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Assessment of Organic Matter and Mercury around Mants'ebo Dumpsite, Maseru, Lesotho

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Abstract- The focus of this study was to assess the contribution of Mants'ebo dumpsite in soil contamination. Deteriorating soil quality is a grave consequence of open waste dumping which can be a public concern.

Surface soil samples (n=15+5) were collected from both the active dumpsite and control site. Significant modifications were observed in the soil properties of the dumping site. Soil at disposal sites showed high pH, moisture content and organic matter regime in comparison to control site. The pH value was 8.1±0.17 in dumpsite and exceeds Federal Environmental Protection and World Health Organisation of 7.00. The study therefore showed that changes in physicochemical characteristics at dumpsite could be attributed to interactions of different soil properties rather a single factor.

Index terms: Dumpsite, Mercury, Moisture content, Organic matter, pH

1 Introduction

1.1 BACKGROUND OF STUDY

A dumpsite is a facility used for disposal of solid waste from different sources. Dumpsite approach as solid waste disposal method is the most primitive stage of solid waste management in many parts of the world [38]. Dumpsite is one of the most poorly rendered services by municipalities and local councils in developing countries as the systems applied are unscientific, outdated and in-efficient. In addition, Biswas *et al* [8] say dumpsite is the cheapest methods for non recyclable waste and since dumpsites are not established using a permit and they do not protect the environment.

Solid waste disposal in open dump creates considerable nuisance and constitutes long lasting risk potential for humans and the environment [20]. The overwhelming environmental significance and impact of leachate on soil and underground water has become a great concern because of its serious threat to the quality of life of human beings that depends hugely on land to sustain their livelihood [29].

Despite lower levels of commercial and industrial activity in developing countries, their solid waste is not necessarily devoid of hazardous substances because regulatory frameworks and enforcement systems to segregate and separately collect such waste are almost non-existent or dysfunctional [28]. Dumpsite problem has become a number one serious environmental problem facing Lesotho because of its consequent effects on the pollution of soil, water and air. Magaji [22] emphasized that, soil is the primary recipient of solid waste and is usually the mostly polluted part of the ecosystem around dumpsites because of the seepage of water through the waste dump that leaches out undesirable components that pollute the soil. These components deteriorate the quality, texture and mineral content of soil and disturb the biological balance of the organisms in the soil.

Raman [33], surface water percolating through the thrash can dissolve out harmful chemicals that are then carried away from dumpsites in surface or subsurface runoff. The water runoff from dumpsite is of huge interest when it contains potentially toxic heavy metals which are particularly insidious and lead to phenomenon of bioaccumulation. Abdus [2] concluded that, these heavy metals constitute to environmental problem and persist for long time in soil.

Mants'ebo dumpsite is found in Maseru district and it is about 20km from Maseru city due south. The dumpsite is easily accessible with proper gravel road and the dumping ground is situated approximately one kilometer from Mants'ebo village. The dumpsite is established in an excavated pit.

In the past, visually the dumpsite received few kilograms of solid waste; hazardous and general waste but in the last three years the volume increased dramatically. There are no exact figures because there is no weighing of solid waste upon its arrival. The solid waste has increased and this increase has put significant pressure on already inadequate dumpsite.

1.2 STATEMENT OF THE PROBLEM

The Mants'ebo dumpsite is surrounded by agricultural fields thus increasing the likelihood of soil pollution by leachate. Soil is the most polluted part of the ecosystem around dumpsite because of the seepage of water through the waste dump that filters out undesirable compounds to the field. These undesirable compounds deteriorate the soil texture, mineral content and disturb the biological balance of organisms in soil. It is therefore important to research on the soil quality around the dumpsite.

1.3 SIGNIFICANCE OF THE STUDY

This research is undertaken to assess current and potential impacts of the Mants'ebo dumpsite on soil as it is placed right above agricultural fields where its leachate poses threat to farmlands by exposing it to more inorganic matter and other synthetic compounds. This research will be beneficial in assessing soil quality around this dumpsite. With all the facts gathered, it will be easier to predict possible future impacts of the dumpsite on soil. Again, advice will be given to Mazenod Community Council to engineer the dumpsite for better solid waste management and prevent soil pollution which often leads to water pollution. The researcher will fulfill the requirement for completion of Bachelor of Science in Environmental Health.

1.4 RESEARCH QUESTIONS

1. What is the amount of organic matter in soil around Mants'ebo dumpsite?

2. What is the amount of Mercury of Mants'ebo dumpsite on soil?

1.5 GENERAL OBJECTIVE

To assess physicochemical properties of soil at Mants'ebo dumpsite

1.5.1 OBJECTIVES

1. To analyse organic matter of soil around Mants'ebo dumpsite

2. To measure Mercury in soil around Mants'ebo dumpsite

1.6 LIMITATION TO THE STUDY

This study was carried out at the Mants'ebo dumpsite, approximately 20km from the Maseru city centre due south.

Data collection was only confined to autumn. The replication of the study at different seasons would enable better generalizing of the findings of the study. Again, research study with larger number of samples would be required to ensure appropriate conclusions.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

Dumpsites are a global problem. They receive roughly 40 percent of the world's waste and they serve about 3.4 billion people. The 50 biggest dumpsites affect the daily lives of 64 million people [26]. As urbanization and population growth will continue, it is expected that at least several hundreds of millions more people will be served by dumpsites, mainly in the developing world [26].

Small fraction of solid waste generated in developing countries is recycled mostly by informal sector. This indicates an overwhelming dependence on land filling as waste disposal option which has been identified as a major threat to the environment. A dumpsite undergoes biologically, chemically and hydrologically mediated changes resulting in a breakdown of waste and as a result becomes a source of pollutants [31].

2.2 HISTORY OF DUMPSITES

Solid waste, moulds of rubbish and garbage are produced every day, and in an attempt to dispose of these materials, the environment has been and is carelessly polluted [28]. It is not a trait of the 20th century but it has been discovered that people dispose waste everywhere on environment (Barbalace, 2003). This has led to establishment of dumpsite to counter littering. Dumpsites are the oldest form of waste treatment and are used in many places around the world. Dumpsites are in the form of a pit or hill on the outskirts of town and played host to disease carrying rodents, insects, and dangerous objects.

In both developed and developing countries, municipalities have now banned unregulated garbage dumps and burning due to the contamination of soil, groundwater supplies and streams as environmental safety. Waste accumulation in these open areas in relation to their contact with soil and the population, have great environmental and health implications that could generate economic losses to people and government [1]. Landfills are now the only sanctioned garbage disposal sites for most municipalities and only qualified personnel are allowed to burry or burn waste.

2.3 CHALLENGES AND IMPACTS OF SOLID WASTE MANAGEMENT

Increasing population level, booming economy and the rise in community living standards have accelerated the solid waste generation rate in developing countries Guerrero [17] which has put significant pressure on municipalities to provide sufficient services for waste management. The problems of solid waste in developing countries are beyond the capacity of municipal authority to tackle mainly due to lack of organization and financial resources.

According to Salam [36], poor management of dumpsites creates a number of adverse environmental impacts including wind-blown littering, attraction of rodents scavenging food and pollutants such as leachate which pollute the underground soil and aquifers. Solid waste poses a potential hazard to the environment (soil, air and water) when improperly disposed of. It contributes a major share towards environmental degradation and soil pollution because of illegal littering and dumping [11].

Dumpsites are known for their smelly and unsightly conditions, they are unsanitary and anaesthetic. These conditions are worse in summer because of extreme temperatures which speed up the rate of bacterial action on biodegradable organic material (Abul 2010). Abul (2010) adds that, developing countries (Lesotho not exception) use dumpsites rather than properly managed and environmentally safe landfills and there is considerable public concern over the possible effects of dumpsites on environment.

Land pollution can damage terrestrial ecosystems, resulting in the deterioration of soil quality and amenity value of the environment [27]. Solid waste pollutants serve as an external force affecting the physicochemical characteristics of soil eventually affecting the plant life on the planet leading towards irreversible erosion [32]. Alam and Ahmade [4] conclude that, the decomposition of organic waste in dumpsites and landfills together with untreated leachate pollutes the surrounding soil and water bodies.

2.4 MOISTURE CONTENT

Moisture content of the solid waste in landfill during active degradation of organic compounds is high and it affects the biological processes [14]. This is highly variable and can change dependant on the climate. This promotes the dissolution and mixing of soluble substrates and nutrients. Eck and Captain [14] stressed that moisture content is an essential environmental requirement for the growth of microorganisms and without the microorganism there is no biodegradation.

2.5 SOIL ORGANIC MATTER

The organic pollutants from mineral substances, solid particulate matter and other synthetic chemical compounds and their byproducts pollute soil in the dumpsite [27]. Organic matter affects both the chemical and physical properties of soil and its overall health. It influences soil structure, moisture content, holding capacity, diversity and activity of soil organisms. Cooperband [13] commented that all these properties contribute to plant growth and reduce soil erosion, because of increased water infiltration and stable soil aggregate formation caused by organic matter.

Chen [12] stated that organic matter is an important parameter that affects the distribution of trace elements in soil and aquatic environment. Organic matter also has the ability to bind pesticides, heavy metals and other solid pollutants hence making them immobile and reducing the negative environmental effects [13]. In addition, organic matter buffers the soil against major swing in pH by taking up or releasing H^+ ions into the soil solution making the concentration of soil solution H^+ ions more constant.

Despite all the benefits in dumpsites and landfills, organics brings challenges. Funderburg [16] complain that, organic materials are unstable in soil, changing form and mass readily as it decomposes to attain stability hence releasing methane and other gases. When organic materials decompose naturally , they give out carbon dioxide(CO_2) which is the main greenhouse gas however it has little impact on global warming fossil fuel [39]. The US Composting Council [39] further stressed that, the same organic matter placed in landfills; the decomposer will act on it and will convert and release the carbon as methane (CH_4) and other volatile organic compounds (VOCs) which do contribute to climate change.

2.6 SOIL pH

The behaviour of organic matter and heavy metals in soil mainly depend soil pH levels. Soil pH is a measure of the acidity or alkalinity in soil as determined by amount of positively charged hydrogen (H^+) ions in the soil. Soil pH is considered a master variable in soil as it controls many chemical processes that take place [41]. It specifically affects plant nutrient availability by controlling the chemical forms of the nutrients.

The optimum pH range for most plants is between 5.5 and 7.0; however some plants have adapted to thrive at pH values outside this range. Most nutrients deficiencies can be avoided between a pH of 5.5 and 7.5 provided that the soil minerals and organic matter contain the essential nutrients. For instance, concentrations of available Nitrogen (N) are less sensitive to pH than of concentration of available Phosphorous (P) [41]. If pH is lower than 6, Phosphorous (P) starts forming insoluble compounds with Iron (Fe) and Aluminium (Al) and if pH is higher than 7.5, Phosphorous starts forming insoluble compounds with calcium (Ca).

2.7 HEAVY METALS

The contamination of soil by heavy metal cause adverse effects on human health, animals and soil productivity. Metals cause physiological disorders in soil as absorption through root system consequently retards plant growth and deprives it of vigour [4]. Contaminants alter the soil chemistry and have an impact on the organisms and plants depending on the soil for nutrition [4]. Ali [4] stressed that, accumulation of chemical elements in plants depends not only on their absolute content in a soil but also on level of fertility, pH and the presence of organic matter.

Muller [24] acknowledge that, heavy metals contamination of soil reduce fungal biomass and alter composition of soil community. Municipal solid waste is found to contain appreciate quality of heavy metal such as mercury (Hg) which will eventually end up in soil and leached down the soil profile [30]. Mercury is problematic environmental pollutant because of its toxicity. Oyedele [30] stressed that there are studies on heavy metals in ecosystem that shows an indication of a silent epidemic of environmental metal poisoning in humid soils.

The behaviour of heavy metals in soil all depends on soil pH, clay content, soil chemistry and organic matter content. Heavy metals like mercury are generally more mobile in the soil in the acidic pH range. Oyelami [31] conducted a study on assessment of the impacts of open waste dumpsite on groundwater quality. In the study, he said that, the most important environmental issues today is groundwater contamination and heavy metals are of particular concern, considering their high toxicity even at low concentration.

Mercury is persistent, mobile and bio accumulative element in the environment and is retained in organism. Mercury when leached to aquatic environment it is changed to various forms, mainly methyl mercury which is the environmental neurotoxicant [7]. Methyl mercury bioaccumulate and is biomagnified in the food wed and enters the human body mainly through consumption of fish [37]. The signs and symptoms of mercury poisoning patients are sensory disturbance in the distal portion of four extremities and concentric contraction of the visual field [23].

2.8 CONCLUSION

Soil is a vital component of terrestrial ecosystems, maintaining essential ecological functions such as primary production and decomposition. When polluted it has some grave consequences ranging from deterioration of soil quality to reduced plant diversity. Unfortunately, it is very sensitive to human activities and difficult to reclaim when degraded [18]. Ali [5] concluded that, the pollutants deprive the ecosystem of the natural balance and bear results beyond any repair.

CHAPTER THREE

METHODOLOGY

3.1 RESEARCH DESIGN

The research was conducted in an experimental study approach. Experimental study is a systematic approach to research in which the researcher manipulates one or more variables and controls and measures any change in other variable [9]. Generally, one or more variables are manipulated to determine their effect on a dependent variable. In this research the variables studied are pH, Organic matter, Mercury and Moisture content.

3.2 DESCRIPTION OF STUDY AREA

The study area is the Mants'ebo dumpsite which is located in Maseru district about 20 kilometers due south of Maseru city. The dumpsite is easily accessible with proper gravel road and the dumping ground is situated approximately one kilometer from Mants'ebo village. The dumpsite is established in an excavated pit.

3.3 SAMPLING TECHNIQUE

A total of twenty soil samples were used for the study. Fifteen soil samples were collected within the vicinity of the dumpsite while five samples were collected away from the dumpsite, which will serve as control samples. Five samples were collected consecutively every week for a month. Samples collected were stored in sealed labeled plastics and then taken to the laboratory for analysis. The soil sampling was done using a transplanter.

3.4 INSTRUMENTS FOR DATA COLLECTION and REAGENTS

Drying oven, Muffle furnace, Tongs, Crucibles, Analytical balance, Measuring cylinder, HANNA pH meter, Beakers, Distilled water, Buffer solution, Sieve, Spatula, Hand transplanter and plastics.

3.5 DATA GATHERING PROCEDURE

Primary source of data collection was used, and in this study was laboratory analysis.

3.5.1 LABORATORY TESTS

It is very crucial to analyze pH as it is an important environmental factor that determines the available and solubility of heavy metals in soil. The pH of the soil samples were measured in water by glass electrode method involving 1:1 soil mixture using HANNA pH meter.

Drying oven was used to dry the soil samples for moisture content. The soil samples were weighed each in separate crucible using analytical balanced then dried for a night at 115^{0}C. It was then weighed again after it cooled to room temperature.

Moisture Content Formula: $\frac{w2-w3}{w3-w1} \times 100\%$

Where: w1 = weight of empty crucible in grams

w2 = weight of moist soil and crucible in grams

w3 = weight of dried soil and crucible in grams

Organic content was determined by weighing soil samples in crucibles using analytical balance and ashed at 550°C for five hours using muffle furnace.

Organic Matter Formula: $\frac{w3-w1}{w2-w1} \times 100\%$

Where: w1 = weight of empty crucible in grams

w2 = weight of soil and crucible in grams

w3 = weight of ashed soil and crucible in grams

3.6 DATA ANALYSIS

Microsoft excel 2007 was used to process data and tables were developed.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

Soil is a crucial component of environment and its management is a key to its quality. The soil samples collected from various points from dumpsite and control site were analysed for organic matter, moisture content and pH. The main physico-chemical pollution parameters by the calculation of average mean and standard deviation are presented in Table 1 below.

Table 1.0 Statistical description of soil physic-chemical properties of control site and dumping site.

ACTIVE SITE				**CONTROL SITE**		
SAMPLE	pH VALUE	MOISTURE CONTENT	ORGANIC MATTER	pH VALUE	MOISTURE CONTENT	ORGANIC MATTER
A	8.16	27.63%	19.17%	7.07	21.10%	9.70%
B	8.1	20.60%	18.10%	7.27	24.20%	10.30%
C	8.34	20.25%	11.47%	7.8	16.80%	12.50%
D	8.05	19.97%	20.47%	7.33	23.40%	7%
E	7.87	19.11%	15.97%	7.05	18.40%	7.50%
MEAN	8.104	21.51%	17.04%	7.304	20.78%	9.40%
STD DEV	0.170675	0.034641622	0.035211901	0.302952	0.031689115	0.022293497

4.1 RESULTS

The results indicated that the moisture content ranges from 19.11% to 27.63% in dumpsite. The pH value varies from 7.87 to 8.34 at dumping site while the pH values in the control site were 7.05 to 7.27(Table 1).The mean value of percentage of organic matter at dumping site was 17.04% while at the control site was 9.40%. The percentage of organic matter and moisture content of the control site were lower as compared to disposal site due to which cleared vegetation, animal waste, pampers and table leftovers were in abundance. Soil pH varied only slightly in control site than in active dumpsite.

There were relationships between organic matter and moisture content in the active dumpsite because organic matter increased generally with increase in moisture content. Again there was no clear relationship between moisture content and pH and no trend observed between pH and organic matter in active dumpsite. In control site there was an increase of organic matter for an increase pH.

4.2 DISCUSSION

Soil pH measures the concentration of Hydrogen ion in the soil. Values of pH in active dumpsite ranged from 7.87 to 8.34, indicating with a mean of 8.1±0.17 which is higher than that of control which ranged from 7.05 to 7.33 with mean of 7.03±0.3 indicating neutral soil. This value of 8.1±0.17 in dumpsite exceeds Federal Environmental Protection Agency and World Health Organisation of 7.00 respectively. In active dumpsite, the soil was generally alkaline and this is attributed to organic content accumulated on the soil [15].

The alkalinity of the dumpsite is also attributed to the agedness of the dumpsite [1] and it proves to be true as the dumpsite has been operating since 1999 although at that time it received less solid waste The pH value is the indication that the dumpsite is in the second stage of anaerobic decomposition and in transition to third stage [28].

Heavy metal cations are said to be more mobile under acidic conditions as they would be soluble and available to the environment according to Badmus [6]. The obtained pH in this study was generally alkaline at active dumpsite consequently the mobility of Mercury ions may not have been favoured completely by the pH.

Moisture content is an essential environment requirement for the growth of microorganisms and without microorganisms there is no biodegradation [14]. It promotes dissolution and mixing of soluble substances and nutrients. As the organic matter decompose by the help of moisture content, the pH is altered to alkaline because it serve buffer and release basic cations. Although the moisture content was not much high in this study but it showed positive correlation with pH and organic matter in the active dumpsite.

Organic matter content depends on a number of factors which include the level of microbial activity proportion of organic refuge, moisture content and the relative age of the dumpsite [2]. Moisture content is highly variable and can change dependant on the climate. This also makes the soil to be more dispersed and make it easy for the ionic species to migrate through the pore network [35].

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CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The main environmental problem associated with the disposal sites is the potential risk posed to the soil. The pH values of soil samples from the vicinity of the dumpsite range from 7.87 to 8.34 and the pH of the dumpsites and landfill is 7.00 according to Environmental Protection Agency. The pH values in the study hovers around slightly neutral to alkaline which is responsible for relative immobility of Mercury in dumpsite. Organic matter ranges from 11.47% to 19.17%. This errand increase moisture content which is 19.11% to 27.63% in the study and soil permeability. These combination make it easy for organic matter to form complex electron structures with heavy metals including Mercury (Hg) which are more stable in soil. Despite the soil being porous, Mercury if present will remain intact or immobile in the dumpsite soil.

5.2 RECOMMENDATIONS

1. There is need for public awareness on the harmful effects associated with dumpsite to discourage people farming close to the dumpsite.

2. Organic wastes should be sorted and composted for use as organic fertilizer to supplement inorganic fertilizers.

3. It is suggested that Mercury (Hg) and other heavy metals should be investigated as a follow up to this study.

4. More research is needed, in order to have a better understanding of the parameters investigated.

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