Predicting Organic Waste Performance in Soil Treatment from X-Ray Fluorescence Analysis

E.J. Bambokela, E. E. Agbenyeku, and E. Muzenda

***Abstract*—** Organic wastes refer to animal or plant based wastes that undergo natural biodegradation. In this study, the soil analysis was carried out on samples collected from a farm located on the out scares of Thokoza Township in Johannesburg, South Africa. The Farm operational site currently used for farming was once a waste dumping site. The moisture content of different samples was determined with an initial weight of 100g; each sample was placed in an oven and heated at 107 °C for 2 hours. The X-Ray fluorescence (XRF) analysis was used in the determination of samples composition. Magnesium (Mg), Calcium (Ca), Potassium (K) and Phosphorus (P) were mainly discussed in this study. Horse dung and crushed bones were reported more suitable as fertilizers due to large amount of K and P considered as potential plant growth catalysts. Wood saw dust revealed particularities in its effect on sand especially in agriculture. The purpose of this study was to analyse, compare and predict the impact of horse dung, crushed bones, and wood sawdust in the land remediation and fertility improvement.

***Index Terms*—** Fertilizer, Horse Manure, Potassium, Sawdust.

I. Introduction

Turning waste into valuable and useful component is one of the most environmental concerns nowadays. Organic waste has gradually attracted high interest. For diverse applications, it has been seen as a potential source of energy and efficient fertilizer [1] – [2]. Animal manures, used as feedstock in Anaerobic Digestion (AD) during biogas production, often contain grass which constitutes the main alimentation for animals in farms [3]. From literature, it is deducted a relationship between animal dung and animal alimentation [3]. The quality of animal dung used as substrate in biomethane production also depends on the pasture's characteristics [3]. It is very important to perform soil analysis when choosing a farm as source of feedstock [4]. In this study, a soil analysis was performed by considering the characteristics of sand collected from the farm in order to determine the impact horse dung, crushed bones and wood saw dust could have on the land while being used as fertilizers.

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Diverse fertilizer formulations used individually or in combination in soils provide macro and micronutrients which are beneficial to plant growth [5]. Nitrogen (N), P, K, Ca and Mg are four important plant macronutrients [5]. Usually, micronutrients are very few and depend on soils pH [5].

Horse dung is an organic matter mixed with urine, grass and dry material deriving from horses and used as organic fertilizer or soil improver in agriculture as well as a source of renewable energy [6]. It adds organic matter and nutrients to the soil that enhances fertility [6].

Animal bones are a good source of P [7]. They contain N that can facilitate the composting processes of lingo-cellulosic waste [7]. Crushed animal bones are also seen as potential soil improver since it provides a fast release of nutrients although its use remains very little in commercial agriculture [7].Crushed bones are mainly used in the treatment of metal-contaminated soil by the formation of insoluble metal phosphates [8]. Metal-contaminated soils are mostly former industrial sites containing metals potentially toxic that can hinder their redevelopment by subsequently contaminating water supplies [8]. As a remediation technique, the addition of bone is used to immobilize Lead (Pb), Zinc (Zn) and Cadmium (Cd) in contaminated soils [9].

Wood is a natural renewable resource that is commercially exploited [10]. It is chemically defined as a biopolymeric composite of cellulose, hemicellulose and lignin [10]. Cellulose is defined as a structural polysaccharide considered as a main component of biopolymers of the wood biomass [10]. Therefore, wood sawdust, also known as dye, which is a by-product of wood and trees, constitute a source for energy production [11]. It is a synthetic chemical compound with aromatic structures used in the textile, plastic, food, pharmaceutical and cosmetic industries [11]-[12]. In Bangladesh, wood sawdust is mainly used in the cultivation of mushrooms [11]-[12].

This investigation aimed at evaluating the efficiency of horse dung, animal crushed bones and wood sawdust used as fertilizers in the soil treatment of contaminated soils to predict their future behaviors after application on the soil.

II. Methods and Equipment

In agriculture, a soil analysis determines nutrient and contaminated content, moisture content, composition, and other characteristics such as acidity or pH level of soil. The purpose of such analysis is to provide nutrients that cannot be adequately auto-supplied by the soil. The analysis finally determines how much of each nutrient the soil will provide to farmer's crop.

Fig.1. Collected samples in crucibles; Wood sawdust (1), Animal crushed bones (2), Horse dung (3).

A. Moisture Content Determination

The first step consisted on determining moisture content of each sample by weighing 100 grams of each sample, heating them in an oven for 2 hours at 107°C. After 2 hours each sample was weighed again to determine the amount of moisture lost. Considering the fact that the samples were highly organic, organic matter determination was run on the sand sample by burning it overnight in a furnace at 500 °C. Moisture contained in samples was determined from equation 1.

$$Moisture(\%) = \frac{Mwet - Mdried}{Mwet} \times 100 \qquad (1)$$

Where

Mwet: Initial weight of sample before heating in the oven.
Mdried: Final Weight of sample after heating in the oven.

Note: The initial and final weights of samples are calculated in grams (g).

B. The X-Ray Fluorescence Analysis

XRF spectrometer is an X-ray device used to analyze chemical composition of fluids, rocks or minerals. XRF spectrometry is widely used in the determination of major and trace elements in natural and geological materials [13].

The XRF device was used to perform an elemental analysis using a Rigaku ZSX Primus II with SQX analysis software (Japan) as shown in fig. 2. Before proceeding, 10 grams of each sample was weighed and placed in an oven at 500 °C overnight to dry them up. Samples were mixed with 3 grams of Sasol Wax used as a pellets binder. The mixed samples were each placed in an XRF container and compressed using a compressor for 2 minutes. The compressed pellets were dried for an hour then placed in the XRF for analysis.

C. Soil pH Determination

The sand pH was also determined by weighing 10 grams of sand and adding it to a beaker.10ml of distilled water was added to a beaker. The solution was vigorously agitated to allow slurry to set. And a stable reading was recorded from the pH meter.

Fig.2: XRF analyzing device (Rigaku ZSX Primus II)

III. Results and Discussions

As shown in table I, the moisture content of different samples was determined with the same initial weight of 100g. Each sample was placed under a temperature of 107 °C. According to the results, it was shown that a high loss of water was observed in sawdust and horse dung.

TABLE I. MOISTURE CONTENT OF COLLECTED SAMPLES

Component	Mwet (g)	Mdried(g)	Moisture (g)
Sawdust	100	80.42	19.58
Sand	100	97.17	2.83
Horse dung	100	81.04	18.96
Crushed bones	100	95.05	4.95

These results are justified by the fact that wood sawdust comes from trees, and trees are subject to the osmosis process whereby the water accumulated by the sand (land) is absorbed by the roots of trees to be distributed across the branches to produce fuel through leaves by photosynthesis. In other words, every plant absorbs water from the land to live. This explains why there is not much moisture content in sand because most of water was already absorbed by existing plants. Since, animals such as horses are very grazing, the amount of water contained in grass is also found in their manures after digestion [3]. This explains why the amount of water content in the manure is high. A small amount of water is seen in the bones since water is found in larger quantity in others parts of living creatures than in bones. Although water constitutes the major components of most body parts of a living body, bones seem to have the least of it.

TABLE II: SAMPLES CHEMICAL COMPOSITION

Component	Horse dung (mass %)	Sand (mass %)	Bones (mass %)	Sawdust (mass %)
Na_2O	0.264	0.0555	0.5409	-
MgO	2.3794	0.3378	0.3422	2.5529
Al_2O_3	3.0221	14.4688	0.6284	7.6116
SiO_2	28.394	60.6032	2.7093	26.7039
P_2O_5	3.758	0.1872	9.0887	3.114
SO_3	6.5855	0.3218	20.3217	8.9661
Cl	5.3906	0.0469	1.3364	3.9156
K_2O	21.5774	1.2786	20.8792	10.2955
CaO	16.1255	0.6726	42.0312	18.2311
TiO_2	0.7517	1.6619	-	-
Cr_2O_3	0.0831	0.1212	-	-
MnO	1.9156	0.2656	0.0518	1.7348
Fe_2O_3	8.8945	19.7174	1.6581	16.3109
NiO	0.0459	0.049	-	-
CuO	0.0707	0.0311	-	-
ZnO	0.3846	0.019	0.0774	0.5635
Br	0.1607	-	0.0114	-
Rb_2O	0.1021	0.0192	-	-
SrO	0.0913	-	0.0498	-
ZrO_2	0.0034	0.1431	-	-
BaO	-	-	0.2735	-

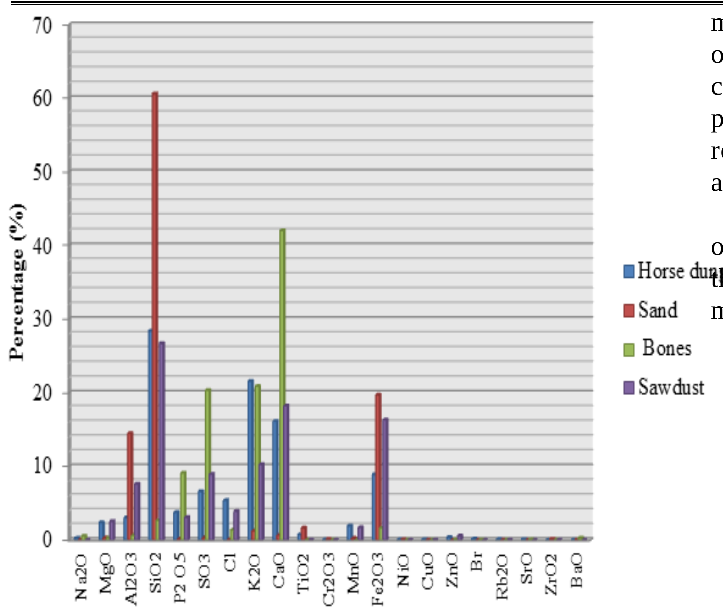

Fig. 3: Chemical composition of collected samples

In fig. 3 and table 2, there was a significant amount of K in compost (horse dung) and crushed bones. K which is considered as an important plant nutrient, [5] participates in various plants functions, including nutrient adsorption, respiration, transpiration and enzyme activity [5], [7]. It enhances the plant growth and does not become part of the plant compounds but remains in ionic form in the plant. Even after harvest, the potassium residues in plants are quickly returned to the soil by water leaching through the plant materials and manures [5]. The largest amount of P was observed in bones and horse dung. Knowing that P constitutes a catalyst for increasing early growth and that plants deficient in phosphorus are subject to abnormal growth, Phosphorus is reported to be one of the most important element in agriculture[7].

The difference of composition determines fertilizers effects on sand there are mixed with. In table II and fig.4, the focus of the analysis was more based on the amount in % of these four major components: Mg, Ca, K and P.

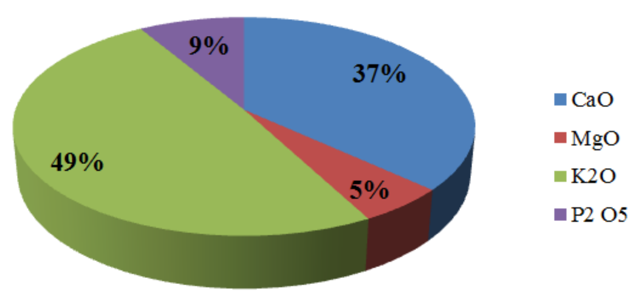

Fig. 4.a: Horse dung composition in mass %.

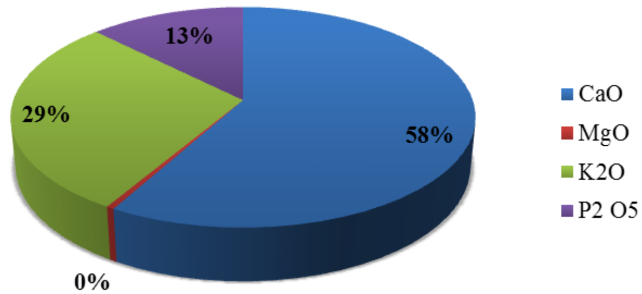

Fig. 4.b: Bones composition in mass %.

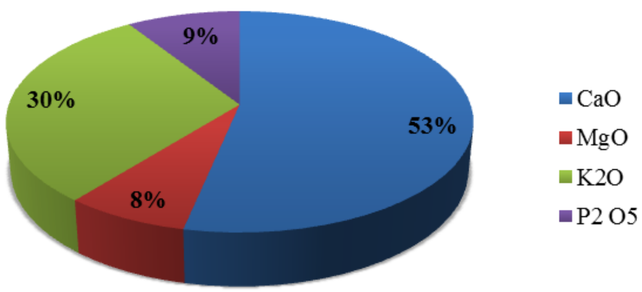

Fig. 4.c: Wood sawdust composition in mass %.

The highest amount of Mg is found in compost (horse dung) and in insignificant amounts in other samples. The high amount of Ca in bones is justified by the fact that bones in themselves have originally a high percentage of calcium [8]. Therefore even as waste the quantity of Ca therein does not really change. Some plants and trees are also considered as good source of calcium. Most of their leaves are sometimes recommended for human beings alimentation with the purpose of strengthening bones. Evidently, grass and different plants consumed by horses are released as manures after digestion with a certain quantity of calcium as well. As per Fig. 5, Aluminum (Al), Iron (Fe), Silicon (Si) were highly present in sand.

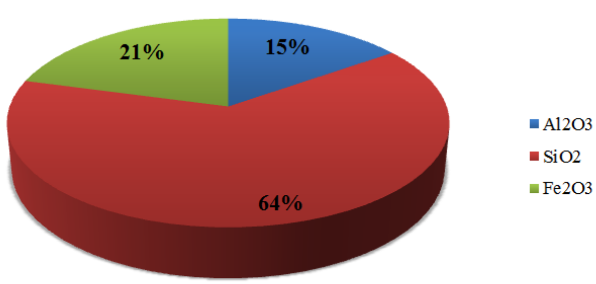

Fig. 5: Sand composition in mass % in terms of Al, Si and Fe.

Although these elements are not inhibitory such as Pb, Zn and Cd, good organic immobilsers should be applied to prevent any negative effect on the vegetation.

The chemical composition of sand sample showed that the land was not a metal-contaminated soil. However as a former damping site, a diversity of waste was observed. Since it is currently exploited for farming purposes, the suitable fertilizers that would remediate or improve the quality of the farming land are the horse dung and the crushed bones. A combined application of both components should enhance the fertility of the land. The high amount of P and K will speedily activate the process of plant growth by treating, and transforming the quality of sand in particular ways.

As stipulated by Moonmoon *et al.*, [11] wood sawdust constitutes a very efficient fertilizer for cultivation purposes. In this case, apart from horse dung and crushed bones, saw dust will be a good catalyst for plant growth as well. Therefore, a combination of dung, bones and wood sawdust would highly improve the land fertility.

IV. Conclusion

By means of soil analysis, nutrient, contaminated content, moisture, composition, and other characteristics such as acidity or pH level of soil were determined. The purpose of such analysis was to provide nutrients that could not be auto-supplied by the farming land. The focus of this analysis was more based on the amount of these four major components: Mg, Ca, K and P. Horse dung had the highest amount of Mg and K. Whereas Crushed bones contained the highest amount of P and Ca. Sawdust composition appeared more closely like sand in terms of Fe, Al and Si. A combination of horse dung, bones and wood sawdust was proposed to remediate the land and increase its fertility although no metal-contamination was observed.

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