Assesment Of The Concentration Of Selected Heavy Metals (Pb, Cu, Cd, Zn) In Soils Within The Nyambera Dumpsite

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ABSTRACT: Heavy metals are part of the soil, but at high concentration levels are considered toxic. With the current exponential population growth, urbanization, industrialization and advancement in agriculture has increased solid waste significantly over time. Due to lack of proper well-structured waste management systems, solid waste has been disposed in open dumpsite which lack any mechanism of control. Over time, due to accumulation-various heavy metals are introduced in the soils and end up being leached, carried away by surface-runoff or introduced to plants by farmers who rely on refuse (from the dumpsite) to plant their crops. This study was aimed at determining the concentration levels of Pb, Cu, Cd and Zn at the Nyambera dumpsite and compare their levels with the WHO recommendation levels for soils. Stratified random sampling was employed and soil samples collected on top of the dumpsites, the slope of the dumpsite and at the banks of river Nyakomisaro which flows adjacent to the dumpsite. Digestion was carried using concentrated hydrochloric acid then topped up to 100ml. Metal analysis was carried out using ICPOES. The results of Pb, Cu, Cd and Zn were as follows 91.31, 281.8, 3.253 and 542.3 ppm respectively. The concentrations were found to be very high at the dumpsite as compared to the recommended levels by WHO. Based on the results obtained the dumpsite should be treated with various remediation methods being applied to help lower the levels of these metals. Farmers using the refuse as manure for their crops should seek other alternatives for their farms.

Key Words: Oxidation, Corrosion, terrestrial, aquatic, Precipitation and Effluents

INTRODUCTION

Waste disposal has not only remained a serious health hazard but also a great menace towards environmental pollution in Kenyan towns and cities[1]. This is owed to the factors like high population densities, location, lack of proper waste management techniques and policies.. The mushrooming of new industries, the exponential use of chemicals in agricultural activities and the ever increasing traffic emissions are some of the major concerns facing Kisii town.

Most of the waste in the dumpsite is burned down which gets rid of the organic part of the materials leaving behind ashes rich in heavy metals. After the process of oxidation and corrosion these metals are dissolved in rain water (any other form of precipitation) or surface run off which results in leaching into the soil hence they are taken up by growing plant and ends up in the food chain. Others carried away by surface runoff ends up in the aquatic bodies hence taken in by aquatic animals. This poses a serious health conditions to humans and animals[2].

Solid wastes amongst all types of wastes poses a serious threat to life as it has the ability to pollute the terrestrial, aerial and aquatic environment. Recent studies have revealed that solid waste can transfer a significant amount of heavy metals to soils hence higher intake by plants [3]. By the action of farmers using fertile soils from the dumpsite they increase the rate of uptake of these toxic and persistent metals to plants. Since they are non-biodegradable they bioaccumalate in the body [4].

Effluents from various industries, chemicals from agricultural practices and emission from vehicles tend to introduce heavy metals in the soils and the surrounding environment of any dumpsite. Heavy metal pollution even at low levels and their resulting long term cumulative effects are among the leading health concerns all over the world [5].

For the last 50 years human infection by heavy metals has increased exponentially due to the increase in the of industrial and human activities which rely on heavy metals. The presence of these heavy metals in soils and foods poses a serious threat to socio-economic

well-being of man[4]. Apart from heavy metal poisoning dangerous diseases like cancer are also caused by the bioaccumulation of these metals.

Solid waste is produced as bulk bye product of normal and fundamental activities of living. They include kitchen refuse, medical waste, mining waste other industrial and agricultural waste. However, the solid waste differs in terms of concentration and variety. The amount produced by recent developments in agriculture and uncontrolled industrialization is staggering .additional factors like land scarcity have also contributed to exponential population growth hence and increased waste disposal.
Land has been for long used for waste disposal for a long time. The materials in solid waste interact chemically and physically with other existing environmental components but this solely depends on the nature, type of material and also the degree of exposure whereas these reactions are time dependent. Some of the recent waste disposal method include incineration, compositing and open dumpsite. The continuous dumping has introduced many substances to our environment which poses a serious hazard to our society e.g. heavy metals[6].
A heavy metal is metal of high density (specific gravity greater than about 5.0) or relative atom weight which includes metals and metalloids. They include chromium, arsenic, cadmium, lead, mercury manganese, zinc etc. They occur naturally in the earth's crust and cannot be depleted. These metals are associated with pollution and toxicity while others are essential in the body although at low concentration[4]. Some of the heavy metals are of essential biological importance as they are needed by the body. They assist in various important biological mechanisms like metabolism When bioaccumulation of these metals exceed the required amount thus leads to heavy metal poisoning[7].
Due to the lack of a proper waste disposal system land, water and air pollution has increased steadily thus increasing the levels of these heavy metals. The rate at which the heavy metals are taken up and stored in the body is faster than they are broken down hence leads to heavy metal poisoning[8]. Because they cannot be metabolized they accumulate in the body exposing it to the risks of poisoning and other deadly diseases like cancer. These heavy metals find their way into the human body through drinking water, food and air in small quantities[9]. The most prevalent group of element in the sub soils is the transition metals otherwise called heavy metals

MATERIALS AND METHODS

The study involved soil samples collected at the Nyambera dumpsite, Kisii town-Kisii county, Kenya. Kisii County located in Nyanza region of Kenya. This is the main dumpsite in Kisii town, it's located near the Kisii teaching and referral hospital next to a quarry along the Kisii Kisumu highway. It's about 1.0 km from Kisii town bus terminal. It's also next to residential homes (Jogoo), river Nyakomisaro and adjacent farms. Therefore the determination of the concentrations of the selected heavy metals has got a direct effect to the surrounding environment. Farmers use the manure from the dumpsite for their crops. The town has a vast growing population of approximately of about 200,000 people[10]. As a result of high population and land scarcity, waste disposal has become a menace in the town and its environs. Surface runoff flows to the river which is used by farmers to irrigate their crops, the community as a source of water and the trader at the Daraja Mbili market who uses the same water to clean their goods. The hospital disposes some of the waste products to the same dumpsite. Mining activities have been carried for a long period of time at the dumpsite.

SCHEMATIC RESEARCH DESIGN

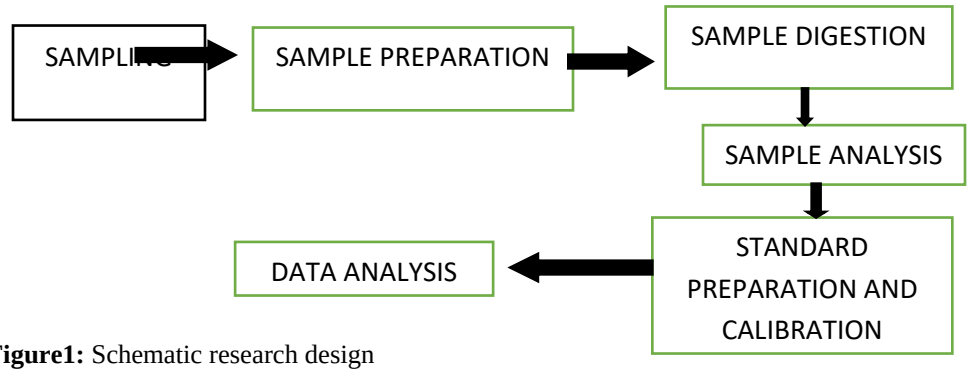

Figure1: Schematic research design

3.4 SAMPLING

In this study, stratified random sampling was employed for soils at the Nyambera dumpsite [11]. The dumpsite was divided into three sampling areas i.e.: the upper side (top of the dumpsite) will be labeled as site A, the slope of the dumpsite labeled as site B and near the river banks of river Nyakomisaro labeled as site C. In each and every site a representative rectangle was drawn on the ground and two diagonals inscribed. At all the corners and the point of intersection of the diagonals soil samples were collected 25cm into the ground. A total of five samples were collected from each section then mixed together. Using the conning and quartering method the sample was reduced and well packed in sample bags and taken to the laboratory.

Soils were dug using a machete and a meter rule used for the measurement of the depth. Three samples were collected. The samples collected were then stored in polythene bags and taken to the laboratory for preparation and analysis.

SAMPLE PREPARATION

The wet soils that were collected were air dried for about 72 hours and mixed frequently to expose fresh the wet surface to dryness. The samples were then oven dried at 110^0c for about three hours. The large particles were ground and sieved through the mesh wire and the powder collected stored for digestion.

SAMPLE DIGESTION

5.0g of the sample were measured from each of the sample added to 100ml beaker and digested with 12ml of 65% Nitric acid on a hot plate at a temperature of 110^0c for 30 minutes. The digested samples were then filtered into 100ml volumetric flask using the Whatman filter paper number 42. The filter paper and beaker were washed thoroughly into the volumetric flask and topped up with distilled water to the mark. The volumetric flasks were properly corked and stored away from direct sunlight until analysis of the heavy metals. 50.0 ml of distilled water was measured using a measuring cylinder and treated the same way as the sample to act as the blank in the analysis.

STANDARD PREPARATION AND CALIBRATION

The multi-element verification standard (ICP Multi-Element standard) was prepared into standards of 1, 5, 10, 50, and 100 ppm from the original stock solution of 1000ppm. The standards were used to calibrate the machine (ICPOES) and thus obtained calibration curves of the metals of interest.

SAMPLE ANALYSIS

The prepared standards were aspirated into the ICPOES machine and their absorbance used to construct the regression curves of each element of interest. The digested soil samples were then placed on the out sampler machine and aspirated into the machine. Their absorbance were recorded and compared against the standard regression curves to obtain their concentrations.

DATA ANALYSIS

The data obtained was used to calculate mean concentration of each element and then used to draw graphs of concentration of the elements using Microsoft Excel.

RESULTS AND DISCUSSION

Table 1: Heavy metal concentrations

S/No	Area	Pb(Mg/kg)	Cu Pb(Mg/kg)	Cd Pb(Mg/kg)	Zn Pb(Mg/kg)
1.	A. (top)	139.2	126.4	1.362	368.9
2.	B. (slope)	54.21	267.5	3.894	593.2
3.	C. (banks)	80.52	451.5	4.502	664.7
	Mean	91.31	281.8	3.253	542.3

Result of heavy metal concentration (mg/kg)

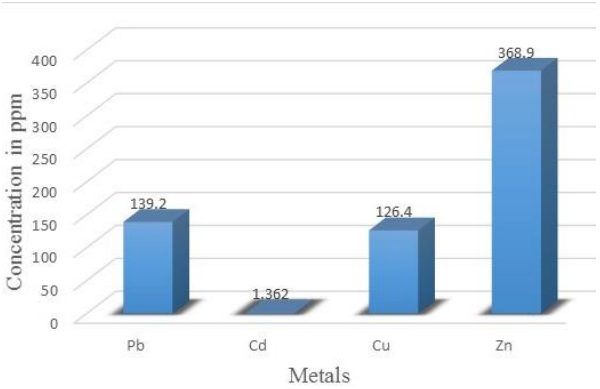

Figure1 : Heavy metal concentration in mg/kg for the top section (A) of the Nyambera

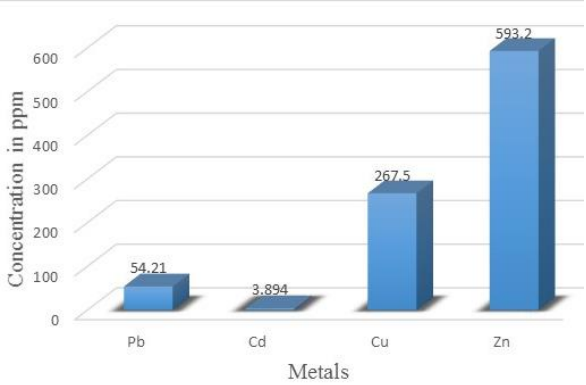

Figure2: Heavy metal concentration in mg/kg for the slope section (B) of the Nyambera

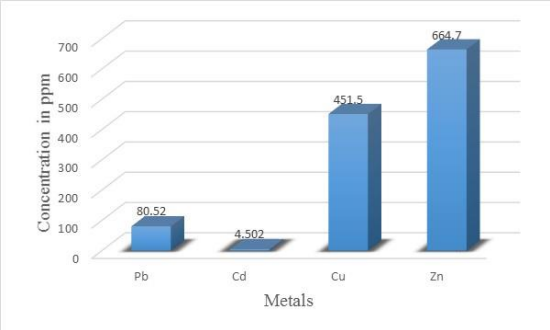

Figure 3: Heavy metal concentration in mg/kg for the river bank section (C) of Nyambera

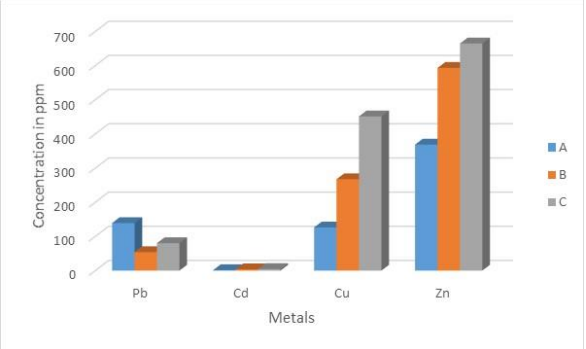

Figure 4: Concentration of the heavy metals at the Nyambera dumpsite.

Table 2: Recommended heavy metal concentrations accepted by WHO (mg/kg) - 2006

No.	Metal	Conc. mg/kg
1.	Pb	85
2.	Cu	36
3.	Cd	0.8
4.	Zn	50

DISCUSSION

The levels of lead at the Nyambera dumpsite were sufficiently high when compared with the recommended levels. On top of the dumpsite where most of the solid waste is deposited lead had a concentration of 139.2ppm which is way high above the recommended level of 85 ppm. This high levels might be attributed to the fact that most waste from the nearby garages and the dumpsite being located adjacent to the ever busy Kisii-Kisumu highway. Being located the former Ouru power limited which used to produce batteries it's expected that the levels of lead would rise due to lead pollution. On the slope the levels of lead were 54.21ppm. This still showed that the levels of lead in the dumpsite were low compared to the recommended levels but along the slope it reduced as compared to the top. This would be attributed to factors like surface run off. Most the lead might have been carried down the slope thus decreasing the levels along the slope. At the river bank the concentration of lead was 80.52ppm. This was an increase from the levels at the slope although still lower than the recommended levels by WHO, 2006.

The fact that river Nyakomisaro flows adjacent to the dumpsite when it over flooded and some lead is deposited at the banks hence raising the concentrations. Also due to surface run off and the almost flat nature of the area around the river bank deposition would also increase the concentration. The lead mean concentration at the dumpsite was 91.31 ppm. This is very high for soils. Due to surface run off lead would be introduced to water at river Nyakomisaro hence be introduced to all those beneficiaries of the water. Farmers who rely on the manure are introducing heavy metals to their soils indirectly.

The mean concentrations of copper was 281.3ppm. At the top 126.4 ppm, at the slope 267.5ppm and at the banks was 451.1 ppm. This shows that the levels of copper were increasing down the slope. The WHO recommended levels for copper are 36 ppm whereas the mean concentration of copper were 281.3ppm. High levels of copper in the dumpsite would be attributed to disposal of electrical materials and other solid waste that would contain copper.

The cadmium levels were 3.253 ppm in the dumpsite. The upper part had 1.362 ppm, the slope section had 3.894ppm and the bank section had 4.502ppm. This again is very high as compared to the WHO recommendations for cadmium which is 0.8ppm. The trend shows that the concentrations increases down the slope. This could be attributed to surface run off and increase mining activities in the quarry. New heaps along the slope and the banks could be linked to increased cadmium levels. This poses a serious threat to miners at the dumpsite and those who live in the proximity of the said dumpsite.

Mean concentration for zinc in the dumpsite was 542.3 ppm. The upper part had 368.9 ppm, the slope had 593.2 ppm and along the river bank it was 664.7 ppm. This was high as compared to the WHO recommendations of 50 ppm in soil sample. Again the levels were increasing down the slope. This implies that wastes carrying zinc was in abundance and as a result of surface run off and flooding of the river the levels of zinc were high.

The results obtained from the soil analysis of the Nyambera dumpsite indicated that there were very high concentration of the metals in question. This implies that the waste making its way into the dumpsite is rich in heavy metals and this poses a serious health hazard to the people of Kisii town and its environs.

CONCLUSIONS

All the selected heavy metals were present at the dump site. The concentrations of each were increasing down the slope apart from lead which was higher at the top of the dumpsite as compared to other parts of the dumpsite. The concentrations of Pb, Cu, Cd and Zn were very high at the Nyambera dumpsite as compared to the recommended levels for soil by WHO [12].

RECOMMENDATIONS

1. Develop and implement an effective waste management plan.
2. Identify the materials and wastes at a particular site and try to manage it.
3. Nyambera dumpsite to be closed and a new dumpsite identified.
4. Dumpsites should be treated before use especially for cultivation.
5. Also the people living around these dumpsites should stop farming on or around them without KARLO certification.
6. Analysis for heavy metals be carried out on River Nyakomisaro.
7. Alternative water source for trader at Daraja Mbili market.
8. Further analysis of the heavy metals should be carried out.

REFERENCES.

1. Tu, C., Zheng, C. R., & Chen, H. M. (2000). Effect of applying chemical fertilizers on forms of lead and cadmium in red soil. *Chemosphere*, *41*(1–2), 133–138.
2.Atafar, Z., Mesdaghinia, A., Nouri, J., & Homaee, M. (2008). Effect of fertilizer application on soil heavy. *Environmental Monitoring and Assessment*, (January). https://doi.org/10.1007/s10661-008-0659-x
3. Kei, R. M., Ndegwa, J. K. M., Ndwiga, T., & Masika, F. (2016). Challenges of Cervical Cancer Screening Among Women of Reproductive Age Challenges of Cervical Cancer Screening Among Women of Reproductive Age in Kisii Town , Kisii County , Kenya. *Medical Journal*, (June). https://doi.org/10.11648/j.sjph.20160404.14
4. Asemave, K., and Anhwange, B. (2014). Evaluation of Heavy Metals in Waste Dumpsites. *Earth Science*, *3*(May 2013), 23.
5. Wang, X. (2013). Heavy Metals in Urban Soils of Xuzhou , China : Spatial Distribution and Correlation to Specific Magnetic Susceptibility. *Scientific Reasearch*, *20*(March), 309–316.
6. Connell, D. W., Miller, G. J., and Miller, G. K. (2002). *Chemistry and ecotoxicology of pollution* (Vol. 8). John Wiley & Sons.
7. Uzoho, B. U., and Oti, N. N. (2006). Effect of municipal solid waste compost (MSWC) on the productivity and heavy metal concentration of cowpea (Vigna unguiculata) in Owerri, South Eastern Nigeria. *International Journal of Agriculture and Rural Development*, *7*(2), 20–25.
8. Selene -H, C., Chou, J., & De Rosa, C. T. (2003). Case studies - Arsenic. *International Journal of Hygiene and Environmental Health*, *206*(4–5), 381–386. https://doi.org/10.1078/1438-4639-00234

9. Abdus-Salam, N. (2009). Assessment of Heavy Metals Pollution in Dumpsites in Ilorin Metropolis. *Ethiopian Journal of Environmental Studies and Management*, *2*(2), 92–99.
10. KNBS. (2013). Exploring Kenya ' s Inequality. In *Exploring kenya's inequality* (p. 122).
Plum, L. M., Rink, L., & Haase, H. (2010). The Essential Toxin : Impact of Zinc on Human Health. *International Journal of Environmental Research and Public Health*, 1342–1365. https://doi.org/10.3390/ijerph7041342
11. Chen, M. (2001). Soil sampling . *Society of America Journal 65:491-499*
12. WHO (2004). Guidelines for drinking-water quality, 3rd ed. Geneva, World Health Organization (http://www.who.int/water_sanitation_health/dwq/gdwq3/en, accessed 18 September 2007).