	8.40	8.25	90.00
4	500 m, southeast the dumpsite	3.95	81.8	8.35	9.15	89.10
5	700 m, southeast the dumpsite	3.55	59.50	7.85	8.30	87.00
6	1000 m, southeast the dumpsite	2.50	54.60	7.50	8.00	86.00
7	300 m, south the dumpsite	3.80	80.10	8.20	8.80	91.00
8	500 m, south the dumpsite	3.70	74.50	8.00	8.60	87.50

9	1200 m, south the dumpsite	1.00	48.20	7.20	8.50	80.00
10	1500 m, south the dumpsite	1.35	44.50	7.15	8.40	80.00
11	1700 m, south the dumpsite	1.00	42.80	6.95	8.20	80.00
12	2000 m, south the dumpsite	0.50	40.20	7.00	8.00	77.50
13	200 m, southwest the dumpsite	3.95	80.50	8.90	10.00	90.00
14	300 m, southwest the dumpsite	3.45	77.80	8.10	4.10	86.00
15	500 m, southwest the dumpsite	3.40	73.50	7.70	8.65	81.50
16	700 m, southwest the dumpsite	2.15	74.10	7.60	8.00	80.00
17	1000 m, southwest the dumpsite	1.10	61.10	7.20	7.80	72.00
18	1500 m, southwest the dumpsite	0.85	50.00	7.00	7.60	70.15
19	2000 m, southwest the dumpsite	0.20	42.50	6.75	7.45	69.50

Source: (Abdel-Monem *et al*., 2011)

The above table 3 present the levels of heavy metals in soils near and around the old Abis MSW dumpsite in Alexdaria. The results also indicated that there is a decrease in heavy metals concentrations with increasing distance from the dumpsite. The highest levels were recorded in soils close to the dumpsite and the lowest levels were found in 200m north El-Montaza MSW dumpsite at Alexdaria. In general, these is a tendency for decreasing the levels of heavy with increasing distance from the dumpsite (Abdel-Monem *et al*., 2011).

Figure 4: The average values of heavy metals concentration (μgm^{-3}) in the soils collected at different sites downwind municipal solid waste dumpsite (MSW) in El-Montaza

No	Site description	Heavy metals concentration (μgm^{-3})				
		Cd	Cu	Ni	Cr	Zn
1	Close to dump site	4.50	71.90	11.50	10.65	105.90
2	200 m, southeast the dumpsite	4.15	65.20	9.20	8.65	96.00
3	500 m, southeast the dumpsite	3.60	60.10	8.40	8.15	86.50
4	700 m, southeast the dumpsite	2.90	51.60	7.95	8.00	79.90
5	1000 m, southeast the dumpsite	1.15	40.50	7.00	7.25	77.90
6	200 m, north the dumpsite	0.30	37.50	6.25	7.10	73.60

Source: (Abdel-Monem *et al*., 2011)

According to study was conducted by Parth *et al*. (2011) the Chromium soil contents was found to be 12.2-80.5mg/kg. Average concentration of Chromium (Cr) exceeded the highest natural background value of 93mg/kg and threshold value of 64mg/kg. Average soil pH of 7.5 is complimentary for the Cr mobility and its high concentration can be seen at regular intervals. Soil Pb content varies from 42.9-1833.5mg/kg. The average concentration of Pb (206.4mg/kg) exceeds the highest natural background value and threshold concentration.

Abandoned mechanic and non-mechanic sites in Abakaliki, Southeastern Nigeria reveal different result in soil contents of heavy metals. The order of Pb increase at 0-20cm depth was abandon mechanic site greater than that non-mechanic site. At 20-40cm depth abandon mechanic site had the Pb content of 35.50MgKg^{-1} while that of non-mechanic site was 6.20 MgKg^{-1}. Abandon mechanic site recorded Pb content of 28.90MgKg^{-1} at 40-60cm depth. Similarly, at depth of 60-80cm abandon mechanic and non-mechanic sites recorded the Pb values of 33.10 and 19.85MgKg^{-1}, respectively.

Abandon mechanic site recorded Pb pit mean and range of 31.63MgKg^{-1} and 28.90-35.50MgKg^{-1}, respectively. Whereas Pb pit mean and range in then non-mechanic site were 14.06MgKg^{-1} and 6.20-19.85MgKg^{-1}, respectively (Njoku and Ngene, 2012).

Regarding to Cd the pit mean content were 1.05MgKg^{-1} and 0.70MgKg^{-1} for abandon mechanic and non-mechanic sites while Cd in the ranged between 0.70-1.15MgKg^{-1} and 0.55-0.95MgKg^{-1} respectively. For the Abandon mechanic site the depth concentration of Cd is 0-20cm, 20-40cm, 40-60cm and 60-80cm are 0.75Mgkg^{-1}, 0.70Mgkg^{-1}, 1.20Mgkg^{-1} and 1.55Mgkg^{-1} respectively but on non-mechanic site is a concentration of 0.60Mgkg^{-1}, 0.55Mgkg^{-1}, 0.95Mgkg^{-1} and 0.70Mgkg^{-1} (Njoku and Ngene, 2012).

The Pb concentrations showed a slight fluctuation in surface depth between two sampling times of except in one sampling point, and these fluctuations were more in 30-60 cm depth according to study was downstream of a municipal waste landfill in Iran (Marzieh, Hosseini and Sarmadiyan, 2010). The other study on the mean concentration (mg/Kg) of the heavy metals in Road deposited sediments (RDS-Nigeria) are Pb (20.41-50.59), Cr (12.34-21.82), and Cd (13.33 -29.38) respectively (Yisa *et al.*, 2012).

The study at the Akouedo landfill nearby Ebrie lagoon had described the concentration of heavy metals. According to the study on Pb concentration is heterogeneous at different location toward downstream. The concentrations at landfill soil is very high compared to other two sites far from landfill. These sites are significantly different ($p=0.0001436$) according to the Kruskal-Wallis test. For the Cd the average concentration is higher nearest to landfill. Distribution of Chromium at the sampling location is broadly similar to that of Cadmium. The Kruskal-Wallis test makes no relationship between the concentration of Cr metal at three sites ($p<0.05$) (Kouame *et al.*, (2010).

The study was conducted by Ideriah *et al.* (2010) heavy metals contamination at soil and vegetation around solid waste dump sites showed less concentration. Based on the study lead concentrations were generally low in the soils of all the study areas.

The lead concentrations ranged between 0.24 and 0.29ppm at the East-West road dumpsite, 0.4 and 5ppm at the Kaduna/Afam street dumpsite. For the soil profile, the concentrations ranged from 0.001 to 0.90ppm with a mean of 0.2 ± 0.08 at the Kaduna/Afam street dumpsite. The levels of lead in vegetation varied between 0.001 and 0.39ppm with a mean of 1.48 at East-West road dumpsite and 0.23 and 74ppm with a mean of 0.39 at Kaduna/Afam street dumpsite. Lead measured in all the stations was found to be less than 1ppm. The highest values obtained at the East-West road stations (0.903ppm) and at the Kaduna/Afam street stations (0.90ppm) were at the vicinity of the waste dumps (Ideriah *et al*., 2010).

The concentration of Cr and Pb were described by the following table in which study was done at different refuse dump sites. Pb ranged between 215.50 to 624.50mg/kg in the top layer (0-15cm depth) of the soil. In virtually all the cases the value of Pb gradually reduced through the soil layers, and at the depth of 45-60cm, the values recorded for Pb were still higher. The concentrations of Cr in soil ranged from 13.15 to 75.55mg/kg, which was higher than that of the control (6.25 to 19.75mg/kg) (Adelekan and Alawode, 2011).

Figure 5: Lead and Chromium content (mg/kg) of soils at four depths at municipal dump sites in Ibadan, Nigeria

Dump site	Lead (mg/kg)				Chromium (mg/kg)			
	Depth (cm)				Depth (cm)			
	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
Agodi	206.50	120.00	98.50	95.50	23.50	44.70	23.95	13.35
Ijokodo	624.50	575.50	369.00	90.50	35.90	75.55	24.65	19.95
Dugbe	364.50	334.50	231.50	363.00	62.75	57.30	44.10	57.15
Challenge	215.50	352.00	198.50	210.50	61.85	34.15	32.60	13.15
Olorunsogo	358.00	266.50	184.50	156.50	41.30	26.90	24.85	22.40
Oja Oba	222.50	108.50	84.00	194.0	17.55	24.40	19.75	16.15
Mokola	306.0	132.5	80.50	45.00	15.30	45.05	14.05	18.20
Control	<0.05	<0.05	<0.05	<0.05	19.75	6.25	8.50	8.25

Source : (Adelekan and Alawode, 2011)

In the same study Cd values at the dumpsites ranged from below detection limit to a high of 16.30mg/kg, while the control samples had <0.002mg/kg. Notably in Oja-Oba, Cd was below detection level at all soil layers of the profile. A similar situation was noticed for Agodi where Cd was measured to be 0.85mg/kg at the depth of 45-60cm while it was below detection limit at all the upper depths (Adelekan and Alawode, 2011).

Study at Enyimba Dumpsite in Aba, Southeastern Nigeria the concentration of cadmium ranges from 0.18-2.60mg/kg with a mean concentration of 1.40mg/kg. Chromium concentration ranges from 0.02-2.78mg/kg with a mean value of 1.34mg/kg. The results show that lead concentration deposited at the dumpsite ranged 0.24-2.15mg/kg with a mean concentration of 1.08 mg/kg (Akobundu and Nwankwoala, 2013).

2.3. Geoaccumulation Pollution Index

An index of geo-accumulation (I_{geo}) was originally defined by Müller in order to determine and define metal contamination in sediments Banat *et al*. (Qingjie *et al*., 2008), also used the comparison current concentrations with pre-industrial levels. It shows quantitative measure of the extent of metal pollution in the studied soil. It can be calculated by the following equation.

$$I_{geo}=\log_2 [C_i/ (1.5C_{ri})]$$

Where C_i is the measured concentration of the examined metal in the soil and C_{ri} is the geochemical background concentration or reference value of the metal i. Factor 1.5 is used because of possible variations in background values for a given metal in the environment as well as very small anthropogenic influences. The pre-industrial or reference level determined from typical mean for background concentration mg/kg of trace element in surface soil for Cd, Cr and Pb are 0.25mg/kg, 60mg/kg and 20mg/kg respectively (Ward, 1995).

The geo-accumulation index (I_{geo}) was distinguished into seven classes by Müller (1979): $I_{geo}\leq 0$, class 0, unpolluted; $0<I_{geo}\leq 1$, class 1, from unpolluted to moderately polluted; $1<I_{geo}\leq 2$, class 2, moderately polluted; $2<I_{geo}\leq 3$, class 3, from moderately to strongly polluted; $3<I_{geo}\leq 4$, class 4, strongly polluted; $4<I_{geo}\leq 5$, class 5, from strongly to extremely polluted; and $I_{geo}>5$, class 6, extremely polluted.

The geo-accumulation index classification of soil at Enyimba Dumpsite in Aba, Southeastern Nigeria indicate that Moderately contaminated for Cd (1.828), Uncontaminated for Cr(-4.920) and Uncontaminated for Pb (-3.101) (Akobundu and Nwankwoala, 2013).

The degree of pollution of the refuse dumps by the metals was assessed using the I_{geo} classification by Förstner *et al*. (1993). ACCRA dump site I_{geo} of heavy metals are Cd (2.40) moderately to strong, Pb (0.54) uncontaminated to moderate and Cr (0.30) uncontaminated to moderate. KUMASI dump site I_{geo} of heavy metals are Cd (2.06) moderate to strong, Pb (0.97) uncontaminated to moderate and Cr (-0.30) practically uncontaminated. MAMPONG dump site I_{geo} of heavy metals are Cd (2.06) moderate to strong, Pb (0.82) uncontaminated to moderate and Cr (-0.14) practically uncontaminated**.** ADIDWAN dump site I_{geo} of heavy metals are Cd (1.57) moderate, Pb (0.15) uncontaminated to moderate and Cr (-0.45) practically uncontaminated (Agyarko et al., 2010).

The Central Jordan geoaccumulation indices of Pb, Cr, Cd, Zn, and Hg were 0.32, <0, 2, 0.01, and 0.42, respectively. This indicates that the soils are classified as uncontaminated to moderately contaminated with Pb, uncontaminated with Cr, moderately contaminated with Cd, uncontaminated to moderately contaminated with Zn, and uncontaminated to moderately contaminated with Hg (Banat *et al*., 2005).

The other study in Manori core shows that all the metals fall within Class 1 and Class 2. This suggests that the mangrove sediments of Manori creek are moderately polluted with Pb and Cu while unpolluted with respect to the remaining metals. From the values of I_{geo} calculated, vehicular traffic in the populated stretch of this creek as well as mechanized boats for fishing may have led to the emission of Pb and its deposition at local scale (Fernandes *et al*., 2012).

According to Chakravarty and Patgiri (2009) the I_{geo} values on their study based on the world surface rock abundance. It is evident that the I_{geo} values for Al, Fe, Ti, Mn, Zn, ***Cr*** and Ni fall in class '0' in all the five sampling locations indicating that there is no pollution from these metals in the Dikrong river sediments. The I_{geo} values of Pb fall in the range 0-1, while those in case of Cu have an almost uniform I_{geo} value of about 2. This suggests negligible pollution from Pb, whereas in case of Cu, the I_{geo} values seem to be influenced.

The degree of pollution in sediments (Nigeria)can be assessed by the determination of indices such as geo-accumulation Index (I_{geo}). Based on the study I_{geo} values for Pb shows that 56.67% of the samples fall in the uncontaminated class (≤0), 36.67% in the uncontaminated–moderately contaminated class (0-1), while the remaining 6.67% are moderately contaminated (1-2). I_{geo} values ≤0 (uncontaminated) for Cu, Cr, Zn, Ni, and Cd accounted for 63.33%, 93.33%, 20%, 26.67%, and 53.33% of the total values respectively. The I_{geo} values for uncontaminated– moderately contaminated are 13.33%, 6.67%, 63.33%, 56.67%, and 40% for Cu, Cr, Zn, Ni, and Cd respectively (Yisa *et al*., 2012).

The average I_{geo} for the observed metals were in the decreasing order of Ni (0.55) > Zn (0.45) > Cu (0.29) > Cd (0.15) > Pb (-0.17) > Cr (-0.46). This implies that Ni, Zn, Cu, and Cd unpolluted – moderately polluted the RDSs (*Nigeria)* while Pb and Cr did not pollute the RDSs. No Igeo value was greater than 4 (i.e. heavily – extremely contaminated), and only two values Cu (3.55) at M5, and Cu (3.12) at J21 are in the heavily contaminated class (Yisa *et al*., 2012).

The concentration of Mn, Ni, Pd, Cu and Cd in Tigris sediments observed in this study ranging between 166-426, 6-30, 7-90,5-55 and 0.3-1.3μg/g dry weight sediment respectively. The I_{geo} grades for this study area sediments varies from metal to metal and site to site (across metals and sites). The I_{geo} for Pb and Cd attain grade 0 in station 1 and station 2 (unpolluted), while, attain in grade 1 in other stations which indicates that sediments of these stations were slightly polluted by Pb and Cd (Rabee *et al*., 2011).

The I_{geo} showed that all heavy metals are in grade 0 and grade 1. This suggests that the sediments of Tigris river are having background concentrations for Mn, Cu, and Ni, and these elements are practically unchanged by anthropogenic influences, while the concentration of Pb and Cd exceeded the average shale value (Rabee *et al,* 2011) .

Apparently, the soil of the studying area (soil around the cement factory) could be classified as moderately to heavily contaminated with (As, Cd, Pb and Ni) and heavily contaminated with Cr, while the studying soil were moderately polluted with Zn (based on the geo-accumulation index). The most contaminated sites were situated in the 0 to 1000 m far from the cement (Al-Omran *et al*., 2011*).*

3. OBJECTIVE

3.1. General Objective

- The General Objective of the Study is to determine the pollution of soil by Heavy Metals and its Physicochemical Properties around Adama City Administration Solid Waste Disposal Sites

3.2. Specific Objectives

- To describe physicochemical properties of soil found around disposal site
- To determine heavy metal concentration in the soil of disposal site
- To evaluate the extent of heavy metal pollution of soil

4. METHODS AND MATERIALS

4.1. Description of the Study Area and Period

Adama (Nazreth) is found within the Wonji Fault Belt, which is one of the main structural systems in the Ethiopian Rift Valley. The city is one of the rapidly growing City of Ethiopia and is located at 9.13^0-9.36^0N & 40.13^0 E- 40.60^0 E at elevation of 1712m in Oromia Region. It is about 100kms southeast of Addis Ababa high way to Harar. The Mean monthly average temperature ranges from 19.33°c to 23.54°c. The mean annual rainfall or periciptation is 72.67cm. Adama has three types of soil: andosols, fluvisols and lithosols. The dominant type is mollic andosols (Tefera, 2010).

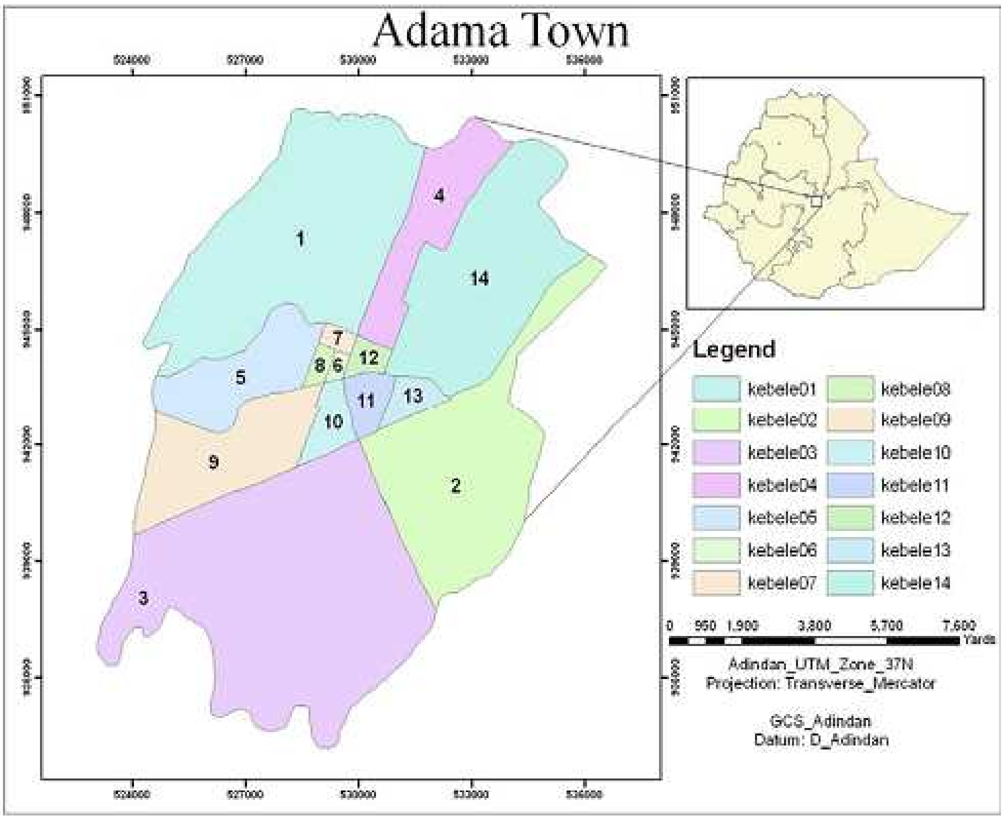

Figure 6: The Map of Adama; the disposal site found in kebebe 09 (NUPI, 2005).

The composition of solid waste in Adama constitute food wastes constitute 37.8 % of the total household wastes by weight. Next to food wastes, ash/dust accounts for (36.2 %) in Adama town. The least solid wastes in terms of weight are rubber, leather and metal wastes constituting only 6%, 0.1% and 0.2% in weight, respectively. High proportion of the households waste (60.5 %) is easily decomposable. According to this study the percapita waste generation is on average 0.15kg/cap/day (Lemma, 2007) but in Tolina (2006) study 0.271kg/cap/day. This doesn not consider the industrial waste.

This study was conducted in Adama (Nazreth) City Administration solid waste disposal sites from March 09/2013 to March 27/2013. There are two disposal sites which are found in kebele 09 (figure 1). The 20 year old one named Qobbo Luxo which is not functional with the area of 3,008m^2 and the new one now functional named as Jogo Dedo which started before 4 years with area of 1, 985m^2. The old disposal site, located 8 km away from the center of the city towards west on the road from Adama to Addis Ababa. The new one is about 15km from the center of the city and 3km from the main road to Addis Ababa as well as situated near the Adama wind electrical power generation station a place.

4.2. Study Design and Sampling Site

The crossectional study was conducted in dry season (March) at Adama solid waste disposal site. The Qobbo Luxo disposal site is surrounded by scattered tree in south east direction, road in west, cattle fattening in south and gully erosion in east direction (Figure 2). The Jogo Dedo dump site is surrounded by mountain in North and West direction. At the East nearby there is gully erosion and there is farm land in south direction (Figure 3). Gully erosion is pass nearby both disposal site.

The sampling location was selected by transect through simple random sampling method from around land in predefined distance toward gully erosion from disposal sites *(*USEPA, 1992*;* Carter and Gregorich, 2008*)*. The landscape around the disposal sites slope towards gully erosion based on GPS (model 72) elevation reading. The sampling location of altitude, longitude and latitude were determined by GPS 72 model and the map was drawn by using the coordinate.

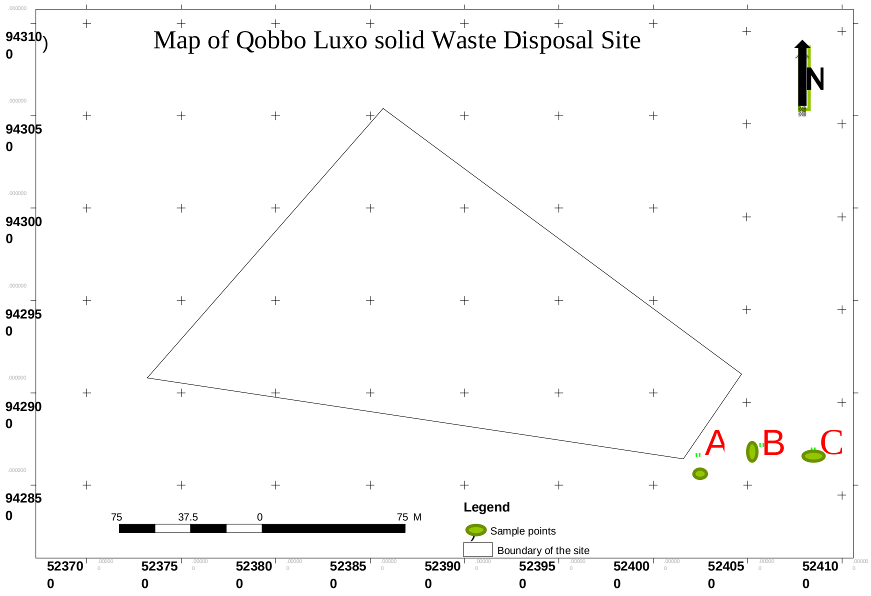

Figure 2: Map of sampling location for soil sample at Adama city Qobbo Luxo (closed) solid disposal site, 2013 (the letter A, B and C indicates sampling point)

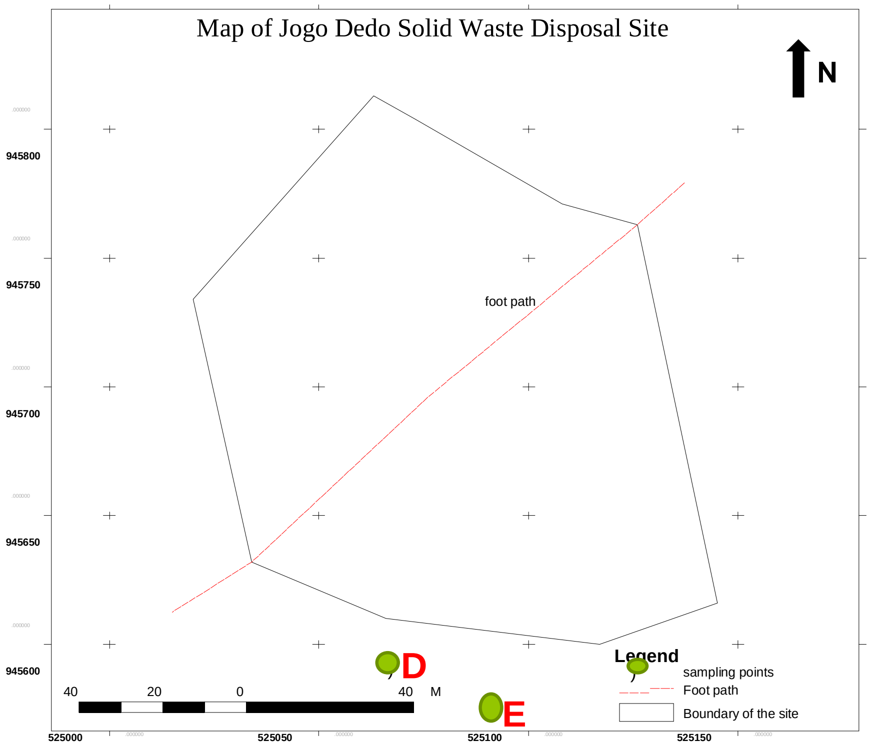

Figure 3: Map of sampling location for soil sample at Adama city Jogo Dedo solid disposal site(currently working), 2013 (the letter D and E indicates sampling point)

4.3. Soil Sample and Sampling Technique

For the Qobbo Luxo disposal site sampling points were taken at A (10m), B (30m) and C (60m) from periphery of disposal site in south east direction toward gully erosion (Figure.2).The sampling points were taken at D (10m) and E (30m) from periphery of Jogo Dedo disposal site to adjacent farm land in south direction (Figure.3). The depth-specific soil samples were taken at the depth of 5-20cm and 20-35cm from each pit fom each sampling point. A 5cm the top surface soil was removed from the sampling point because to prevent the effect of application of different chemical in agricultural land nearby the disposal sites *(*USEPA, 1992; Carter and Gregorich, 2008). There is no leachate around the disposal site so I rely on soil sample. A total of 12 soil samples were collected around solid waste disposal sites 6 from Qobbo Luxo, 4 from Jogo Dedo and 2 control soil sample were taken at 10km far from the disposal site in higher altitude. The detail for the field sampling code is explained in Annex.

The field data work was conducted from pre-determined Adama solid waste disposal sites. The total soil from the field were dug by stainless steel trowel including knife from pre-determined depth of 10cmx10cm size to have enough amount of soil. The dug soil was displayed on the disposable polyethylene plastic on the stainless steel tray for homogenization. The total amount of soil which were dug at field was 15cmx10cmx10cm (1500cm^3/ 1500gm). The quarter of total soil from the pit at specific depth (i.e. 375gm) were collected by high dense polyethylene bag and labeled accordingly. The collection materials were washed and air dried before sampling from next site. The samples were stored at 4^{0}C after collection and transported to City Government of Addis Ababa Environmental Protection Agency Laboratory within 3hours (USEPA, 1992; Carter and Gregorich, 2008).

4.4. Variables

4.4.1. Independent variables

Horizontal distance from the periphery of disposal site (10m, 30m and 60m)

Depth of the pit (5-20cm & 20-35cm)

4.4.2. Dependent variables

Physicochemical properties of soil (pH,EC, CEC and Soil Porosity)

Heavy metals concentration (Cr, Cd and Pb)

4.5. Sample Treatment and Analysis

The soil samples from the study area were subjected to Electrical Conductivity, pH, Soil porosity and Cation Exchange Capacity of soil properties as well as heavy metals concentration analysis. The air dried soil samples for 72 hours were disaggregated with mortar and pestle and finely powdered to 2mm mesh size using a swing grinding mill. After that the soil sample were thoroughly mixed to make the sample homogeneous. Soil samples were sieved to pass through 2mm were processed by coning and quartering to get representative sample.

The subsample of <2mm were used for parameters analysis (Van Reeuwijk, 2002). The pH was measured with pH meter model 3510 by using a glass electrode. The Electric Conductivity (EC) was analyzed by extracts of 1:2.5 soil-to-water extraction methods and the extract was measured by model 4510 EC meter (Van Reeuwijk, 2002). Soil cation exchange capacity was determined by ammonium acetate method. Porosity was measured by placing an oven-dry soil core in a pan of water until all of the empty pore space is filled with water. An aqua regia method (concentrated HCl and HNO_3) was used for heavy metals extraction based on USEPA method3051a. The concentration of soil heavy metals were measured by Graphite Furnace atomic absorption spectroscometer (AAS) model novAA400 Analytikjena. The detail procedure for each parameters is described in annex part.

Statistical Analysis

Statistical analysis was performed using the Microsoft Excel window, SPSS version20. Descriptive statistics were used to present different soil properties and heavy metals concentration. Kruskal-Wallis and Mann-Whitney U test were used to show the significance difference of heavy metals in different sample location with the probability of $P < 0.05$.

4.6. Data Quality Management

Material used for field sampling were made of stainless steel. Soil sample collection tools were cleaned prior to use and before shifting to the next site. Duplicate were done for the single soil sample test and the average was taken. Soil samples extractions and digestions were carried after 3days. This keeps the analyte in the resulting extraction phase thereby stabilizing the analyte. As a result, a sample extract can be held for a longer time, up to the maximum limits as specified by the method. Bias that occurs as a result of sub-sampling was improved by procedures such as grinding and homogenizing the original samples. Data verification was done after the data analyses were completed. Measuring equipment was calibrated by using standard solution and calibration curve was also drawn. Detection limit of Graphite AAS was determined for heavy metals analysis. The instrument was calibrated using standard solutions of Cadmium, Chromium and Lead based on the known amount of prepared solution for each heavy metals The collection, handling and preservation of soil samples were done based on Soil Sampling Quality Assurance User's Guide (USEPA, 1989).

4.7. Ethical Consideration

Ethical approval was obtained from Ethical Clearance Committee of Jimma University; informed permission was obtained from Adama City Administration Municipality and farmers nearby the disposal sites.

4.8. Dissemination Plan

The finding of this study was disseminated to Jimma University College of Public Health and Medical Sciences community based education office, Department of Environmental Health Sciences & Technology and Adama City Administration Municipality. Further attempt will be made to publish it on National or International Environmental Journals.

4.9. Limitation of the Study

Some of the limitations are lack of adequate background information regarding to the disposal site. The finding doesnot represent the rainy season.

4.9. Calibration

The calibration curve and linear regression of the metals were prepared from the absorbance and concentration of standard solution by using origin 7 computer software. The calibration curve equation was used to check the accuracy of the instrument, the concentration of heavy metals in the sample whether in the given range or not, and to cross check the concentration measured by instrument.

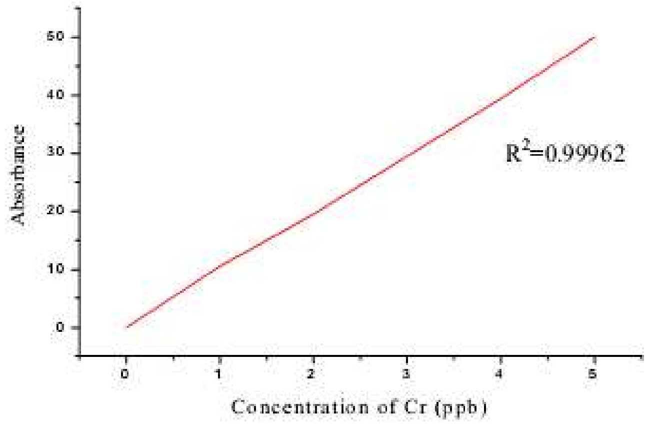

Figure 4: Calibration curve for standards solution of Cr using GAAS

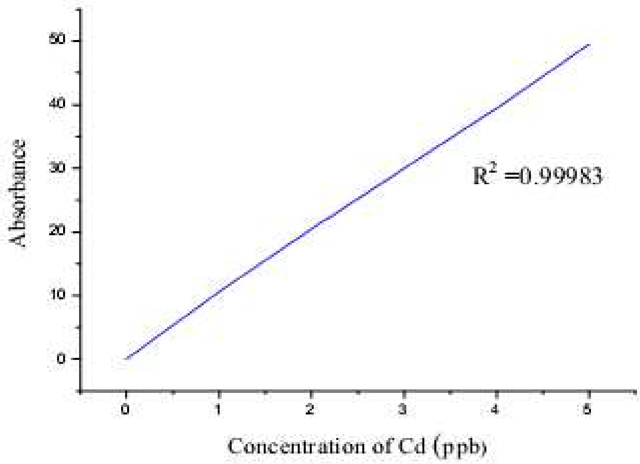

Figure 5: Calibration curve for standards solution of Cd using GAAS

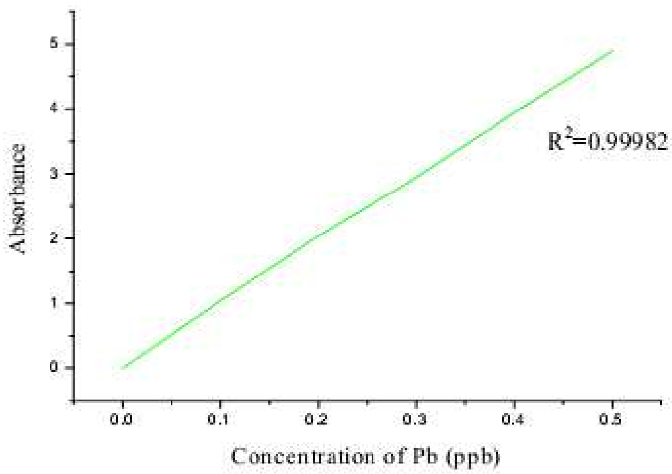

Figure 6: Calibration curve for standards solution of Pb using GAAS

5. RESULT

5.1. Physicochemical Properties

The soil samples were collected from two Adama city solid waste disposal sites. The samples were taken from downstream direction towards gully erosion. The two depth soil samples were taken at 3 points (A, B and C) in Qobbo Luxo and 2 points (D and E) in Jogo Dedo disposal sites with two depth interval 5-20cm and 20-35cm. The soil samples were analyzed for different physicochemical parameters like pH, EC, CEC and Soil porosity as well as Cd, Cr and Pb concentration for the two solid waste disposal sites which exist for about 4 years (Jogo Dedo disposal site) and 20 years (Qobbo Luxo disposal site). The 4 years one is active (currently working) and the 20 years old one is now closed.

In the Qobbo Luxo disposal site the EC, CEC, pH and soil porosity ranges from 0.03-0.21ms/cm, 15-30 meq/kg soil, 7.46-8.08 and 50-53.94% respectively. The mean of CEC at Qobbo Luxo disposal site is 23.17±4.96 meq/kg but the mean value of EC is 0.12±0.075 ms/cm (Table 6).

For the Jogo Dedo disposal site the EC, CEC, pH and soil porosity ranges from 0.08-0.23ms/cm, 17-32 meq/kg soil, 7.81-8.13 and 47.43-55.11% respectively. The mean value of CEC at Jogo Dedo disposal site is 25±7.09 meq/kg and the mean value for EC is 0.13±0.066ms/cm (Table 6).

Figure 6: Electric Conductivity and Cation Exchange Capacity of soil around two Adama city solid waste disposal sites in relation with the respective horizontal distance and soil profile, 2013

Disposal Site	Distance (m)	Depth (cm)	EC (ms/cm)	CEC (meq/kg soil)
Qobbo Luxo	10 (A)	5-20	0.03	15
		20-35	0.13	24
	30 (B)	5-20	0.05	25
		20-35	0.10	21
	60 (C)	5-20	0.20	24
		20-35	0.21	30
	Mean± Standard deviation		0.12±0.075	23.17±4.96
Jogo Dedo	10 (D)	5-20	0.08	17
		20-35	0.11	32
	30 (E)	5-20	0.23	23
		20-35	0.11	31
	Mean± Standard deviation		0.13±0.066	25±7.09
	Control	5-20	0.1	25
		20-35	0.1	24

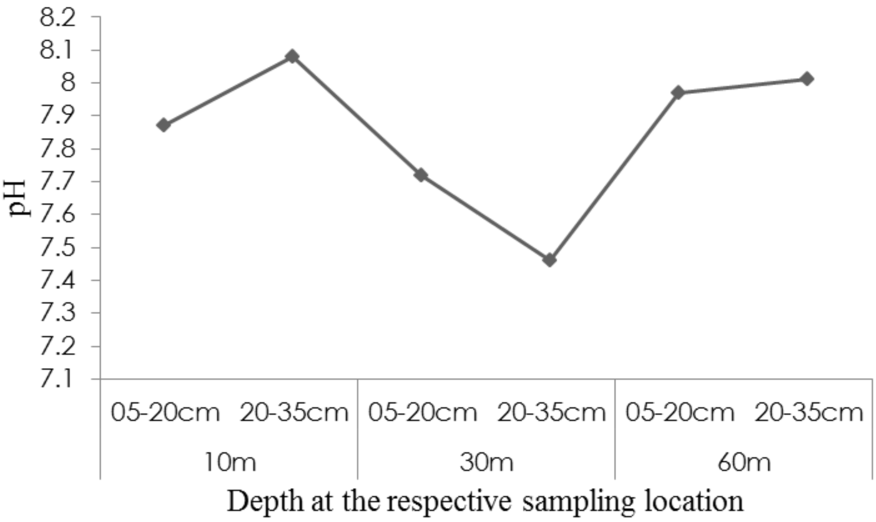

Figure 7: pH of soil around Qobbo Luxo solid waste disposal site at sampling location with respective soil depth, 2013.

The pH of soil at Qobbo Luxo disposal site is indicated in figure 7. It ranges from 7.46-8.08 with the mean value of 7.85±*0.23* which is slightly basic.

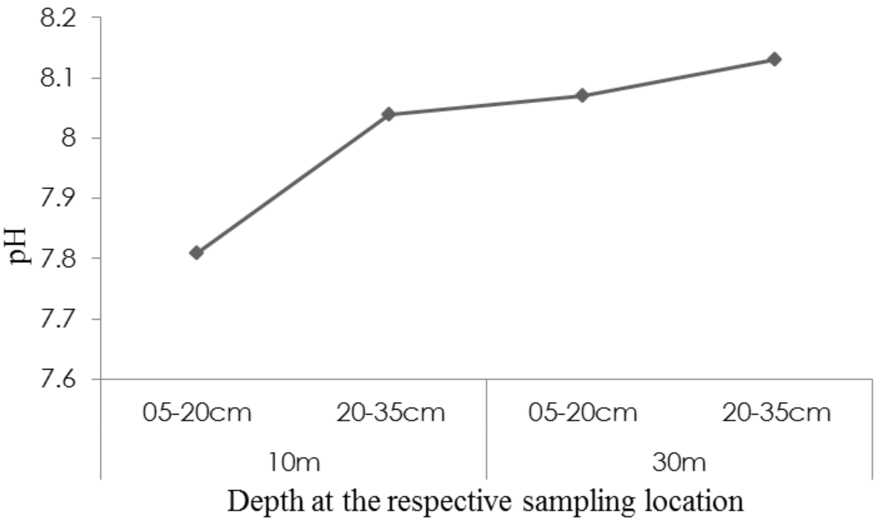

Figure 8: The pH of soil around Jogo Dedo solid waste disposal site at sampling location with respective soil depth, 2013

The pH of soil at Jogo Dedo disposal site is explained in above figure 8. It ranges from the 7.81-8.13 with the mean value of 8.01±*0.14* which is basic. The control soil sample pH are 8.42 at 5-20cm and 8.47 at 20-35cm.

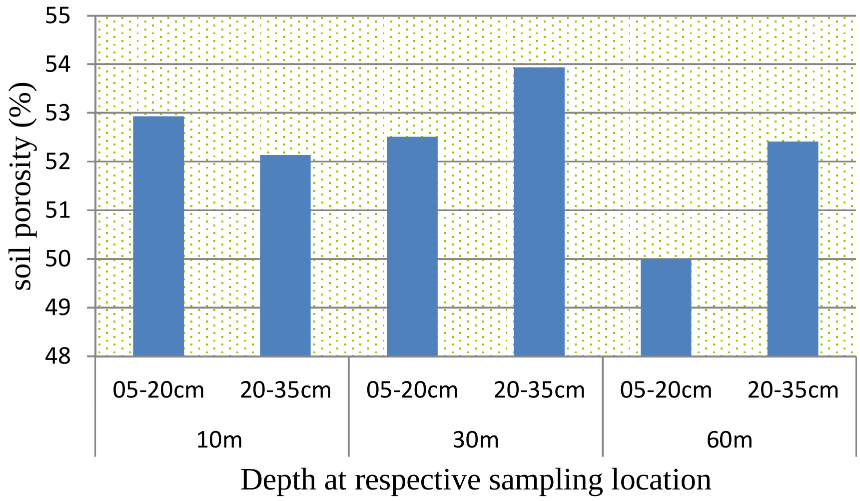

Figure 9: Soil porosity around Qobbo Luxo solid waste disposal site at a sampling location with respective depth, 2013

From the above figure 9 the average soil porosity at the Qobbo Luxo disposal site is 52.32% with the ranges 50-53.94%

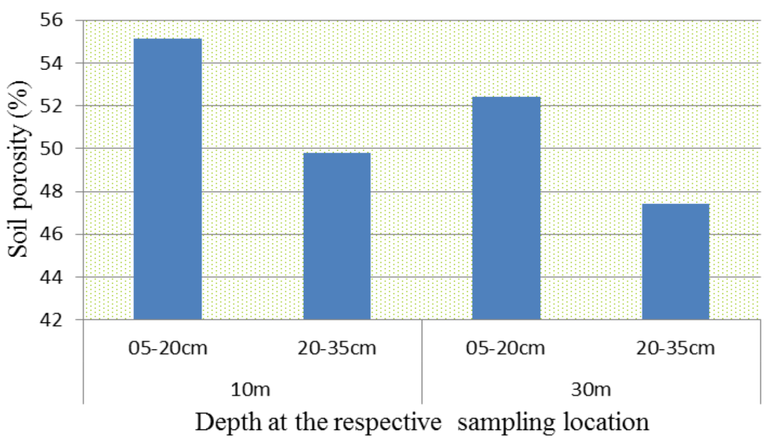

Figure 10: Soil porosity around Jogo Dedo solid waste disposal site at a sampling location with respective depth, 2013

From the above figure 10 average soil porosity at the Jogo Dedo disposal site is 51.19% with the ranges 47.43-55.11%. The control soil sample porosity are 53.1% (5-20cm) and 52.76% (20-35cm)

5.2. Heavy Metals Concentration

Level of heavy metals were determined in soil around the two Adama solid waste disposal sites are presented in Table 7. The concentration of Cd, Cr and Pb are different at different horizontal distance and at different depth.

Figure 7: Concentration Cd, Cr and Pb of soil around the two Adama city solid waste disposal sites in relation with the respective horizontal distance and vertical distance (depth), 2013

Disposal site	Sampling location	Depth (cm)	Concentration (ppm)		
			Cd	Cr	Pb
	10m	5-20	0.10	11.99	1.15
		20-35	3.67	16.25	1.68
	Mean		1.93	14.12	1.42
	30m	5-20	0.15	14.37	1.13
Qobbo Luxo		20-35	2.92	16.47	0.76
	Mean		1.54	15.42	0.96
	60m	5-20	0.42	14.76	0.76
		20-35	0.12	16.98	1.33
	Mean		0.27	15.87	1.05
	10m	5-20	2.49	12.44	0.08
		20-35	0.16	16.53	1.58
Jogo Dedo	Mean		1.33	14.49	0.83
	30m	5-20	2.00	11.66	1.19
		20-35	0.14	16.56	2.05
	Mean		1.07	14.11	1.62
Control		5-20	0.07	9.03	0.45

	20-35	0.15	10.05	0.92
Mean		0.11	9.54	0.685

Table 7 represents the concentration of heavy metals Cd, Cr and Pb in soil nearby Qobbo Luxo and Jogo Dedo disposal sites at different sampling location. The concentration of heavy different at different sampling location.

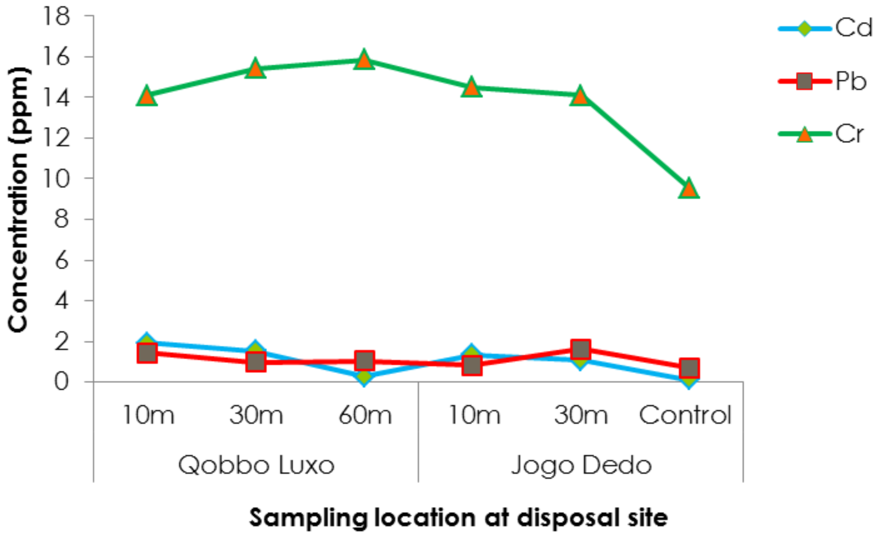

Figure 11: The average concentration of heavy metals in the soil profile (pit average) in both disposal sites at sampling location and its control, 2013

The average value of soil profile of heavy metals was described in figure 11 that illustrates the trend against horizontal distance from the disposal site. The total average surface concentration of heavy metal at Qobbo Luxo for Cd (0.2233ppm), for Cr (13.7066ppm) and for Pb (1.0133ppm) as well as at Jogo Dedo for Cd (2.245ppm), for Cr **(**12.05ppm) and for Pb (0.635ppm).

5.3. Geoaccumulation Pollution Index

The Geo-accumulation index consists of seven grades ranging from unpolluted to very extremely polluted. Table 8 presents the geo-accumulation index for the quantification of heavy metal accumulation in the study area which describes the degree of soil pollution.

Table 1: The calculated geo-accumulation index (I_{geo}) and grade of pollution intensity of heavy metals in soil for depth concentration around Adama city solid waste disposal sites, 2013

Sampling Location	Depth (cm)	I_{geo} value			Pollution Intensity		
		Cd	Cr	Pb	Cd	Cr	Pb
A*	05 -20	0.08	0.04	0.01	1	1	1
	20-35	2.98	0.05	0.02	3	1	1
B*	05-20	0.12	0.05	0.01	1	1	1
	20-35	2.34	0.06	0.008	3	1	1
C*	05-20	0.34	0.05	0.008	1	1	1
	20-35	0.096	0.06	0.01	1	1	1
D**	05-20	1.998	0.04	0.0008	2	1	1
	20-35	0.13	0.06	0.02	1	1	1
E**	05-20	1.61	0.04	0.01	2	1	1
	20-35	0.11	0.06	0.02	1	1	1
Control	05-20	0.06	0.03	0.004	1	1	1
	20-35	0.12	0.03	0.009	1	1	1

*Sampling location from Qobbo Luxo disposal site within A (10m), B (30m) and C (60m)

** Sampling location from Jogo Dedo disposal site within D (10m) and E(30m)

1= unpolluted to moderately polluted, 2=moderately polluted and 3=moderately to strongly polluted

Figure 9: The calculated geo-accumulation Igeo and grade pollution intensity of heavy metals of soil for average pit (soil profile) concentration around Adama city solid waste disposal sites, 2013

Sampling Location	I_{geo} value			Pollution Intensity		
	Cd	Cr	Pb	Cd	Cr	Pb
A*	1.55	0.05	0.014	2	1	1
B*	1.24	0.052	0.0096	2	2	2
C*	0.22	0.053	0.01	1	1	1
D**	1.07	0.06	0.0083	2	1	1
E**	0.86	0.05	0.02	1	1	1
Control	0.080	0.03	0.007	1	1	1

*Sampling location from Qobbo Luxo disposal site within A (10m), B (30m) and C (60m)

** Sampling location from Jogo Dedo disposal site within D (10m) and E(30m)

1= unpolluted to moderately polluted, 2=moderately polluted and 3=moderately to strongly polluted

Table 9 describes degree of soil pollution of heavy metals unpolluted to moderately polluted for the average soil profile concentration except Cd which showed moderately polluted. The pollution intensity and calculated geo-accumulation index of total surface average concentration for horizontal distribution of Cd (0.18), Cr (0.05) and Pb (0.01) in Qobbo Luxo disposal site that showed unpolluted to moderately polluted soil. For the Jogo Dedo disposal site Cd (1.8), Cr (0.04) and Pb (0.007) that showed unpolluted to moderately polluted soil for Cr and Pb except Cd which is moderately polluted.

6. DISCUSSION

6.1. pH, CEC and EC of Soil

Soil samples were analysed for physicochemical properties of soil and heavy metals concentration. The pH of soil at Qobbo Luxo and Jogo Dedo disposal sites range from the 7.46-8.08 with the mean value of 7.85±0.23 and 7.81-8.13 with the mean value of 8.01±0.14 respectively, which is slightly basic in Qobbo and basic in Jogo disposal site. This value agree with the soil of Akouedo landfill is a reducer medium with a pH ranging from 7.24 and 8.70 (Kouame *et al.*, 2010). But much more greater than soils at the vicinity of Ampar Tenang site (ATS) were characterized by acidic soil (pH; 2.44 and 3.01) (Bahaa-Eldin *et al.*, 2008). The study at municipal refuse dumpsites in Ibadan, Nigeria, also reveal that the soils were slightly acidic (pH; 5.3 to 6.2). There is slight differences throughout the depth in all dump sites (Adelekan and Alawode, 2011).

In both disposal sites in this study have slightly increases from the surface to depth but no fixed pattern in Qobbo Luxo site. This condition is not similar with the soils in the vicinity of Ampar Tenang site, which showed a slight decrease from the surface to a depth of 70cm and then pH remained unchanged. A study was conducted by Ideriah *et al*. (2010) in different direction in solid waste dump site is also reveals different finding which are acidic except few sampling site that is neutral. Abdus-Salam (2009) describes in Nigeria Ilorin Metropolis different dump sites the active one (exhibit neutral to slightly basic pH) agree with this study but old site (exhibit slightly acidic pH) disagree.

When comparing the pH values of the two disposal sites the Qobbo Luxo (old one) is the slightly lower i.e. slightly basic (7.85) than the Jogo Dedo (active site) i.e. basic (8.01). The study was conducted in Addis Ababa disposal site slightly basic with pH value of 8.17±0.95 in the dumps site and 7.37±0.37 in the grazing land (Beyene and Banerjee, 2011). This show the pH value of Qobbo Luxo disposal site is similar with grazing land nearby dump site Addis Ababa and the Jogo Dedo disposal site is similar with disposal site.

The difference may be due to the age of the disposal site and constitutes of waste among this study as well as the Addis Ababa. The study at Owerri Municipal is in Imo State of Nigeria at different disposal site reveal condition of acidity which are different from the present study (Ubuoh *et al*., 2012).

In the Qobbo Luxo disposal site the CEC ranges from 15-30meq/kg soil with mean of 23.17±4.96meq/kg soil. For the Jogo Dedo disposal site the CEC ranges from 17-32meq/kg soil with the mean value is 25±7.09. The result in both disposal sites are much less than many studies some of them are the Ampar Tenang site samples are characterized by a cation exchange capacity of 14.32meq/100g (Bahaa-Eldin *et al.*, 2008). The Effective Cation Exchange Capacity (ECEC) was 64.34mol kg^{-1} in the study was conducted by Beyene and Banerjee (2011). The soil cation exchange capacities for the three dumps were found to have increased above the control sites at all three horizons it ranges 8.259-49.497meq/100g (Ubuoh *et al*., 2012). The difference may be due dry environmental conduction detorerates the CEC of the soil, difference in the soil properties and study period.

The EC of soil at Addis Ababa area dump site and grazing land nearby are much more greater than this study (Beyene and Banerjee, 2011). The difference may be due study period and nature soil. The mean value of the disposal area are 0.12±0.075ms/cm for Qobbo Luxo disposal site and 0.13±0.066ms/cm for Jogo Dedo disposal site. The two results almost the same this shows there is no difference in both disposal sites. This may be due similarity of soil in both disposal site. The control soil sample had similar with the soil sample nearby disposal sites.

6.2. Heavy Metals Concentration

The heavy concentration of Cd, Cr and Pb in the two disposal sites were determined by taking soil sampling land toward gully erosion. Heavy metals were also analyised to determine the degree of soil pollution.

6.2.1. Cadmium

Cd is one of the heavy metal which was analyised along the horizontal distance and vertical depth. The concentration of Cd increase along the depth of 5-20cm and 20-35cm in Qobbo Luxo site but decrease in Jogo Dedo site. The result of Qobbo Luxo agree with similar study was conducted by Adelekan and Alawode (2011) that shows increment in soil profile at Agodi dump site and Challenge dump site. The Jogo Dedo disposal site had the similar result with Ijokodo, Dugbe and Olorunsogo dump site which shows decreasing concentration in soil profile (Adelekan and Alawode, 2011). This difference in concentration against depth may be do to porosity.

The Qobbo Luxo disposal site agree with the study was conducted in Abakaliki, southeastern Nigeria that explain increment of Cd concentration along the depth. According to the study Abandon mechanic site the depth concentration of Cd is 0-20cm, 20-40cm, 40-60cm and 60-80cm are 0.75Mg/kg, 0.70Mg/kg, 1.20Mg/kg and 1.55Mg/kg respectively but on non-mechanic site is a concentration of 0.60Mg/kg, 0.55Mg/kg, 0.95Mg/kg and 0.70Mg/kg (Njoku and Ngene, 2012). The concentration has greater than present study. The concentration of Cd in control soil is less than all soil sample and its average values.

When come to the average concentration of Cd soil profile decreases toward gully erosion from periphery of both disposal sites. The sites are no significantly different ($p=0.275$ for Qobbo Luxo & $p=0.121$ for Jogo Dedo) according to kruskal-Wallis test. This result supported by study conduct in Alexandria, in El-Montaza and Abis dump sites in different direction. But the concentration in this study is less than the Alexandria one (Abdel-Monem *et al*., 2011). The difference may be due differences in study period or different in soil properties. Other similar study in Ivory Coast reveal that Cd, the average concentration is higher at nearest sapling point that is significalt different (Kouame *et al*., 2010). This shows the land disposal of solid waste can increase the of concentration of heavy metals nearby lands.

The average contents pit of Cd in this study sites is less than the study conducted by Njoku and Ngene (2012) with concentration abandon mechanic site ($1.05MgKg^{-1}$) and non-mechanic site

(0.70MgKg^{-1}). The concentration of Cd obtained at Reppi solid waste dump site and nearby grazing land are more than the this study may due the age disposal site and the constitutes of MSW enter in to the landfill in Rappi contain more industrial than Adama (Beyene and Banerjee, 2011). The ranges of mean concentration of Cd in Road deposited sediments (RDS-Nigeria) is 13.33-29.38mg/Kg (Yisa *et al*., 2012). This is much more than result in both disposal sites; may be due Cd releasing material along the road.

The total average surface concentration of Cd at Qobbo Luxo for Cd (0.2233ppm) and Jogo Dedo for Cd (2.245ppm). This finding at Qobbo Luxo is less than study at Enyimba Dumpsite (Cd= 1.40mg/Kg) but the Jogo Dedo one is greater (Akobundu and Nwankwoala, 2013).

6.2.2. Lead

The concentration of Pb in two disposal sites increase in depth in different sampling location but in Jogo Dedo site almost double in 20-35cm than 5-20cm are 1.58ppm and 0.08ppm respectively within 10m. The result of this site agree with the finding on the which shows less concentration than present study but it increase along the soil profile (Ideriah *et al*., 2010). This may be due to creeps of Pb bottom layer especially pH at upper layer favor for availability of for leaching. The concentration of Pb in control soil is less than all soil sample and its average values.

The concentration of Pb in Qobbo Luxo site indicated that the concentration show difference along the depth but no in fixed pattern. The differences depends on the slight differences on soil pH. The Qobbo Luxo site reveal similar result with Pb concentrations showed a slight fluctuation in surface depth according to study (Marzieh *et al*., 2010). Similar study in Nigeria also support slight decreasing and increasing scenario of Pb in different depth; 0-20cm (28.94Mg/kg), 20-40cm (35.50Mg/kg), 40-60cm (28.90Mg/kg), 60-80cm (33.10Mg/kg) at Abandon mechanic site and 0-20cm (17.84Mg/kg), 20-40cm (6.20Mg/kg), 40-60cm (12.35Mg/kg) and 60-80cm (19.85Mg/kg) at non-mechanic site (Njoku and Ngene, 2012).

The concentration of Pb in this study is less than from different similar study that shows 42.9-1833.5 mg/kg in India, 280ppm in Ivory Coast and 17-852ppm & 67-271 ppm in Addis Ababa (Parth *et al*., 2011; Kouassi *et al*., 2010; Beyene and Banerjee, 2011). The difference is due to quantity and constitute of Municipal solid waste that contains Pb contents as well as the site may be nearby urban road that can be sources of Pb from air deposition. The ranges of mean concentration of Pb in Road deposited sediments is 20.41-50.59mg/Kg (Yisa *et al*., 2012). This is much more than in both disposal site; may be difference study site road exposed for more Pb sources.

The soil profile mean concentration distribution of Pb decrease along the distance in Qobbo Luxo site except at distance of 60m which show high but increase in the Jogo Dedo site. But the difference stasstically insignificant according to Man-Whitney U and Kruskal Wallis test. In the present study the lead is show mobility but immobile in study by Kouassi *et al.*, (2010) because it highly retained by organic matter. The total surface mean concentration of Pb in Qobbo Luxo (Pb=1.033) is greater than Jogo Dedo (Pb=0.635) which is not stastically significance with a P value 0.05 based on Man-Whitney U and Kruskal Wallis test. Similar result revealed Abandon mechanic site recorded Pb pit mean of 31.63 Mg/Kg^{-1} than non-mechanic site were the content is $14.06MgKg^{-1}$ (Njoku and Ngene, 2012). The concentration on this study is less due to the constitutes of waste materials in disposal site and geological differences. The total surface concentration of Pb in present study at Qobbo Luxo disposal site in consistence with the study at Enyimba Dumpsite in Aba but inconsistence with Jogo Dedo site (Akobundu and Nwankwoala, 2013).

6.2.3. Chromium

The concentration of Cr slightly increased towards the depth in both disposal sites in all sampling locations table 7. The study was conducted by Adelekan and Alawode (2011) which shows fixed pattern in concentration in most of dumpsites regarding to depth in different sampling location does not consistence with finding of this study. The concentration difference in present study along depth may be due to the pH of the soil that make favourable condition for mobility (Parth *et a*l., 2011). The porosity & EC also support mobility of Cr. The total average surface concentration of Cr at Qobbo Luxo site (Cr=13.71ppm) is greater than Jogo Dedo site (Cr=12ppm). This concentration is much more greater than study at Enyimba Dump site in Nigeria (Cr=1.34 mg/kg). This need attention for the remedial action in resent disposal sites (Akobundu and Nwankwoala, 2013).

The average soil profile value shows slight difference in Qobbo Luxo site at 10m (Cr=14.12ppm), 30m (Cr=15.42ppm) and 60m (15.87ppm) but almost the same in Jogo Dedo site. The difference is stastistically insignificant (p=0.248) according to Mann-Whitney U test. This result disagree similar study in Abis dump site (Alexandria); to the dumpsite, the highest levels of metals relative to all other sites (i.e. Cr =10.20μg m^{-3}**)** ; the other in 200m, east the dumpsite the average concentration of Cr=9.10μg m^{-3}. In El-Montaza dump site (Alexandria); the average concentration of Cr=10.65μg m^{-3} in close to dumpsite and Cr=8.65 μg m^{-3} in 200 m, southeast the dump site (Abdel-Monem *et al*., 2011). The content of Cr in this study much more less than the concentration of Cr obtained at Reppi solid waste dump site in different sampling points are 157 ppm, 561 ppm, 185 ppm and 70 ppm for Cr; as well as on grazing land 46ppm and 513 ppm for Cr (Beyene and Banerjee, 2011).

The ranges of mean concentration of Cr in Road deposited sediments (RDS-Nigeria) is 12.34-21.82 mg/Kg (Yisa *et al*., 2012). This is agree with result in Qobbo Luxo and Jogo Dedo disposal sites. Even though it is less when compare to different study, it is much more than the typical least normal range for background concentration according to Alloway (1990). The concentration of Cr in control soil is less than all soil sample and its average values.

6.3. Geoaccumulation Pollution Index (I_{geo})

The I_{geo} grades that shows the pollution intensity for the study soil varies from metal to metal and site to site. Table 8 presents, Geo-accumulation indices for the depth sample of the Cr and

Pb shows the pollution status unpolluted to moderately polluted for all soil sample in both disposal sites. For the Cd six soil sample shows from unpolluted to moderately polluted four in Qobbo Luxo site and 2 in Jogo Dedo site. Cd also shows moderately polluted to strongly polluted in 2 soil sample for Qobbo Luxo site and 2 moderately polluted for Jogo Dedo site. The result in the Central Jordan geoaccumulation indices of Pb, Cr and Cd were 0.32, <0 and 2 respectively. This indicates that the soils are classified as uncontaminated to moderately contaminated with Pb, uncontaminated with Cr, moderately contaminated with Cd (Banat *et al*., 2005) have consistence with Pb and Cd but not Cr which unpolluted to moderately polluted.

The degree of pollution in sediments (Nigeria) study Igeo values for Pb shows that 56.67% of the samples fall in the uncontaminated class (≤0), 36.67% in the uncontaminated–moderately contaminated class (0-1), while the remaining 6.67% are moderately contaminated (1-2). Only 36.67% consistence with this study regarding to Pb. But not consistence with Cr which most of site were uncontaminated and Cd was about half sample have shown uncontaminated soil (Yisa *et al*., 2012).

In table 9 Qobbo Luxo site geo accumulation indices for average concentration for the depth at 10m and 30m shows moderately polluted for Cd but unpolluted to moderately for Cd, Cr and Pb in all the rest sampling location. For Jogo Dedo site geo accumulation indice show moderately polluted for Cd at 10m and unpolluted to moderately for Cd, Cr and Pb in all the rest sampling location.

Qobbo Luxo site geo accumulation indice for total surface average concentration shows that unpolluted to moderately polluted for all three heavy metals. The Jogo Dedo site shows unpolluted to moderately polluted for the Cr and Pb but moderately polluted to Cd. Study on the mangrove sediments of Manori creek are moderately polluted with Pb does not consistence show with Pb pollution classification of soil (Fernandes *et al,* 2012).

But the I_{geo} values of Pb in the Dikrong river sediments fall in the range 0-1, This suggests negligible pollution from Pb (Chakravarty and Patgiri, 2009). This shows that the Pb pollution which is unpolluted to moderately polluted both sites have drawn due attention for environmental pollution concern. The study was conducted in Tigris the I_{geo} for Pb and Cd attain grade 0 in station 1 and station 2 (unpolluted), while, attain in grade 1 in other stations which indicates that sediments of these stations were slightly polluted by Pb and Cd (Rabee *et al*., 2011). The control soil sample had showed unpolluted to moderately polluted in both disposal sites but I_{geo} value is nearly zero for Cd, Cr and Pb in soil sample and their mean value.

The study was conducted in Ghana different solid waste dump sites compared as follows. The ACCRA dump site I_{geo} of heavy metals are Cd (2.40) moderately to strong, Pb (0.54) uncontaminated to moderate and Cr (0.30) uncontaminated to moderate. This result disagree for Cd, and agree for Cr and Pb in both disposal sites in this study. In KUMASI dump site I_{geo} of heavy metals are Cd (2.06) moderate to strong, Pb (0.97) uncontaminated to moderate and Cr (-0.30) practically uncontaminated. The degree of soil pollution regarding to Cd and Cr are disagreement but Pb is agree in both disposal sites in this study. The result of MAMPONG dump site I_{geo} of heavy metals are similar to KUMASI dump site but ADIDWAN dump site I_{geo} of heavy metals are disagreement with Cd for Qobbo Luxo site but agree with Jogo Dedo and disagreement to Cr for both site as well as agree with Pb (Agyarko *et al.,* 2010). The differences are due to difference in dump site in Ghana which includes rural as well as metropolitan city like Accra.

The soil around the Cement Factory could be classified as moderately to heavily contaminate with (Cd and Pb) and heavily contaminated with Cr. The most contaminated sites were situated in the 0 to 1000m far from the cement (Al-Omran *et al.*, 2011). The above study reveals quite different result than this regarding to all elements. The reason may be due different sources of pollution cement factory produce heavy metals by means of air droplet that causes deposition in soil.

7. Conclusion and Recommendation

7. 1. Conclusion

Generally, the mean value of pH, EC, CEC and soil porosity were 7.85±*0.23* , 0.12±0.075 ms/cm, 23.17±4.96 meq/kg and 52.32% respectively for Qobbo Luxo disposal site. For the Jogo Dedo site pH (8.01±*0.14*), EC (0.13±0.066ms/cm), CEC (25±7.09meq/kg) and Soil porosity (51.19%) respectively.

The contents of Cr, Cd and Pb increases along the depth almost in all sampling location at Qobbo Luxo disposal site and in Jogo Dedo disposal site the same trends was observed except Cd which shows decreasing trend. The average surface concentration greater at Qobbo Luxo disposal site.

The Geo-accumulation Index of average concentration of soil profile at Qobbo Luxo disposal site shows that the soil classification are unpolluted to moderately polluted by Cd, Cr and Pb in sampling location except Cd that shows moderately polluted at 10m and 30m. In Jogo Dedo disposal site the average soil profile concentration geo-accumulation index show that the soil classification is unpolluted to moderately polluted by Cd, Cr and Pb in all sampling location except Cd that show moderately polluted at 10m. The pollution status of soil have the same trends in disposal sites but the I_{geo} grades value higher in the Qobbo Luxo. The soil nearby Jogo Dedo have been at a risk of pollution if the waste disposal continues. The soil pollution classification order is Cd >Pb >Cr. The soil pollution degree is signal for the intervention to overcome nearby environmental compartment.

7.2. Recommendation

The Adama city municipality should construct sanitary landfill in Jogo Dedo site because most of soil sample shows unpolluted to moderately polluted as well as the concentration of heavy metals will likely increased due continues disposal of waste.

The Adama city municipality should create buffer zone around Jogo Dedo disposal site because the place is currently used for disposal of solid waste and the nearby land is used for agricultural purposes.

The waste pile from the old disposal site should be excavated to generate electric power and the land can be used for economic purposes

Remedial action especially phytoremediation should take place in closed site (Qobbo Luxo disposal site) because there may be possibility of leaching to seasonal gully erosion which joins to the Awash river.

Researcher should conduct further study on transfer of heavy metals to food chain and public health risk as well as seasonal variation of heavy metals.

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