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Comparative Analysis of Pit Composting and Vermicomposting in a Tropical Environment

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***Abstract*—**Biodegradable solid waste disposal and management has been a major problem in Nigeria and indiscriminate dumping of this waste either into watercourses or drains has led to environmental hazards affecting public health. The study investigated the nutrients level of pit composting and vermicomposting. Wooden bins 60 cm × 30 cm × 30 cm^3 in size were constructed and bedding materials (sawdust, egg shell, paper and grasses) and red worms (*Eisenia fetida*) introduced to facilitate the free movement and protection of the worms against harsh weather. A pit of 100 cm × 100 cm × 100 cm^3 was dug and worms were introduced into the pit, which was turned every two weeks. Food waste was fed to the red worms in the bin and pit, respectively. The composts were harvested after 100 days and analysed. The analyses gave: nitrogen has average value 0.87 % and 1.29 %; phosphorus 0.66 % and 1.78 %; potassium 4.35 % and 6.27 % for the pit and vermicomposting, respectively. Higher nutrient status of vermicomposting over pit composting may be attributed to the secretions in the intestinal tracts of worms which are more readily available for plant growth. However, iron and aluminium were more in the pit compost than the vermin compost and this may be attributed to the iron and aluminium already present in the soil before the composting took place. Other nutrients in ppm concentrations were aluminium 4,999.50 and 3,989.33; iron 2,131.83 and 633.40 for the pit and vermicomposting, respectively. These nutrients are only needed by plants in small quantities. Hence, vermicomposting has the higher concentration of essential nutrients necessary for healthy plant growth.

***Keywords*—**Food wastes, pit composting, plant nutrient status, tropical environment, vermicomposting.

I. Introduction

GLOBAL food waste has been quantified over several decades and such assessments are reliant on limited datasets collected across the food supply chain (FSC) at different times and extrapolated to the larger picture. According to [3], as much as half of all food grown is lost or wasted before and after it reaches the consumer. Food wastes may be referred to as wholesome edible material intended for human consumption, arising at any point in the FSC that is instead discarded, lost, degraded or consumed by pests and this may include edible material that is intentionally fed to animals or is a by-product of food processing diverted away from the human food [8], [4]. However, global population has been predicted to continue to grow and likely to plateau at some 9 billion people by roughly the middle of this century, resulting in higher food consumption and a greater demand for processed food, meat, dairy, and fish, all of which add pressure to the food supply system [1].

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These food wastes constitute a greater percentage of economic losses in developing countries with its attributed meagre financial resources. A way out of these economic losses, with its attendant limited financial resources, is waste to wealth through recycling; and waste reduction by recycling, which is an important part of any integrated waste management system according to [7]. Management of organic waste is a major course of concern worldwide, as unsafe disposal of this waste can adversely affect the environment (air, water and soil) thereby causing offensive odour, ground water contamination and soil pollution, and also poses a risk to human health. These researchers also reported various physical, chemical and microbiological methods of disposal, which are either time consuming or involve very high cost due to inputs. Thus, vermicomposting and pit composting have turned out to be a promising way out for the safe disposal of organic waste in developing countries with limited resources [6].

Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product. Similar, is the process of pit composting in which biological aerobic transformation of an organic by-product takes place and results in different organic product that can be added to the soil without detrimental effects to crop growth. Unlike other composts, vermicompost also contains worm mucus which helps prevent nutrients from washing away, holds moisture better and thus helps in increased plant growth [2]. Vermicomposts are earthworm-processed organic wastes, finely divided peat-like materials with high porosity, aeration, drainage, and water holding capacity. The vermicomposting is bio-oxidation and stabilization of organic material involving the joint action of earthworms and microorganisms. Although, microbes are responsible for the biochemical degradation of the organic matter, earthworms are the important drivers of the process, conditioning the substrate and altering biological activity [10].

II. Materials and Methods

The experiment was carried out at Agricultural and Environmental Engineering Department, University of Ibadan between April to August 2012 to analyze the chemical elements in pit- and vermin-compost using the same composting materials. The compost pit dug was 100 cm × 100 cm × 100 cm^3. The compost pit was filled with layers of materials in the following sequence: A layer of 20 cm to 25 cm thick dry plant materials was introduced into the pit. The compost materials were sprinkled with the water to make it wet. This was followed by a layer of moist (green) plant materials until the pit was full to the top and covered with soil material, wet mud mixed with grass and wide banana leaves. The compost pile was turned every two weeks so as to ensure that the pile was well aerated and to ensure that the whole composting materials were evenly decomposed. The compost was harvested after 120 days.

Materials used for vermicomposting include: plant weeds, kitchen wastes, grasses, sawdust, red worms, and worm bin. The worm bin was constructed with wood of 60 cm × 30 cm × 30 cm^3. The bedding for the bin was made of shredded papers, sawdust, grass clippings and egg shell. These materials were soaked for three days (72 hours), after which the water was squeezed out from the bedding. The bin was filled to 22 cm of bin depth with the damp bedding materials. The bedding was gently placed in position avoiding compaction, as air spaces are necessary for successful composting, helping to control odours and facilitating freer movement and air for the worms. The vermicomposting was terminated at exactly 100 days. The pit- and vermin-compost samples were taken to the laboratory to determine the nutrient composition.

III. Results and Discussions

Six replicates each of both the vermicast and pit compost were collected and tested for nutrients and samples of pit compost were labeled A_1-A_6, while samples of the vermicast were labeled B_1-B_6. Replicates were made to increase the accuracy of the analysis and for objectivity of the analysis and results obtained.

TABLE I
Chemical Analysis of Pit Compost

Parameters	A1	A2	A3	A4	A5	A6	Average
pH	6.8	6.38	6.57	6.83	6.72	6.96	6.71
EC($Mscm^{-1}$)	3.78	3.65	3.81	3.72	3.94	3.69	3.77
Nitrogen (%)	0.88	0.81	0.9	0.91	0.84	0.88	0.87±0.04
Nitrate Nitrogen (ppm)	370.5	340.3	365.2	353.4	390.5	398.3	369.70±21.92
Phosphorus (%)	0.56	0.51	0.66	0.6	0.97	0.66	0.66±0.165
Potassium (%)	3.98	4	4	4.45	4.67	5	4.35±0.43
Calcium (%)	2.28	1.87	2.11	2.17	2.83	2.35	2.27±0.29
Sodium (%)	0.05	0.05	0.06	0.05	0.05	0.05	0.05±0.004
Magnesium (%)	0.21	0.27	0.21	0.22	0.26	0.29	0.24±0.03
Iron (ppm)	2646	3107	2604	2323	926	1185	2131.83±874.68
Zinc (ppm)	55	79	74	100	105	98	85.17±17.56
Manganese (ppm)	192	180	190	222	223	214	203.50±16.83
Copper (ppm)	40	21	34	36	26	28	30.83±6.44
Aluminium (ppm)	5445	6961	3945	5048	4131	4467	4999.50±1016.38

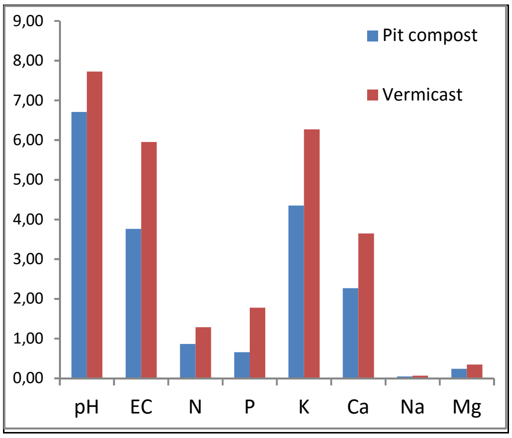
From Table I, the pH has values ranging between 6.3–6.9 and 7.4–8.1 for the pit- and vermicompost respectively. This is indicative that pit compost is slightly acidic while the vermicompost is slightly basic. The difference may be attributed to the use of un-ripped orange substrate present as part of food wastes for the pit composting but not present for the vermicomposting. Electrical conductivity has values ranging between 3.7–3.8 and 5.3–6.8 for the pit- and vermicompost, respectively. This implies that vermicast contained more soluble salts than the pit compost, thereby making soluble nutrients more readily available for the planted crops. This agrees with the works of [9], [11]. which stated that an important feature of vermicompost during the processing of the various organic wastes by earthworms, many of the nutrients are changed to forms that are more readily taken by plants such as nitrate or ammonium nitrate, exchangeable phosphorous and soluble potassium, calcium and magnesium. Therefore, vermin-compost contains more exchangeable plant nutrients than pit composted materials.

Furthermore, nitrogen has values ranging from 0.81–0.91 % and 0.88–1.76 %, nitrate nitrogen 340.3–398.3 ppm and 400.5–500.8 ppm, phosphorus 0.51–0.97 % and 1.49–1.89 %, potassium 3.98–5.00 % and 5.06–7.00 %, calcium 1.87–2.83 % and 2.58–4.40 %, sodium 0.04–0.06 % and 0.06–0.07 %, magnesium 0.21–0.29 % and 0.30–0.40 %, zinc 55–105 ppm and 99–164 ppm, manganese 180.0–223.0 ppm and 750–840 ppm, copper 21.0–40.0 ppm and 47.0–68.0 ppm, aluminium 3945.0–6961.0 ppm and 2537.0–4992.0 ppm, iron 926.0–3107.0 ppm and 517.0–2543.0 ppm in the pit compost and vermicompost, respectively. The result showed that almost all the nutrients were more concentrated in the vermicompost than in the pit compost with the exception of aluminium and iron.

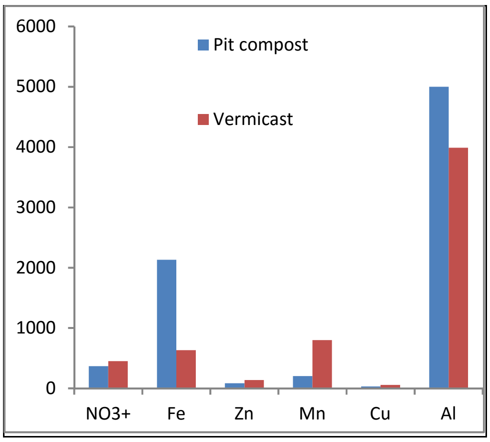
These results agree with [10], which stated that vermincomposted results indicated the presence of some growth-promoting substances in the worm-processed material and also contained a considerable amount of some essential plant micronutrients such as Cu, Fe, Mn and Zn that might be responsible for better plant growth and productivity. This was also reported by [5] that the higher growth of various plant characteristics in vermicompost compared to normal composts was not only because of the presence of greater amounts of most of the plant nutrients, but also due to the presence of microbial metabolites, plant-growth promoting hormone-like substances that promoted stem elongation, root initiation and root biomass, suggesting the linkage between the biological effects of vermicompost and microbial metabolites that influence plant growth and development. These previous researchers however opined that the quality of the vermicompost and its effects on plant growth may depend on a variety of other factors, which need further investigations. However, iron and aluminium were the nutrients more concentrated in pit- than the vermin compost and this may be due to the iron and aluminium readily present in the soil before the composting took place.

TABLE II
CHEMICAL ANALYSIS OF VERMI COMPOST

Parameters	B1	B2	B3	B4	B5	B6	Average
pH	7.41	7.59	8.07	7.8	7.82	7.67	7.73 ±0.23
EC(Mscm^{-1})	5.79	5.26	5.34	6.08	6.83	6.42	5.95 ±0.61
Nitrogen (%)	1.13	1.76	1.5	1.31	1.18	0.88	1.29 ± 0.31
Nitrate Nitrogen (ppm)	480.3	420.7	500.8	473.5	400.5	440.1	452.65 ± 38.51
Phosphorus (%)	1.74	1.49	1.89	1.86	1.85	1.87	1.78 ± 0.15
Potassium (%)	6	5.06	6.07	6.83	7	6.63	6.27 ± 0.71
Calcium (%)	2.58	3.31	3.32	3.83	4.47	4.4	3.65 ±0.66
Sodium (%)	0.06	0.07	0.07	0.07	0.07	0.07	0.07 ± 0.004
Magnesium (%)	0.32	0.3	0.37	0.35	0.39	0.4	0.35 ± 0.03
Iron (ppm)	2543	517	522	597	605	926	633.40 ± 150.80
Zinc (ppm)	191	122	136	164	118	99	138.33 ± 30.73
Manganese (ppm)	810	760	840	820	820	750	800.00 ± 33.167
Copper (ppm)	63	67	68	55	59	47	59.83 ± 7.27
Aluminium (ppm)	4074	2537	4922	4475	3988	3940	3989.33 ± 733.10



(a)



(b)

Fig. 1 (a) Evaluation of Pit- and Vermi-compost, (b) Evaluation of Pit- and Vermi-compost

IV. CONCLUSIONS

Disposal of solid waste is a problem in most developing countries. Composting can be an alternative way of waste disposal. Composting process will help to manage food and yard waste, and also serve as a source of fertilizer for growing crops in the field. The results of this study showed how rich in nutrients both pit compost and vermicompost were, but also laid emphasis on the fact that vermicompost was richer in nutrients than the pit compost.

If the composting process is carried out solely to obtain manure for the growing of crops, vermicomposting is better suited. However, both methods of composting will help manage waste efficiently. Farmers should be enlightened and encouraged not to only use pit compost, but also vermicompost, because it is richer in nutrients than the pit compost.

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