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Vermicomposting Potential of *Eudrilus eugeniae* and Its Biological and Chemical Properties

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Abstract – *The use of various waste as feedstock is very crucial in the production of vermicast with high nutrient content. It helps harness the biological effectiveness of Eudrilus eugeniae as vermicomposting agent in the reduction of biodegradable waste. This study determined the vermicomposting potential of E. eugeniae using experimental research design that employed laboratory techniques to ascertain the biological and chemical composition of the vermicast. Analysis of Variance and the Tukey HSD test were the statistical methods utilized. Results showed that using animal waste as feedstock for E. eugeniae generated higher amount of vermicast. The chemical analysis revealed higher N and P using kitchen waste whereas agricultural waste had the highest levels of K. Likewise, there were greater microbial counts observed in vermicast. When compared to fungi, bacteria have a significantly higher number of colony forming units.*

Keywords – *organic waste, vermicast, vermicomposting*

INTRODUCTION

The art of composting has been part of the global culture since the ancient times. The basic principles are quite simple and adhering to them will result in an efficient and successful outcome. Studies have shown that home composting can divert an average of 700 lbs of material per household each year from the waste stream. Municipal composting carries a greater environmental cost, but not nearly as high as when leaf and yard wastes are disposed of by conventional means ("Vermiculture, The Management of Worms," 2012).

A recently introduced methodology in composting which makes use of earthworms is known as vermicomposting. Vermicomposting provides a way for waste management and reduction. Other than offering potential sources of supplemental income to organic farmers, it also generates high quality compost. Because of the benefits of vermicomposting, farmers and governments around the world are beginning to vermicompost like never before, especially in places which have warmer climates. India and Cuba are leading the way.

The direct physical role of earthworms in organic decomposition is through ingestion, digestion, and egestion. During ingestion and digestion, earthworms create tubular soil pores, making burrows and channels 1-10 mm in diameter and can extend to depths of two meters or more. Earthworms mediate transport of both organic matter and inorganic matter into the soil. Egestion results in the production of feces (cast or crumbs) which contain humic acid.

Humification causes increased soil microbial respiratory activity and thus enhances soil chemical fertility (Gómez, & Domínguez, 2013).

Along with these great benefits, the use of various wastes as feedstock is therefore very crucial in producing vermicast with high nutrient content. Likewise, much work is still needed to harness the biological effectiveness of *Eudrilus eugeniae*.

Therefore, this research was carried out to determine vermicomposting potential of *E. eugeniae* and its biological and chemical properties with *E. eugeniae* as the vermicomposting agent along with its great potential to waste management program.

OBJECTIVES OF THE STUDY

This scientific study investigated the vermicomposting potential of *E eugeniae* and its biological and chemical properties from various wastes.

Specifically, it aimed to:

1. determine the amount of vermicast produced by *E. eugeniae* and the significant differences among the various wastes:
   1.1 agricultural waste
   1.2 animal waste
   1.3 kitchen waste
   1.4 mixed waste;
2. analyze the chemical composition of the vermicast

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3. examine the biological composition of the vermicast

Materials and Methods

Completely Randomized Design (CRD) was used as an experimental design of the study with *E. eugeniae* as vermicomposting agent. In this study, there were four treatments employed which served as feedstocks. Each treatment was replicated ten times and coded as follows: T1 – agricultural waste, T2 – animal waste, T3 – kitchen waste and T4 – mixed waste.

The study utilized CRD because it allowed complete flexibility as to the number of treatments and replicates other than its appropriation in small experimental study.

Materials

Construction Materials

Sheltered wormery was recommended to protect the worms from excessive sunlight and rain. Galvanized iron sheets, roofing nails and coconut lumber served as the roofing material while the fence was constructed using one-inch square hole galvanized iron welded wire mesh held by a coconut lumber of 2 in. x 3 in. x 8 ft. The flooring was made of slab materials using hollow blocks, sand, pebbles, and cement.

Weighing scale

A 60 kg excellently calibrated Fuji mechanical table scale as measuring device from one of the most trust-worthy brands which is to measure several materials in the study such as the amount of the bedding materials, earthworms, feedstock, and the vermicast collected per container.

Water

Non-chlorinated water or water taken from deep well was used to moisten the bedding material. Initially, 500 ml of water was used per container in the worm bin.

Beddings

The bedding materials were composed of various biodegradable residues such as cardboard, soil and sand. The selection of the bedding materials on the use of cardboard was based on the findings of Monroe (2008), that shredded paper or cardboard made an excellent bedding particularly when combined with typical on-farm organic resources such as straw and hay. In this study, the bedding material for vermicomposting systems consist of 500g of cardboard, 250 g of sand and 1000 g of soil.

Worms

The African night crawler (*E. eugeniae),* Red worms *(Eisenia foetida)* and composting worm *(Pereonyx excavatus)* are promising worms used for vermicompost production. All the three worms can be mixed for vermicompost production. The African worm *(E. eugeniae)* was preferred over other two types, because it generates higher production of vermicompost in short period of time and younger ones in the composting period. Edwards and Arancon (2006) also cited that African night crawler (ANC) is only one of the most common species of earthworms that have been identified worldwide as having the best potential for breaking down organic materials. Thus, the African night crawler *(Eudrilus eugeniae)* was used in the study.

Twenty kilograms of *E. eugeniae* was used as vermicomposting agent. This was purchased at the Municipal Recovery Facility of Balungao, Pangasinan.

Procedures

Site Identification for Vermicomposting

The vermicomposting site was situated under a mango tree which was somewhat shady and cool. This provides an ideal condition to produce vermicast and for *E. eugeniae* which live and reproduced at temperatures between 21 and 29˚C. The area was near the residence of the researcher who manage the site for constant monitoring and maintenance. Water supply was also considered to maintain climatic conditions required in handling vermicast.

Construction of Vermicomposting Facility

The vermicomposting facility was constructed with a slab flooring with an area of 36 ft^2. The floor was elevated to prevent flooding in the area during rainy season. The area provided an adequate space to permit ease of movement for activities done inside the structure. The vermicomposting facility was enclosed with an iron mesh wire with 1x1 square holes for proper ventilation and aeration. Corrugated galvanized iron sheets roof was also provided to protect the process from climatic conditions such as rains and other types of weather.

Collection of Various Wastes

Various organic wastes in the forms of animal, kitchen, and agricultural which are used as feedstock to *E. eugeniae* were collected. Plastic containers were

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properly labeled and provided in the area. Each container served as a collecting medium for every waste. The wastes in the compartments were pre composted for two weeks that made them easier to digest by *E. Eugeniae*. Organic wastes were reduced to smaller sizes and were mechanically separated from non-biodegradable wastes before they were placed in the compartments. This process partially composted the materials making them fit for earthworm consumption.

Construction of Vermicomposting Bin

Since storage areas for vermicomposting were diverse, the researcher made modifications on the design to meet the needs of the study.

The containers were big enough to hold more than two kilograms of organic waste provided in a week. Their size also offers greater surface area for ease of adding feedstock and removing the vermicast. Each container has a well-fitting lid to prevent rats from eating its contents and to protect it from light. Using a 3/8 drill bit size, 30 2–3-inch holes were made across the entire cover. The holes provide aeration inside the container. The edge of the holes was smoothened using a sandpaper. A plastic faucet at the bottom of the container was attached using an all-purpose structural adhesive (Epoxy).

Moreover, dirt and odor were removed from the plastic bins by washing them thoroughly with soap and water. A thick, porous plastic mesh was placed beneath the bottom of the container to allow the passage of excess amount of moisture but prevent the passage of earthworms and other substrates in the faucet. To secure the plastic bin in place, a total of four, two layered galvanized square tube iron stands were constructed. Each iron stand held 10 plastic bins which served as replicates for each treatment. The bins held by the iron stand were arranged following the CRD inside the vermicomposting facility.

Preparation of Bedding Materials

Bedding materials used in this study were prepared by placing 500 g of cut cardboard material strips. These were placed on top of the plastic mesh inside the vermicomposting bin. A layer of 250 g of fine sand was spread over the strips of cardboard material followed by another 250 g of garden soil. The sand provided an added "grit" for the *E. eugeniae* to digest their food better. The bedding materials were moistened by placing 250 ml of water to achieve a 75 percent water content by weight. Over these materials, ½ kg of *E. eugeniae* was placed uniformly.

Addition of Earthworms into the Vermicomposting Bin

Each vermicomposting bin received 500 g of *E. eugeniae*. Over the top of the prepared bedding, *E. eugeniae* were distributed gently. After the worms were added, they were given a day to work their way into the bedding before feedstock was given to them.

Adding Feedstock to the Vermicomposting Bin

E. eugeniae were fed regularly, usually once a week every morning. Under ideal conditions, *E. eugeniae* can consume about half of their body weight or more each day. Since 500 g of *E. eugeniae* was placed in each vermicomposting bin, two kilograms of various wastes per treatment were introduced weekly in each container. The various wastes were taken from the containers where wastes were pre composted. A weighing scale was used to measure the various wastes before placing them inside the vermicomposting bin. After giving the feedstock, 250 ml of water was sprayed on top to maintain proper moisture contThe properroper recording was done to find out the rate of consumption of the feedstock given.

Harvesting of Vermicast

When the feedstock and bedding were mostly digested, the vermicast was collected from the bins. The vermicast formed on the top layer was collected once a week. Using a trowel, the vermicast was scooped out, sieved and placed in a container. The harvesting of vermicast was limited to the earthworm present on top layer. The harvested vermicast was measured and stored under a shady place to retain moisture and allow the growth of beneficial microorganisms.

Maintenance of the Worm Composting Bin

To ensure that the system ran properly, the researcher made sure that the worms were within their feedstock and bedding. During the feeding time, observations were employed to find out what was happening in their bin. Feedstock was introduced when various wastes were almost composted in the system. The bedding material should be moist but not wet. Daily watering was not required for vermi bed, but 75 percent moisture must be sustained throughout the process. Water was sprinkled over the bedding materials if necessity arises. Watering was stopped before the harvest of vermicast. Otherwise, the castings will get compacted when watering was done. Using a laboratory thermometer, temperature was measured inside the container, because the temperature in the moist bedding must be lower than the outside air

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temperature. Bedding temperature should not be higher than 32˚C because it will be harmful and sometimes fatal to the *E. eugeniae* populations. Proper aeration must be monitored to avoid foul odors in the system.

Analysis of Vermicast

Since there were ten vermicomposting bins per treatment, a sample was taken in each bin and mixed thoroughly. The sample was reduced to one kilogram of vermicast per treatment, sufficient for the analysis of its chemical and biological content. The vermicast was submitted to Regional Soils Laboratory in San Fernando, La Union for chemical analysis while the biological component was analyzed in the Department of Agriculture, Bureau of Soil and Water Management in Diliman, Quezon City.

Results and Discussion

Amount of Vermicast Produced by *E. eugeniae* and Differences among the Various Kinds of Wastes

The efficiency of various organic wastes in decomposition process to produce an ample amount of vermicast using *E. eugeniae* depends on the characteristics of the feedstock used. The amount produced can be attributed to the nature and characteristics of the waste such as particle size, moisture, and chemical content.

Table 1 indicates the amount of vermicast produced by *E. eugeniae* from various wastes such as kitchen waste, animal waste, and agricultural waste as well as the combination of the three as mixed wastes. The mean value was obtained by adding the amount of vermicast generated in every container and divided it with the total number of containers used in each treatment after feeding it with uniform amount of 260 kg of agricultural waste, animal waste, kitchen waste, mixed waste and two kilograms of consumable bedding materials.

The highest amount of vermicast generated among the four treatments is in the form of animal waste with a mean value of 240.8 kg followed by mixed waste with 220.8 kg, agricultural waste with 208 kg and kitchen waste being the least of 196 kg. The highest amount of vermicast produced from animal waste indicates that animal waste can be easily decomposed by *E. Eugeniae* as compared to the other wastes used in the study since it was already digested and composted from its source. Several studies were conducted in vermicomposting and the feedstock used in most cases were in the form of animal manure particularly cow dung. These were evident in the work of Vodounnou, Kpogue, Tossavi, Mennsah, and Fiogbe (2016), Lalander, Komakech and Vinneråsa (2015) and Ayyobi et al. (2014). The former discovered that the first substrate favored by *Eisenia fetida* was the cow dung.

Table 1. Amount of Vermicast Produced by *E. eugeniae* Fed with 262 kg of Various Wastes and their Differences

Treatment	Mean (kg)	F value	P value
T_1 - Agricultural Waste	208.0		
T_2 - Animal Waste	240.8	6.210*	0.002
T_3 - Kitchen Waste	196.0		
T_4 - Mixed Waste	220.8		

* Significant at the 0.05 level.

Animal waste particularly cow manure was regarded as the "ultimate" food for worms. Ultimate because it is loaded with microorganisms, has a carbon-to-nitrogen ratio in the ideal range, and it has excellent water-holding capabilities. Other than feedstock, it is also regarded as the best material for earthworms by promoting growth, stimulating reproduction, and providing an excellent habitat (Satyawati, Kaviraj, Santosh, & Padma, 2005).

The use of animal waste in the form of manure is known to be source of zoonotic pathogens and if left untreated can pose a major risk factor for the spread of disease to animals and humans. Using it as feedstock for earthworm can alleviate the negative effects of poor organic waste management. (Lalander, Komakech, & Vinneråsa, 2015).

However, feeding the *E. eugeniae* with kitchen waste was not advisable since it causes mortality of the earthworms in the container which resulted in a lower amount of vermicast production. The mortality of *E. eugeniae* in the container was due to the unfavorable environment within the container considering the bad odor and provision of too much moisture within the system. This situation was recognized in the Vermicomposting Bedding Guide by Uncle Jim's Worm Farm (2017), that the cause of the undesirable smell was due to the unhealthy environment and too much acidity in the system.

On the other hand, the differences of the vermicast produced from various wastes such as kitchen waste, animal waste, agricultural waste, and

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mixed waste were analyzed using Analysis of Variance (ANOVA) and the results are also shown in Table 1.

Table 1 also reflected the differences of the vermicast produced from various wastes. As presented, there is significant difference between groups in various wastes as revealed by the significant value of .002.

The p-value of .002 tells that the vermicast from various wastes varied significantly from each other in terms of the amount produced. It is noted that the most abundant amount of vermicast was produced using animal waste and the least amount came from kitchen waste. The difference can be associated to the nature of various wastes introduced to *E. eugeniae*. These includes the texture, size, odor, and moisture content of the wastes. Wastes that are rotted, soft and wet enough to be suck off are the wastes which are much easier to be composted by *E. eugeniae*. Vodounnou (2016), and Rameshwar (2016) also observed that biodegradation of organic waste results in differences in the amount of vermicast produced depending on the substrate given and species of earthworm. Other factors were also recognized by Chaoui (2010) that the change from organic wastes into casts depends on the density of waste, earthworm maturity and food preferences. With the foregoing findings, animal waste therefore is the best feedstock to be used in converting organic wastes to produce vermicast.

The p-value of .002 tells that the vermicast from various wastes varied significantly from each other in terms of the amount produced. It is noted that the most abundant amount of vermicast was produced using animal waste.

Furthermore, to provide detailed information about the differences in the vermicast produced from various waste, Tukey HSD results in Table 2 was subjected to a class of post hoc test employing a pairwise comparison analysis tests.

Shown in Table 2 is the pairwise comparison of the vermicast produced from various wastes. Based on the results, there was a significant difference of the vermicast produced from various wastes among the following pairs, T1-agricultural – T2-animal waste and T2-animal waste – T3-kitchen waste with mean difference of 3.28000, 4.48000, respectively. Pairs compared with T2-animal waste and T3-kitchen waste shows to be significantly higher. All other pairs are statistically the same in terms of the production of vermicast.

The value suggests that animal waste is more efficient in the decomposition process when compared to agricultural waste and kitchen waste in the production of vermicast.

The difference in the production of the vermicast coming from the different kinds of wastes can be attributed to the nature of the wastes. Animal waste in the form of carabao manure provides a better environment for *E. eugeniae* as compared to kitchen waste. Moreover, animal waste is more granulized, soft and serves as normal habitat for earthworms since it contains microorganisms which aid in vermicomposting.

Similarly, Wani, Mamta, and Rao (2013), recovered greater amount of vermicompost from the tub with cattle dung as compared to the tub with kitchen waste and the garden waste. The results of this study are also in agreement to the findings of Sinha, Herat, Agarwal, Asadi, and Carretero (2002), that earthworms will slowly accept kitchen wastes directly if no bait material like cattle dung is available thus resulting to a lower conversion of the waste into vermicast. With the foregoing findings, animal waste therefore is the best feedstock to be used in converting waste to produce vermicast.

Table 2. Pairwise Comparisons of the Vermicast Produced from Various Waste

Treatments		Mean Difference	Sig.
T_1 – Agricultural Waste	T_2 – Animal Waste	-3.28000*	.023
	T_3 – Kitchen Waste	1.20000	.690
	T_4 – Mixed Waste	-1.28000	.645
T_2 – Animal Waste	T_3 – Kitchen Waste	4.48000*	.001
	T_4 –Mixed Waste	2.00000	.272
T_3 – Kitchen Waste	T_4 –Mixed Waste	-2.48000	.122

Legend: * - significant at $\alpha = 0.05$ level

Analysis of the Chemical Composition of Vermicast

Vermicast

The chemical composition of the vermicast was taken from the results in the sample provided to the Department of Agriculture. The chemical analysis of

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the vermicast samples were analyzed at the Regional Soils Laboratory Division in San Fernando, La Union.

Table 3 indicates the chemical composition of the vermicast. Presented below are the percentages of the constituents as received in terms of its Nitrogen (N), Phosphorus (P) and Potassium (K). Nitrogen, Phosphorus and Potassium are the primary macronutrients that plants need to be healthy and these form the basis of NPK fertilizer compounds both for organic and commercial fertilizer.

Of the four treatments, T3 - kitchen waste generates the highest value for N which is 1.21 percent followed by T1 - agricultural waste 1.19 percent, T2 - animal waste 1.18 percent and T4 - mixed waste one percent. Since kitchen wastes are derived from vegetables and fruit peelings which are nitrogen rich, it is no wonder that it could produce higher nitrogen content. This is in consonance with the study of Haydar and Masood (2011), showing that nitrogen content depends upon the amount of nitrogenous materials in the feed stock.

Table 3. Chemical Composition of the Vermicast

Treatment	% Constituents as Received		
	N	P_2O_5	K_2O
T_1 - Agricultural Waste	1.19	0.48	2.01
T_2 - Animal Waste	1.18	0.59	0.69
T_3 - Kitchen Waste	1.21	0.71	1.34
T_4 - Mixed Waste	1.00	0.65	1.20

Mixed waste was recorded to be the lowest in terms of nitrogen content as compared to other treatments. The total volume of mixed waste comprises kitchen waste, animal waste and agricultural waste. The combination of these wastes specifically kitchen waste and agricultural waste decreases the percentage composition of N due to their moisture content. According to Green (2015), moisture content is another factor that reduces or dilutes the Nitrogen and Phosphorus concentrations of organic fertilizers. It also causes denitrification to occur resulting in loss of N as a gas (Fluence News Team, 2016). Thus, it can be cost ineffective to transport high-moisture organic fertilizer in long aeration (oxygen levels) and salt content through leaching, runoff, or denitrification (USDA-NRCS, 2018). There is possibility that the combined effect of the organic waste used in the study could increase the temperature, oxygen levels, and even the salt content that decomposes the N more quickly which leads to the decreased percentage content of nitrogen in the mixed waste. It can also be associated that the decreased in the percentage content of nitrogen in mixed waste were brought by bacteria that use oxidized nitrogen known as denitrifiers. They break down nitrates (NO_3) to metabolize oxygen, nitrogen gas is released (Fluence News Team, 2016).

On the other hand, the substrates used in agricultural waste were composed of banana trunks, rice hull, and hay. Based on the substrate used, all are plant-based in nature. Plant-based organic nitrogen sources tend to be less concentrated and have a lower percent of nitrogen.

In animal waste, substrate used was pure cow manure. In the nutrient policy and data of the United States Environmental Protection Agency, different animal types produce fecal matter with dissimilar nitrogen and phosphorus concentrations, of which chicken dung has the highest amount of N. It is no wonder therefore for cow manure to have lower concentration of N in its form. Puerto Rico have developed a uniform state fertilizer bill which says that available P_2O5 and soluble K_2O must be guaranteed by the manufacturer and the guaranteed analysis must be expressed in the oxide form.

Kitchen waste has the highest amount of P_2O_5 with a percentage value of 0.71 followed by mixed waste 0.65 percent, animal waste 0.59 percent and agricultural waste 0.48 percent. The highest value for kitchen waste in terms of phosphorus content can be linked to some food sources that have high levels of phosphorus such as banana peels and most grains and nuts which were used as feedstock in the study.

Animal waste (cow dung) and agricultural waste obtained considerable percentage value of 0.59 percent and 0.48 percent, respectively. The reason behind could be associated to the phosphorus concentrations in plant materials and farm manures which are too low for both materials to be of practical sources (Barker, 1999). A portion of the P in manure is in organic form and not readily soluble. The P content of a manure source varies depending on animal species, diet and the handling and storage of the manure. Manure testing is recommended to determine the P content of the manure (Robertson, Ketterings, Hunter, Czymmek, and Kilcer, 2012). Organic phosphorus derived from bat guano contains high P that could last for 2-3 years while chicken and pig manure could only last for 3-12 months. Rich organic sources of P include rock phosphate occurring

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as sedimentary deposits of marine organisms and bonemeal from cattle bones and fish (Organic Phosphorus Fertilizers, 2018).

After nitrogen, potassium is the most important nutrient plants need and is usually the nutrient responsible for the quality of the plant such as shape, color, size, and taste. Potassium served several functions in plant such as enzyme activation, stomata activity, photosynthesis, transport of sugars, water and nutrient transport, protein, and starch synthesis as well as crop quality (Tajer, 2016).

The percentage value of K_2O in agricultural waste shows the highest with a value of 2.01 percent followed by kitchen waste of 1.34 percent. Such value can be attributed to the kind of feedstock used in agricultural waste such as sliced banana trunks being rich in K_2O. Kitchen waste, on the other hand, used banana peels and other fruit and vegetable sources that gave a considerable amount of potassium.

A similar study was conducted by Wani et al. (2013), wherein animal waste, kitchen waste and agricultural waste were also fed to E. eugeniae and the vermicast produced were subjected to chemical analysis. Results showed that the NPK content was not similar as compared to the recent study. Such observations were also manifested in the studies of Lakra, Swaroop and Tarence (2017); Sinha, Patel, Soni, and Li (2014); and Chaoui (2010) The percentage value in the chemical analysis of vermicast were different in every study because of the differences in the feedstock given to earthworms.

It is worthy to note, however, that the varying chemicals detected for vermicast does not affect its positive effects to plant as fertilizer. It was still recognized as the best single-constituent organic source for balanced NPK fertilizer for providing quick and slower-releasing nutrients that supply a small, steady amount of nutrients over a course of time and in sustaining the growth of plants throughout the season as well as providing beneficial bacteria and fungi in helping plants assimilate nutrients.

Moreover, vermicast generally have a 1-0-0 NPK rating. This is lower than the required value of commercial fertilizers which offer ratings like 6-6-6, 10-10-10, 20-20-20 and up to 43-0-0 for commercial fields like golf courses. It has already been established that using vermicast in crops makes the plants grow healthy and produces nutritional products. The fact that vermicast can achieve that goal with the desired lower ratings of NPK is part of the real "miracle" of the casting. By keeping a lower rating of nitrogen (N) and phosphorus (P) to achieve the desired results is a major advantage in keeping our environment sustainable ("Is It Desirable for Castings to Have A Low NPK Rating?" 2018).

Phosphorus is needed for root development, stem formation, and fruiting in summer. P is elemental phosphorus. P_2O_5 is the fertilizer equivalent of phosphorus. Kitchen waste has the highest amount of P_2O_5 with a percentage value of 0.71 followed by mixed waste 0.65 percent, animal waste 0.59 percent and agricultural waste 0.48 percent. The highest value for kitchen waste in terms of phosphorus content can be linked to some food sources that have high levels of phosphorus such as banana peels and most grains and nuts which were used as feedstock in the study.

Analysis of the Biological Composition of Vermicast

The ability to enhance soil biodiversity by promoting the beneficial microbes is through the production of vermicast and aqueous extracts and these were determined through the microbial counts of the bacteria and fungi present in both forms.

The biological composition of vermicast is shown in Table 4. In terms of its biological composition, presence of bacteria and fungi were tested using pour-plate method. The test results were expressed in terms of the number of colony-forming units per milliliter (CFU/ml).

Table 4. Biological Composition of the Vermicast

Treatment	No. of Colony-forming Units/ml (CFU/ml)	
	Bacteria	**Fungi**
Agricultural Waste	$33x10^6$	$81x10^3$
Animal Waste	$13x10^6$	$82x10^3$
Kitchen Waste	$28x10^6$	$76x10^3$
Mixed Waste	$16x10^6$	$10x10^4$

Results show that the biological composition of vermicast in all the treatments given to *E. eugeniae* were dominated by bacteria as compared to fungi. This is in accordance to the study of Hendrikson (1990), as cited by Emperor and Kumar (2015), wherein high

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bacterial population in earthworm cast was also recorded.

The vermicast produced using agricultural waste yielded the highest microbial counts of bacteria with 33x106 CFU/ml while kitchen waste, mixed waste and animal waste resulted in 28x106 CFU/ml, 16x106 CFU/ml and 13x106 CFU/ml, respectively. This indicates that the different feedstock used in the present study had the potential of initiating the proliferation of bacteria in the production of vermicast. Another reason cited by Emperor (2015), is that the high population of bacteria may be due to bacterial growth during its transit through the gut of earthworms. Bernard et al. (2011) also suggested that earthworms promote the growth of bacteria.

Moreover, bacteria are the amplest organisms in the vermicompost system and recognized as the principal decomposers of organic matter on earth. They work on organic material by producing enzymes which separate the bonds holding molecules together, thus facilitating and decreasing the molecules to their integral elements for absorption. As bacteria cut down the organic matter, they make it usable to earthworms and other organisms in the system as well (Bot and Benitez, 2005).

The microbial count of fungi in the vermicast as recorded in Table 4 indicates higher value of 10x104 CFU/ml for mixed waste while animal waste, agricultural waste and kitchen waste microbial counts resulted to 82x103 CFU/ml, 82x103 CFU/ml and 76x103 CFU/ml, respectively. The microbial count for mixed waste being the highest can be accounted to the nature of feedstock that comprises it. Mixed waste is a combination of equal ratios of animal waste, agricultural waste, and kitchen waste. The nature of feedstock in all these wastes were plant-based. In plants, the main constituents in its cell wall are cellulose. Cellulose as fibrous carbohydrate, also known as fiber, is found in many fruits, grains, vegetables, and other plant materials and is the most prolific organic compound on earth. Fungi are cellulose decomposers. Cellulose favors the growth of fungi. The higher amount of carbon also dictates the microbial community for fungi.

However, comparing the microbial counts of bacteria to fungi in the present study, the CFU/ml for both microorganism is far higher in bacteria as compared to the fungi. Several studies showed similar observations. Sivasankari, Unnamalai, Ananthi, Arunkumar, and Perumal (2016), reported that among the CFU, the actinomycetes load was higher followed by the bacteria and fungi. Yami, Bhattarai, and Adhikari (2003), showed that the vermicast were predominated by bacteria followed by fungi and actinomycetes as shown in the microflora analysis while Huang, Li, Wei, Fu, and Chen (2013) and Brandón, Lores, and Domínguez (2013), found that vermicomposting caused the decrease in microbial activity as well as bacterial and fungal densities. Earthworm as primemover in the decomposition process, induces a predominant bacterial population in soil by destroying fungal hyphae; hence less fungal growth was generally observed.

Nevertheless, bacteria and fungi are of equal importance in providing sources of nutrition for earthworms in which earthworms could not grow in pure cultures of microorganisms.

It is worthy to note, however, that the varying chemicals detected for vermicast does not affect its positive effects to plant as fertilizer. It was still recognized as the best single-constituent organic source for balanced NPK fertilizer for providing

CONCLUSION AND RECOMMENDATION

Based on the findings of the study, the following conclusions were drawn:

1. Higher amount of vermicast can be generated using animal waste as feedstock for *E. eugeniae.* Animal waste in the form of carabao manure was the best feedstock to use in the production of the vermicast as compared to other forms of organic waste since it was already composted.
2. The chemical analysis for vermicast results to a higher percentage value for N and P using kitchen waste while agricultural waste generates higher percentage value of K.
3. The biological composition of the vermicast was generally higher compared with vermicast aqueous extracts. In both forms, bacteria gives the highest number of colony forming units when compared with fungi.

Based on the conclusions of the study, the following recommendations are offered:

1. Other forms of organic waste when fed to earthworms should always be mixed with animal waste in the form of manure. Poultry and other farm animals can also be used as feedstock for *E eugeniae.*
2. Soil type and the needs of the plants should be considered so that the appropriate feedstock will be

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given to the earthworms, since different feedstock gives different nutrient content.

3. To enhance the population of beneficial microorganisms other methods such as the use of vermitea brewing machine in the preparation of vermicast aqueous extract may also be considered.

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