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Heavy Metal Contaminated Soil and its Effects on Humans Health

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Abstract

Polluted soils are causing serious threat to food safety and public Health in the world. Because of this, a research was conducted to evaluate metals contaminations in the studies soils collected from a dumping site in Monrovia. This study aims to determine the accumulation of heavy metals Cd, Pb, As, Zn and Ni contaminant in the soil. Three soil samples were collected and placed in a sample bag and taken to the Environmental Protection Agency (EPA) laboratory. Sample 1 was taken directly from the landfill body and sample 2 and 3 from the edge of the landfill. The allocation of sample site was chosen on the basis the accessibility and permission of authority.

All three samples were collected at a depth of 0-25cm and an interval of 75m between each. These samples were tested/analyse using the X-ray fluorescence (XRF). The WHO limit for these heavy metals in soil as set as a threshold for the experiment. All of the samples tested exceeded the threshold for Cd, Pb, Zn and Ni, with sample 1 attaining the highest value followed by sample 2 and 3. Thus, Cd, Pb, and Zn are contaminating the soil in this area. The study area, wein town is owned and operated by the Monrovia City Corporation (MCC) and was constructed in 2010 in order to enhance a better waste management in and around the wein town area. The facility operates 365 days and receives about 300 tons of municipal waste per day from Monrovia and its environs. The objective this research is to examine the effect of soil contamination caused by landfills. The soil samples were prepared for heavy metal analysis using acid digestion and heavy metal concentrations were determined using X-ray fluorescence (XRF) method. The results showed that the accumulation of heavy metals in the polluted soil follows Zn>As>Cd >Ld >Ni. It was observed that the Concentrations of Cd and Zn in the soil corresponded with the permissible limits of Cd and Zn in soil set by the WHO: Cd=0.01 and Zn=6.07.

Keywords: Metal, Soil, Humans Health, UTM

1. Introduction

Land degradation caused by human activities has significant adverse effects on the environment and ecosystem worldwide, and solid waste is an important emerging environmental problem (Newell, 1979) [57]. It was estimated that 0.5-4.5kg per person per day of solid waste is produced in different regions of the world (Department of The Environment And Energy, 2018) [28]. The most common ways to manage such waste disposal are landfills and incinerator (World Health Organization (WHO)- Europe, 2007) [82]. Actually up to 95% total municipal solid waste collected is disposed of in landfills worldwide, and land filling is the major MSW disposal method used in modern cities (Johari *et al*., 2014) [49]. Landfills were thought to be safe disposal method of municipal solid waste, but this is true only for proper engineered landfill sites (Yedla, 2005) [83]. An engineered landfill site allows final disposal of solid waste in a secure manner by minimizing the impacts on the environment as modern landfills are often lined with layers of absorbent material and sheets of plastic to keep pollutants from leaking into the soil and water (NSW Enviornmental Protection Authority (EPA), 2016) [58].

The improper management of waste disposal raises public concern over potential harmful effects to local communities and the environment (Ruíz, 2015). These concerns probably have become more pragmatic when recent intensive studies demonstrated increased human health risk caused by exposure to toxic chemicals, such as dioxins and related compounds and metals in these dumping sites (Bouzayani *et al*., 2014) [12]. Landfills containing hazardous materials are under critical observations today for potential hazards, resulting in the need for thorough risk analysis along with soil and groundwater that have been contaminated with chemicals leaching from landfills (Singhal *et al*., 2010) [70]. Several reports have been published which are documented on the leachate characterization and its effects on groundwater pollution, but little information is available on the effect of landfills on soil contamination and its toxicological effects (Aziz *et al*., 2013) [8].

Integrated solid waste management practices which include source reduction, reuse, recycling, and composting have decreased the use of landfills (Abdel-Shafy & Mansour, 2018) [1]. However, land filling still remains the most common form of removal and disposal of municipal solid waste (Schiopu & Gavrilescu, 2010) [65]. Landfills are one of those humans' activities that are changing the fate of the natural ecosystems (Danthurebandara *et al*., 2013) [26]. In total, 1.3 billion ton of municipal solid wastes are produced globally per capita. However, by 2025, this amount will increase to about 2.3 billion ton per year (Adamcová *et al*., 2016) [3]. Although final disposal of municipal solid waste is considered the least desirable option, it remains the predominant solution worldwide (Caicedo-Concha *et al*., 2016) [17]. Approximately 80% of global MSW is placed in waste disposal sites, which only 20% is contained in engineered and controlled landfill sites (Caicedo-Concha *et al*., 2016) [17].

Soil is the key part of the Earth system as it controls the hydrological, erosional, biological, and geochemical cycles (Smith *et al*., 2015) [73]. The system also offers goods, services, and resources to humankind (Darwin & Origin, 2009) [27]. This is why it is necessary to research how soils are affected by the use of human societies.

Pollution is one of those damaging human activities, and we need more information and assessment of land pollution (Assembly, 2017) [7]. Land and soil pollution by heavy metals have become a critical environmental concern due to its potential adverse ecological effects(Chopra *et al*., 2009) [20]. Heavy metals occur naturally at low concentration in soils (Slavko Smiljanić, Neda Tešan Tomić, Mitar Perušić1, Ljubica Vasiljević, 2019) [72]. However, they are considered soil contaminants due to their widespread occurrence as well as their acute and chronic toxicity (An, 2004) [6]. Soil is a major source of nutrients for productivity and a source of too many resources found on earth. One of the major challenges faced with soil in our local environment is the contamination of soil with land fill being a major driver of those contaminants. However, the potential damage of soil by landfill is partly realized by contaminators and the effects are never known potentially. However, landfill plays a major role in contaminating a soil. It degrades a soil by means of heavy metals that are most likely harmful to human health and the environment as well, thereby leading to low productivity. Liberia is a tropical region that has a very good soil in almost every part, but the proper management of those soils is not known to local farmers in the country. As a result, local farmers have not realized the harmfulness of landfill on the environment. There is limited research on the effect of landfill leading to soil pollution in Liberia. This paper will help local farmers or conservationist to know the effect of landfill in soil pollution. Farmers in Liberia will have a broad knowledge on the effect of landfill on the environment as a gap to soil pollution. It will make farmers to know the effect of landfill on the environment when they experience low production caused by soil pollution. It will also help students who are interested in knowing about soil contamination to have a broad knowledge on landfill as a major driver of soil contamination. The government and policy maker will benefit from this research because the information gathered will be given to them for proper implementation and will also be able to provide information to local farmers around the country. Therefore, the objective of this paper is to examine the effect of soil contaminated soil and its effects on Human and animals' health.

2. Materials and Methods

2.1 Study Area Description

The Wein Town landfill is located approximately 13.8 km NE of Monrovia with UTM coordinates (314890, 699065) and Latitude & Longitude (6.32170982266962, -10.6734125037003) and can be accessed by the Monrovia-Gbarnga highway. The landfill is owned and operated by Monrovia City Corporation (MCC) and was constructed in 2010.The facility operates 365 days and currently receives about 300 tons of municipal waste per day from Monrovia and its environs. The average topography of the area is 7m above sea level, making the landfill a towering feature in a relatively low laying swampy terrain with soil grain ranging from 0.05-0.04mm in size.

2.2 Collection of Sample

The soil sample collection was done by using soil auger and polyethylene bags from the landfill site and its surrounding at the depth of twenty-five (25cm) and an interval of approximately seventy-five meters (75cm), sample 1 was taken directly from the landfill body and sample 2 and 3 was taken from the edge of the landfill; the allocation of samples site was chosen on the basis of the accessibility and permission of authority. Each sample labelled as AK001, AK002 and AK003 (Alex Kolleh 1, 2 and 3). Table 1 provides various UTM and elevation. Each sample was collected and placed in a polyethylene bags and label respectively.

Table 1: Sample collected at the research site

Sample ID	Eastern UTM	Northern UTM	Elevation
Landfill	314890	699065	N/A
AK001	314890	699104	23m
AK002	314990	699175	17m
AK003	314893	699199	17m

2.3 Sample preparation and Analysis

To achieve the objective of this work, the X-ray fluorescence (XRF) technique was used to evaluate and analyse soil pollution and heavy metal concentration such as (As, Cd, Ni, Pb, and Zn) in the vicinity of Wein town in Monrovia. XRF (X-ray fluorescence) is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) X-ray emitted from the sample when it is inserted by a primary X-ray source. Each of the elements present in the sample produces a set of characteristic fluorescent X-rays ("a fingerprint") that is unique for that specific element, which is why XRF spectroscopy is an excellent technology for qualitative and quantitative analysis of material composition.

The collected samples were oven dry at 60^0C for 48h. after that, the samples were taken to the preparation laboratory; in the preparation laboratory, the samples were placed in a laboratory mortar and crush to homogenize out grains of the same size, the crushed sample was placed into a sieve of 180 micrometres for sieving; in which the clay/silt size particle was placed into a plate and labelled -180 micrometres and the fine and coarse grain were both placed into another plate labelled as (+180) micrometres, the sieving was done for all three samples using the same sieve size of 180 micrometres. After the sieving; the very fine grain was placed in a laboratory beg and was taken to the analysis laboratory for final analysis this sample preparation was done only for analysis method one.

2.4 Data Collection and Analysis

All the data collected was firstly written and calculated in excel. The statistical analyses were performed using SPSS Version 22 for Windows. The significance of differences between the means of treatments was evaluated using ANOVA, followed by Duncan's multiple range tests at ($p < 0.05$).

3. Results and Discussions

3.1 Results

The result obtained from the analysis of the sample collected from the wein town landfill was compared to the WHO pollutant standard to determine the level of contamination. From the analysis, the occurrence of these heavy metals varies in each soil sample as shown in the table below. From the results, Cd, Pb and Zn it is evident that the presence of the formal three elements exceeded the established WHO limit thereby indicating the contamination of these heavy metal elements in the soil. Also, from the result, As and Ni concentrations did not exceed the WHO set standard limit in all three-sample analysed.

Table 2: Laboratory results of heavy metal content in soil samples

Parameters	Dry units	Method	AK001	AK002	AK003	Control	WHO Limit
Cadmium (Cd)	Mg/kg	XRF	3.50	3.56	3.94	0.09	0.01
Arsenic (As)	Mg/kg	XRF	0.06	0.09	0.07	ND	0.5
Lead (Pb)	Mg/kg	XRF	2.46	2.04	2.49	0.73	1.0
Nickel (Ni)	Mg/kg	XRF	0.002	0.004	0.002	ND	<1.0
Zinc (Zn)	Mg/kg	XRF	6.83	6.73	6.59	1.32	6.07

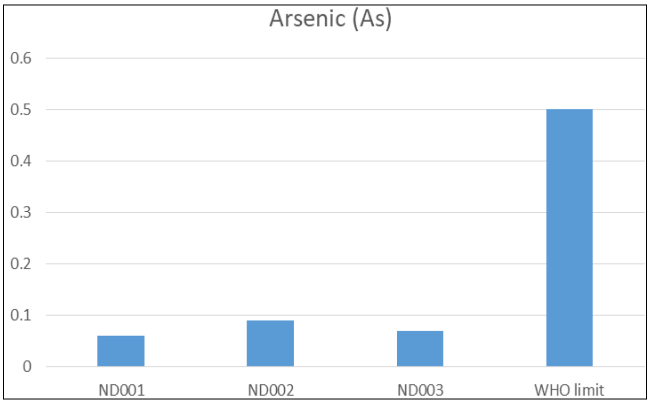

Fig 1: The percentage of arsenic (As) in the soil sample collected from the research site

Fig 1 shows the result of Arsenic in all of the samples (AK001, AK002 & AK003). From the result it was concluded that the concentration of Arsenic is below the WHO standard limit (0.5), thus indicating that it does not pose any threat to human and animals health. Arsenic have proven to be very dangerous and can be absorbed orally or inhaled and it is stored mainly in the liver, kidneys, heart, and lungs, with smaller amounts accumulating in muscle and nerve tissue, and has-been defined as carcinogenic. It can lead to nervous systems disorders, liver and kidney failure as well as anaemia and skin cancer.

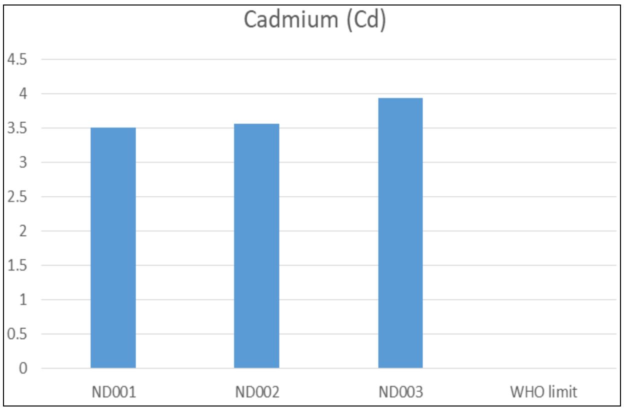

Fig 2: The percentage of cadmium (Cd) in the soil sample collected from the research site

Fig 2 shows the result of Cadmium in all of the samples (AK001, AK002 & AK003). From the result it is evident that the concentration of Cadmium in all three samples is above the WHO standard limit thus indicating that it does pose threat to human activities. Research have proven that cadmium when absorbed via food intake can penetrate through the placenta during pregnancy, damaging membranes, and DNA and disrupting the endocrine systems, and can stimulate kidney, liver and bone damage.

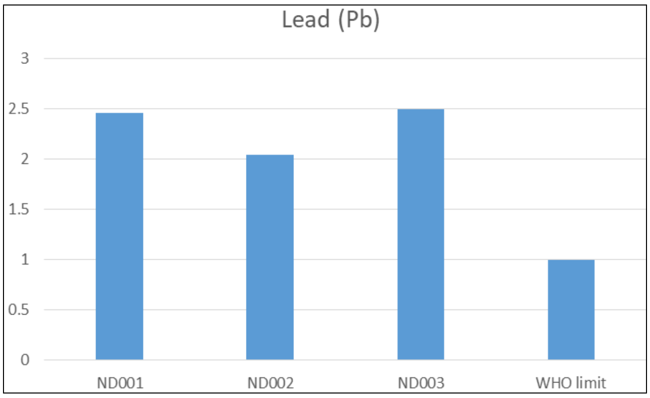

Fig 3: The percentage of lead (PB) in the soil sample collected from the research site

Fig 3 shows the result of Lead in all of the samples (AK001, AK002 & AK003). From the result it is evident that the concentration of Lead in all three samples is above the WHO standard limit thus indicating that it does pose threat to human activities. Previous research indicates that Lead (Pb) affect several organs, causing a biochemical imbalance in the liver, kidneys, spleen, and lungs, and causing neurotoxicity, mainly in infants and children.

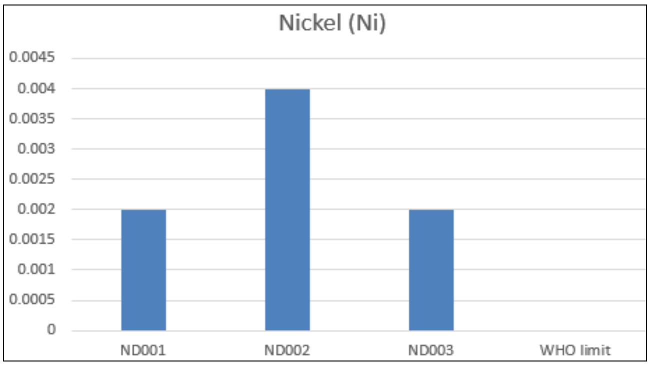

Fig 4: The percentage of nickel (Ni) in the soil sample collected from the research site

Fig 4 shows the result of Nickel in all of the samples (AK001, AK002 & AK003). From the result it is evident that the concentration of Nickel in all three samples is below the WHO standard limit thus indicating that it does not pose threat to human activities. Previous studies done on Nickel (Ni) indicates that it causes gastric, Liver, and kidney defects and neurological effects.

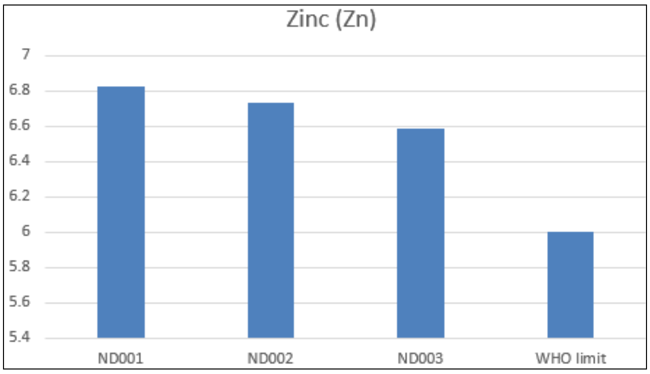

Fig 5: The percentage of zinc (Zn) in the soil sample collected from the research site

Fig 5 shows the result of Zinc in all of the samples (AK001, AK002 & AK003). From the result it is evident that the concentration of Zinc in all three samples is above the WHO standard limit thus indicating that it does pose threat to human activities.

4. Conclusion

The study evaluated the contamination of soil by heavy metals due to solid waste disposal in an uncontrolled dump site in the Wein Town neighbourhood. The site was a non-engineering open dump that was capped (covered with a final layer of soil) and closed when it reached its full capacity. Samples collected from the site was tested and found to contain heavy metals Cd, Ni, Pb, As, and Zn.

The concentration of Cd, Pb, and Zn were found out to be greater than the WHO limit (used as a standard) for the concentration of these heavy metals within soils, indicating that these heavy metals are contaminating the soil. The only protective layer at this site (soil used as Cap to cover the waste during closure) is being washed away by erosion and human activities. Based on the findings from this research, it can be concluded that the environment and inhabitants are at a high risk of pollution from Cadmium, Lead, and Zinc.

Based on the findings of this research, it is recommended that further research is done in this area so as to determine the presence of other heavy metals in the soil not treated in this paper and the presence of harmful (explosive) gases generated from solid waste.

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