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Heavy Metal Contents of Vermicasts Produced in the Visayas Region, Philippines

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ABSTRACT

The Philippine National Standard set a minimum requirement for a soil organic amendment to be classified as an organic fertilizer or soil conditioner. Soil organic amendments have been used through the years and many farmers have developed their own to restore soil fertility and increase the production of food crops. This study was conducted (a) to characterize the physico-chemical properties of vermicast and to determine if they could be classified as organic fertilizer or soil conditioner and (b) to measure the heavy metal content (Cr, Cd, Zn, Fe, and Cu) of the different vermicast produced in the Visayas Region to determine if these are safe to use for farming. Vermicast were collected from different farms from regions 6, 7, and 8 (Visayas Region). Majority of the vermicast were brown to black in color with moisture content ranging from 10-35%. Iron and Zinc were found to be the highest metal concentrations in all samples. Meanwhile Chromium, Cadmium, and Copper were only found in low concentrations based on the criteria set by the PNS (2016).

Keywords: vermicast, soil organic amendment/organic fertilizer/soil conditioner, heavy metal, physico-chemical properties, and Visayas Region, Philippines.

INTRODUCTION

Due to the adverse effects of chemical fertilizers and pesticides used by farmers to increase crop yield, interest has grown in the use of organic fertilizers. The application of these materials is one of the soil management techniques used to maintain the fertility status of the soil. The Philippine Organic Agriculture Act (RA 10068) was approved to promote and implement the practice of organic agriculture in the Philippines. This aims to cumulatively condition and enrich the fertility of the soil, increase farm productivity, reduce pollution, and reduce the destruction of the environment.

Organic fertilizers are used to substitute inorganic fertilizers that contain and provide nitrogen, phosphorus, and potassium as well as other elements essential for plant development and overall good health. According to the PNS (2016), an organic fertilizer is any product in solid or liquid form, of plant (except by-products

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from petroleum industries) or animal origin, that has undergone substantial decomposition and can supply available nutrients to plants with 5-10% total Nitrogen, Phosphorus (P_2O_5) and Potassium (K_2O). On the other hand, in soil conditioners, the release of nutrients from organic fertilizer is gradual as microorganisms in the soil breakdown and decompose the organic matter and make the nutrients available for plants (Mencide 2011). Nevertheless, the effectiveness of an organic fertilizer requires time but its effects are sustainable in the long run. This may be enriched by microbial inoculants and naturally occurring minerals but no chemical or inorganic fertilizer material should be used in the production or added to the finished product to affect the nutrient content. There are different sources of organic soil amendments, it can be plant residues or animal wastes at different stages of decomposition and the nutrient content would vary depending on the material.

There has been growing interest in organic farming by farmers as a possible alternative to chemical-based farming. As a result, many farms in the Philippines have formulated and developed their own, claiming these as organic fertilizers without undergoing certification. However, some farmers cannot afford to have their product quantified for its nutrient content. Also, some of these are being sold since these are claimed to lead to good crop performance. Therefore, there is a need, to determine the physical and chemical properties of organic fertilizers to assess their quality as a fertilizer. Data on the physico-chemical qualities could also be used as benchmark for every specific region. This particular research focuses on vermicast since majority of the farmer's association in the Visayas are into vermicomposting.

MATERIALS AND METHODS

COLLECTION AND PREPARATION FOR THE ANALYSES OF VERMICASTS

Samples were collected from the different farms around Visayas, Philippines (Figure 1). Fresh vermicast were placed in labeled plastic bags and brought to the National Abaca Research Center (NARC) Analytical Laboratory, Visayas State University (VSU), Visca, Baybay City, Leyte. A composite sampling of the solid organic soil amendments was done following the BAFS Soil Amendments Standard (PNS-2016). Samples were properly prepared for the physico-chemical analysis.

PHYSICAL PROPERTIES

A 2 g air-dried sample was weighed and analyzed using a moisture meter at 130 degrees Celsius for 5 minutes to determine the moisture content. The color was determined using a Munsell Color Chart. Air-dried vermicast was compared to the color chips on the chart to determine which color matches closely .

The pH was determined potentionmetrically (PCARR 1980). The percent organic matter (OM) was determined following the Walkley-black method (Nelson and Sommers, 1982). The total N (%) was analyzed using the Micro-Kjeldahl method (ISRIC, 1995). The total K (%) was determined using the Aqua Regia method (Chen and Lena, 2001). The total P (%) was determined by using the extract from the total K analyses and was quantified following Murphy and Riley's method (1985).

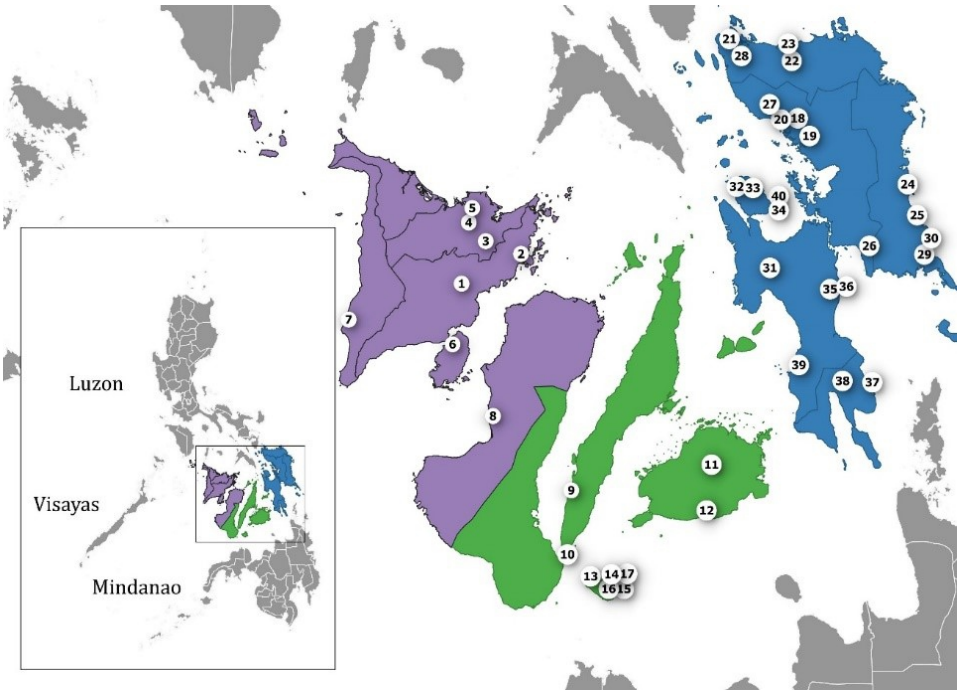

Figure 1. Map of the Visayas region in the Philippines showing the location of the sampling areas

Legends: 1- Bongloy, Dingle, Iloilo, 2- Silagon, Ajuy, Iloilo, 3- Astorga, Dumarao, Capiz, 4- Bangon-bangon, Sigma, Capiz, 5- Malapad Cogon, Sigma, Capiz, 6- Alaguisoc, Jordan, Guimaras, 7- Magcalon, San Jose, Antique, 8- Enclaro, Binalbagan, Negros Occidental, 9- LGU- Alegria, Cebu, 10- Sibulan, Negros Oriental, 11- Montesuerte, Carmen, Bohol, 12- Dimiao, Bohol, 13- Caipilan, Siquijor, Siquijor, 14- Cabal-asan, Maria, Siquijor, 15- Cabal-asan, Maria, Siquijor, 16- Bonga, Maria, Siquijor, 17- Olang, Maria, Siquijor, 18- Santa Margarita, Samar, 19- San Agustin, San Jorge, Samar, 20- Mike Pedroso Farm, Carayman, Calbayog, Samar, 21- Sabang, Allen, Northern Samar, 22- McKinley, Catarman, Northern Samar, 23- Milagrosa, Galutan, Catarman, Northern Samar, 24- Enderios farm Sitio Bontay, Brgy.Campesao, Borongan City, Eastern Samar, 25- Cantubi, Balangkayan, Eastern Samar, 26- Legaspi, Marabut, Samar, 27- Bontay, Calbayog City, Samar, 28- Buenasuerte, Victoria, Northern Samar, 29- Calutan, General MacArthur, Eastern Samar, 30- San Miguel, Hernani, Eastern Samar, 31- San Jose, Ormoc, Leyte, 32- Eamiguel, Naval, Biliran, 33- Capiñahan, Naval, Biliran, 34- Uson, Caibiran, Biliran, 35- Cabatoan, Dulag, Leyte, 36- San Jose, Dulag, Leyte, 37- Manalog, Hinunangan, Southern Leyte, 38- Buac Gamay, Sogod, Southern Leyte, 39- Cabulisan, Inopacan, Leyte, and 40- Canaan Hills Farm Canaan, Caibiran, Biliran

HEAVY METALS (Cr, Cd, Zn, Fe, & Cu) ANALYSES

This was determined using the Aqua Regia method (Chen & Lena 2001) wherein a 0.1 g sample that has passed through a 2-mm wire mesh was mixed and digested with 10 mL concentrated HCl and 5 mL of concentrated nitric acid. The samples were placed in a microwave digester after which the sample was diluted with deionized water and volume to 50 mL. The values of the analysis will be compared to PNS. 2016.

Table 1. Maximum Allowable level of Heavy Metals for Organic Fertilizers (PNS-BAFS, 2013 & 2016)

Heavy Metals	Maximum Allowable Level (ppm/ Dry Weight)
Arsenic (As)	20
Lead (Pb)	50
Chromium (Cr)	150
Mercury (Hg)	2
Cadmium (Cd)	5
Zinc (Zn)	5
Copper (Cu)	300

DATA ANALYSIS

In the characterization of vermicast, means and standard devation were determined. The occurrence of samples per region were elucidated through the use of frequency distribution table.

RESULTS AND DISCUSSION

STUDY AREA AND RAW MATERIALS USED

Vermicast were collected from the different farms of the three regions in the Visayas. Western Visayas, or Region 6, is composed of six provinces: Aklan, Antique, Capiz, Guimaras, Iloilo, and Negros Occidental. Region 7, known as Central Visayas, is composed of four provinces: Cebu, Bohol, Siquijor, and Negros Oriental. Region 8, or the Eastern Visayas, is composed of four provinces: Biliran, Eastern Samar, Northern Samar, Leyte, and Southern Leyte. Figure 2 shows that the majority of the raw materials used were manure in regions six (23%) and eight (32%) followed by cereal biomass (17%) and leguminous plants (25%). In region seven it was mostly leguminous plants (33%) followed by manure (25%). Some of the raw materials used by the farmers in making their vermicast came from the waste of the different crops obtained from their farm or in the market.

PHYSICAL ANALYSES

MOISTURE CONTENT

According to the PNS (2016), the actual moisture content of both organic fertilizer and soil conditioner should be 10-35%. Based on the results, there were 25 out of 40 whose moisture content was within the range of 10% - 35% (Table 2). Moisture content is one of the most commonly measured properties of fertilizers as this can affect their legal and labeling requirements. There are legal limits set for the maximum and minimum amount of water that can be present in the material. Moisture can also affect the economic value of the fertilizer and, lastly, its quality. Quality issues arise if moisture levels in fertilizers exceed the recommended levels. Most of the vermicast collected in all regions had a moisture content between 10-35%.

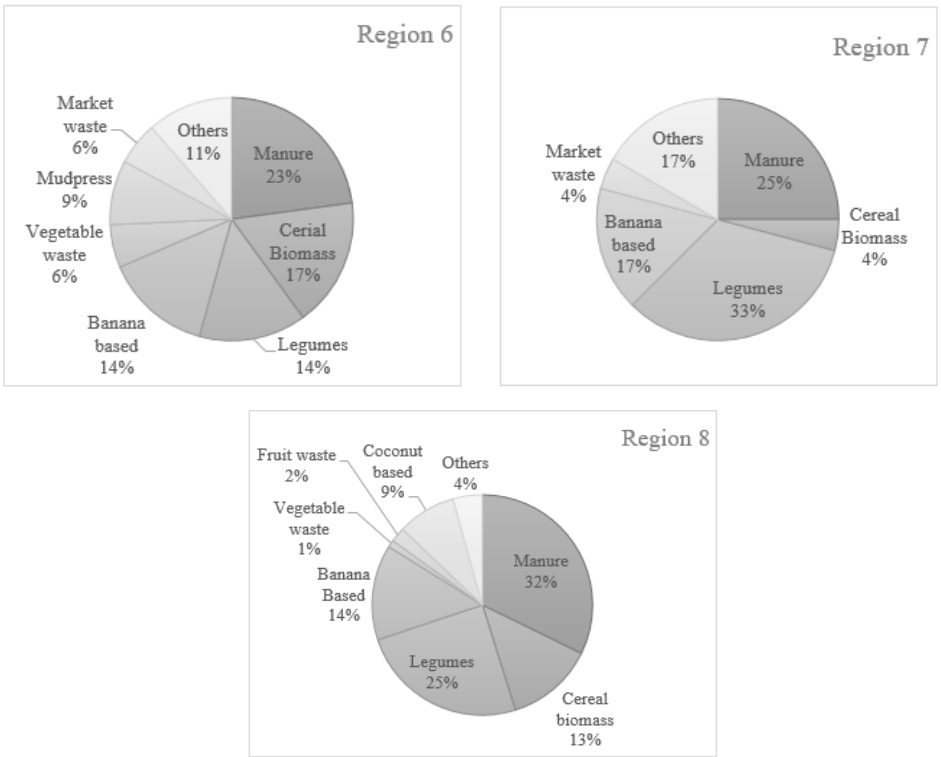

Figure 2. Raw materials distribution (%) per region in the Visayas, Philippines

Table 2. Frequency of the Moisture Content of vermicasts produced in the Visayas Region (PNS-BAFS 2016)

Percent Moisture Content	Frequency			Total
	Vermicasts			
	VI	VII	VIII	
0%-9.9%	1	0	6	7
10%-35%	2	7	16	25
>36%	5	2	1	8
Total	8	9	23	40

COLOR

The color of the soil can be associated with its fertility as well as organic fertilizer. It is believed that the darker or the blacker the fertilizer, the more nutrients it contains. The PNS (2016) states that an organic fertilizer should have a brown to black color. The majority of the samples collected have a brown to black color. The color of the organic fertilizer depends on the raw materials used and the type of fertilizer. The application of the dark-colored fertilizer may increase the soil temperature and thus have a possible effect on the microbes.

CHEMICAL ANALYSES

pH

One of the most important properties that can dictate the growth of the plant is the pH value or "hydrogen ion activity" of the soil. This parameter affects a wide variety of chemicals and biological phenomena in soils (Jahn et al 2004).

Figure 3 shows the pH percentage from the different regions in the Visayas. The pH values in region 6 range from 4.72 - 7.58. Samples from 1, 2, 4, and 8 possessed a pH of neutral to slightly alkaline and it is worth mentioning that these contained cow manure. These results confirmed the study of Whalen et al., (2000) that cattle manure amendments can increase the soil pH and supply considerable amounts of plant-available nutrients.

Among the vermicast produced in the Eastern Visayas, it was found that three (3) vermicast had a strongly alkaline pH and those are from (13) Hernani, Eastern Samar with a pH of 9.94, (3) Mike Pedroso farm, Calbayog, Samar with a pH of 8.72, and (1) Santa Margarita, Samar with a pH of 8.52. On the other hand, vermicast produced in (24) Cabulisan, Inopacan, Leyte had the lowest pH and is categorized as moderately acidic with a pH value of about 6.08. Vermicast derived from carabao manure, cow manure, ipil-ipil, kakawate, and peanut is strongly alkaline as in the case of Mike Pedroso's farm in Calbayog, Samar, and Hernani, Eastern Samar. The application of vermicast possessing high pH could amend the widespread soil acidity in the Philippines. For many nutrients, optimum availability occurs at near-neutral pH and the availability decreases as pH values become more extreme which can lead to nutrient deficiencies in crops.

Some soil organic amendments have a liming effect. In fact, the study of Naramabuye (2007) concluded that organic wastes can act as a liming material when added to acidic soils and that the resulting increase in pH and decrease in Al concentrations might provide a window of opportunity for the establishment and early growth of crops. Manure additions resulted in a decrease in the percentage of Al present in solution as Almono, and this was attributed to the complexation of Al by soluble organic matter originating from the manures.

ORGANIC MATTER (%)

Organic matter (OM) is used to describe all organic materials: living insects, microorganisms, plants, and animal residues at various stages of degradation and transformation as well as substances synthesized by soil population (Brady, 1990). Table 3 shows the frequency of the organic matter of vermicast in Visayas Region, Philippines. The Philippine National Standard or PNS set a minimum requirement for the classification of organic fertilizer or compost/soil conditioner and it should have organic matter (%) greater than 20%. The majority of the samples from the Visayas region possessed a remarkable percentage value of organic matter. Table 3 shows that 36 vermicast possessed organic matter greater than 21% and can be qualified as organic fertilizer.

In region 6, seven out of eight vermicast had organic matter value that is greater than 21 percent. These had organic matter ranging from 23.73% - 32.46%. Only site number 5 failed to meet the criteria, having an OM content of only 20.41%. It was

found that majority of these sites used manure as one of their raw materials for vermicomposting. In the case of site number 3 (Astorga, Capiz), which had the highest percent organic matter (32. 46%) in region 6, three (3) cereal biomass (corn stover, rice hull, and rice straw) were added in their vermicompost instead of manure.

In region 7, all of the samples contained organic matter (%) that is greater than 21% and can be classified as organic fertilizer. These nine (9) samples' organic matter value ranged from 25.87 % - 49.27%. Despite having organic matter greater than 21%, site number 9 (LGU-Alegria, Cebu) had the lowest value of 25.87%. Data reveals that among the sites in region 7, only site number 5 did not use manure in making vermicompost.

Data reveals that there were 20 out of 23 samples from region 8 having an organic matter (%) that surpassed 21% and can be classified as organic fertilizer. There were only three (3) sites where organic matter was below the limit set by the PNS and these were (22) MIDOFSFA, Catarman, N. Samar, (23) Milagrosa Galutan, Catarman, N. Samar, and (26) LEFFA Marabut, Samar having values of only 15.47%, 13.65%, and 2.08%, respectively.

High organic matter indicates that the soil is healthy and fertile. In fact, Martin et al. (2006) stated that organic matter is one of the critical components of the soil that is necessary for soil aggregation as well as supplying nutrients.

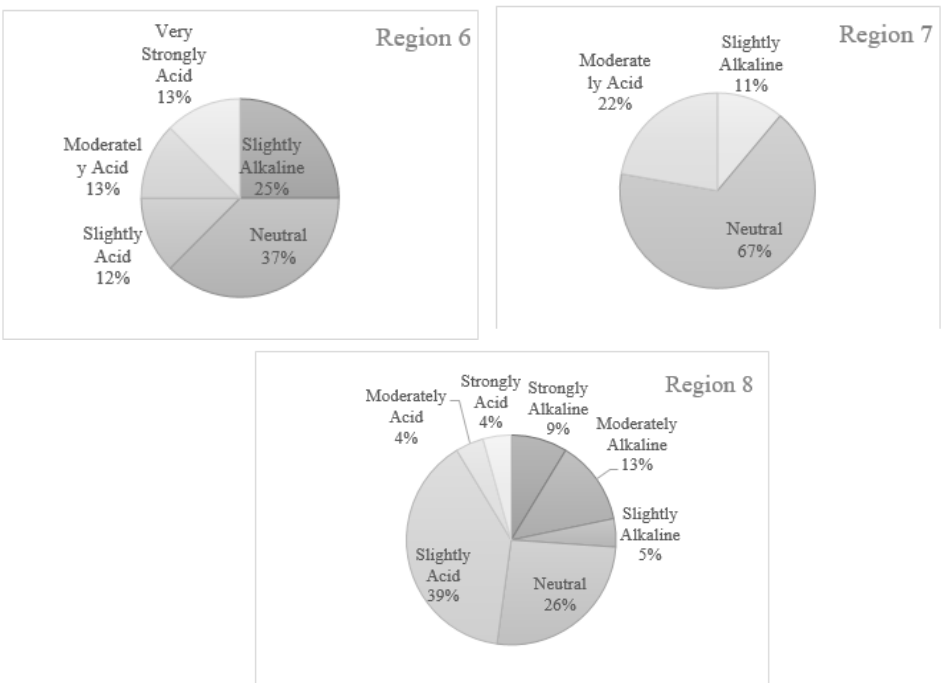

Figure 3. pH distribution (%) per region in the Visayas, Philippines

Table 3. Percent organic matter of vermicasts produced in the Visayas Region, Philippines

	Region 6	Organic Matter (%)				
		R1	R2	R3	Average	STDEV
1	Bongloy, Dingle, Iloilo	29.10	29.98	29.84	29.64	0.47
2	Silagon, Ajuy, Iloilo	25.26	24.81	24.81	24.96	0.26
3	Astorga, Dumarao, Capiz	32.66	32.45	32.26	32.46	0.20
4	Bangon-bangon, Sigma, Capiz	28.30	29.07	29.21	28.86	0.49
5	Malapad Cogon, Sigma, Capiz	20.15	20.53	20.55	20.41	0.23
6	Alaguisoc, Jordan, Guimaras	26.33	26.41	26.82	26.52	0.26
7	Magcalon, San Jose, Antique	23.98	24.03	23.17	23.73	0.48
8	Enclaro, Binalbagan, Negros Occidental	26.23	25.86	25.85	25.98	0.22
	Region 7					
9	LGU- Alegria, Cebu	25.44	26.17	26.00	25.87	0.38
10	Sibulan, Negros Oriental	28.01	28.50	28.51	28.34	0.29
11	Montesuerte, Carmen, Bohol	42.35	43.14	43.02	42.84	0.42
12	Dimiao, Bohol	40.86	41.72	41.05	41.21	0.45
13	Caipilan, Siquijor, Siquijor	50.63	48.59	48.59	49.27	1.18
14	Cabal-asan, Maria, Siquijor	46.26	45.90	45.71	45.96	0.28
15	Cabal-asan, Maria, Siquijor	44.98	44.84	44.15	44.66	0.45
16	Bonga, Maria, Siquijor	41.21	40.71	40.74	40.89	0.28
17	Olang, Maria, Siquijor	48.37	48.05	47.29	47.91	0.55
	Region 8					
18	Santa Margarita, Samar	32.87	33.83	33.14	33.28	0.50
19	San Jorge, Samar	45.93	46.28	46.63	46.28	0.35
20	Mike Pedroso Farm, Carayman, Calbayog, Samar	27.99	28.14	28.11	28.08	0.08
21	AOVR Allen, N.Samar	50.44	50.18	50.70	50.44	0.26
22	MIDOFSFA Mckinley, Catarman, N. Samar	15.17	15.73	15.51	15.47	0.28
23	Milagrosa Galutan, Catarman, N.Samar	13.65	13.39	13.91	13.65	0.26
24	Enderio's Farm Borongan, E.Samar	35.96	35.10	35.02	35.36	0.52
25	BACCFA Balangkayan, E.Samar	46.78	46.13	46.32	46.41	0.33
26	LEFFA Marabut, Samar	2.22	2.00	2.02	2.08	0.12
27	Bontay, Calbayog, Samar	24.71	24.60	24.40	24.57	0.16
28	BUERMI Victoria, N.Samar	33.95	32.50	33.00	33.15	0.74
29	Gen.Macarthur, Calutan, E.Samar	54.25	54.63	54.92	54.60	0.34
30	Hernani, E.Samar	26.40	25.32	25.11	25.61	0.69
31	San Jose, Ormoc City, Leyte	22.20	22.49	22.00	22.23	0.25
32	P.S. Eamiguel, Naval Biliran	47.21	46.10	47.09	46.80	0.61
33	Capiñahan, Naval Biliran	35.14	34.38	35.00	34.84	0.40
34	Caibiran, Biliran	43.27	42.23	43.20	42.90	0.58
35	Cabatuan, Dulag, Leyte	21.27	20.62	22.46	21.45	0.93
36	San Jose, Dulag, Leyte	22.82	23.10	23.50	23.14	0.34
37	Manalog Hinunangan So.Leyte	38.55	37.23	39.66	38.48	1.22
38	Buac Gamay, Sogod So. Leyte	47.17	48.16	47.80	47.71	0.50
39	Cabulisan, Inopacan, Leyte	36.16	35.74	35.74	35.88	0.24
40	Canaan Hills Farm Canaan, Caibiran, Biliran	37.16	36.39	37.21	36.92	0.46

TOTAL N (%), AVAILABLE P_2O_5, AND AVAILABLE

The PNS (2016) defines organic fertilizer as any product that could either be solid or liquid form, except those products from petroleum industries, or animal origin that undergoes partial decomposition that can supply nutrients needed by plants specifically N, P_2O_5, and K_2O, the content of which should be five to ten percent (5-10%).

Table 4 shows the frequency of the Total N, P_2O_5, and K2O values of vermicast produced in the Visayas region. The data reveals that the total N, P_2O_5, and K_2O of the samples in Eastern Visayas were 1.30 – 2.93, in Central Visayas from 1.90 – 3.49, and in Western Visayas from 0.64 – 4.36. Despite having values less than the range set by the PNS (2016) for the qualification of organic fertilizers, it is still worth mentioning that the vermicast from (18) Santa Margarita, Samar, (25) BACCFA Balangkayan, E. Samar and (29) Gen. Macarthur, Calutan, E. Samar possessed a desirable amount of total N, P_2O_5, K_2O. The values of the mentioned vermicast were 4.32, 4.35, and 4.36, respectively.

Table 4. Total N, P_2O_5, K_2O values of vermicast produced in the Visayas Region, Philippines

	Region 6	N- P_2O_5- K_2O				
		R1	R2	R3	Average	STDEV
1	Bongloy, Dingle, Iloilo	2.15	1.86	2.09	2.03	0.16
2	Silagon, Ajuy, Iloilo	2.77	2.89	3.12	2.93	0.18
3	Astorga, Dumarao, Capiz	2.29	1.99	2.22	2.17	0.15
4	Bangon -bangon, Sigma, Capiz	2.37	2.58	2.81	2.58	0.22
5	Malapad Cogon, Sigma, Capiz	1.97	1.35	1.58	1.63	0.31
6	Alaguisoc, Jordan, Guimaras	1.95	1.86	2.09	1.97	0.12
7	Magcalon, San Jose, Antique	1.31	1.18	1.41	1.30	0.12
8	Enclaro, Binalbagan, Negros Occidental	2.16	2.05	2.08	2.09	0.06
	Region 7					
9	LGU- Alegria, Cebu	2.85	2.83	3.06	2.92	0.13
10	Sibulan, Negros Oriental	2.92	2.85	3.00	2.92	0.08
11	Montesuerte, Carmen, Bohol	2.71	2.79	3.02	2.84	0.16
12	Dimiao, Bohol	2.87	2.08	2.31	2.42	0.40
13	Caipilan, Siquijor, Siquijor	0.57	3.39	3.62	2.52	1.70
14	Cabal -asan, Maria, Siquijor	3.50	3.37	3.60	3.49	0.12
15	Cabal -asan, Maria, Siquijor	2.60	2.49	2.72	2.60	0.12
16	Bonga, Maria, Siquijor	1.94	1.77	2.00	1.90	0.12
17	Olang, Maria, Siquijor	2.94	2.83	3.02	2.93	0.10
	Region 8					
18	Santa Margarita, Samar	4.33	4.20	4.43	4.32	0.12
19	San Jorge, Samar	2.63	2.19	2.42	2.41	0.22
20	Mike Pedroso Farm, Carayman, Calbayog, Samar	3.30	3.05	3.28	3.21	0.14
21	AOVR Allen, N.Samar	2.38	2.42	2.65	2.49	0.15
22	MIDOFSFA Mckinley, Catarman, N. Samar	0.58	0.55	0.78	0.64	0.13
23	Milagrosa Galutan, Catarman, N.Samar	1.32	1.17	1.40	1.29	0.12
24	Enderio 's Farm Borongan, E.Samar	1.52	1.30	1.53	1.45	0.13
25	BACCFA Balangkayan, E.Samar	4.00	4.40	4.63	4.35	0.32
26	LEFFA Marabut, Samar	2.04	2.08	2.11	2.08	0.03
27	Bontay, Calbayog, Samar	2.06	1.98	2.21	2.08	0.12
28	BUERMI Victoria, N.Samar	1.21	1.09	1.32	1.20	0.12
29	Gen.Macarthur, Calutan, E.Samar	4.69	4.08	4.31	4.36	0.30
30	Hernani, E.Samar	0.94	0.75	0.98	0.89	0.12
31	San Jose, Ormoc City, Leyte	2.03	1.68	2.31	2.01	0.32
32	P.S. Eamiguel, Naval Biliran	2.04	2.17	2.40	2.20	0.18
33	Capiñahan, Naval Biliran	1.63	1.58	1.81	1.67	0.12
34	Caibiran, Biliran	2.15	2.54	2.57	2.42	0.23

Table 4. Continuation.

	Region 6	N- P_2O_5- K_2O				
		R1	R2	R3	Average	STDEV
35	Cabatuan, Dulag, Leyte	1.66	1.59	1.82	1.69	0.12
36	San Jose, Dulag, Leyte	1.23	1.33	1.56	1.37	0.17
37	Manalog Hinunangan So.Leyte	1.64	1.22	1.45	1.44	0.21
38	Buac Gamay, Sogod So. Leyte	1.85	1.34	1.57	1.59	0.25
39	Cabulisan, Inopacan, Leyte	1.65	1.42	1.65	1.57	0.13
40	Canaan Hills Farm Canaan, Caibiran, Biliran	1.43	1.29	1.52	1.42	0.12

HEAVY METAL CONTENT OF VERMICAST

CADMIUM AND CHROMIUM

The heavy metal composition of the different organic fertilizers found in the Visayas region is quantified below. The data shows that heavy metal composition varies according to location. The analysis for Cd was below the detection limit (BDL) using the atomic absorption spectrometer. The values obtained for the heavy metals in the vermicast were compared to the Philippine National Standard (2016) for the maximum acceptable concentrations which is below 5 ppm (Table 1).

Table 5 shows the frequency of the Cr (mg/kg) content from the vermicast produced in the Visayas region. The results show that all of the samples were safe to use according to the PNS (2016). It also shows that the values measured were below the detection limit for some of the samples.

During the year 2013, the Philippine National Standard released an allowable level of heavy metals and these were; Arsenic, Zinc, Lead, Copper, Chromium, Nickel, Mercury, and Cadmium for organic fertilizers, compost, plant growth regulator, and organic plant supplements. Some of the heavy metals mentioned such as Copper and Zinc were omitted in the current PNS/BAFS 40:2016.

COPPER AND ZINC

The copper and zinc contents of the different vermicast produced in the Visayas region are shown in Tables 6 – 8. According to the PNS (2013), the maximum allowable level of copper for vermicast should not exceed 300 ppm. Also, the study of Kabata-Pendias and Pendias (2001) mentioned that the copper threshold levels in soil is 60-125 mg/kg. The copper content of all vermicast in the Visayas region ranged from 12.75 ppm – 373.60 ppm, indicating that all samples were safe to use except for the sample from (26) LEFFA Marabut, Samar.

In the case of Zinc content, according to the PNS (2013), the samples should not exceed 5 ppm. Laboratory analysis shows that the value of the vermicast ranged from 70 ppm to 1108.30 ppm. Laboratory analysis reveals that all of the samples were beyond the threshold level for Zinc. Also, the sample from (26) LEFFA Marabut, Samar had the highest amount of Zinc with a value of about 1108.30 ppm. It was found that one of their raw materials used in making their vermicast was guano. The use or extraction of guano or bat manure is subject to DENR regulations (PNS, 2016).

Table 5. Chromium content of vermicast produced in the Visayas Region, Philippines

	Region 6	Chromium (ppm)				
		R1	R2	R3	Average	STDEV
1	Bongloy, Dingle, Iloilo	1.29	1.59	1.17	1.35	0.22
2	Silagon, Ajuy, Iloilo	0.40	0.61	0.19	0.40	0.21
3	Astorga, Dumarao, Capiz	BDL	BDL	BDL	BDL	BDL
4	Bangon-bangon, Sigma, Capiz	1.12	1.81	1.39	1.44	0.35
5	Malapad Cogon, Sigma, Capiz	0.38	0.62	0.20	0.40	0.21
6	Alaguisoc, Jordan, Guimaras	BDL	BDL	BDL	BDL	BDL
7	Magcalon, San Jose, Antique	4.36	6.10	5.68	5.38	0.91
8	Enclaro, Binalbagan, Negros Occidental	BDL	BDL	BDL	BDL	BDL
	Region 7					
9	LGU- Alegria, Cebu	BDL	BDL	BDL	BDL	BDL
10	Sibulan, Negros Oriental	BDL	BDL	BDL	BDL	BDL
11	Montesuerte, Carmen, Bohol	BDL	BDL	BDL	BDL	BDL
12	Dimiao, Bohol	1.88	2.27	1.85	2.00	0.23
13	Caipilan, Siquijor, Siquijor	BDL	BDL	BDL	BDL	BDL
14	Cabal-asan, Maria, Siquijor	0.72	1.28	0.86	0.95	0.29
15	Cabal-asan, Maria, Siquijor	BDL	BDL	BDL	BDL	BDL
16	Bonga, Maria, Siquijor	0.10	0.13	0.07	0.10	0.03
17	Olang, Maria, Siquijor	BDL	BDL	BDL	BDL	BDL
	Region 8					
18	Santa Margarita, Samar	1.93	2.02	1.60	1.85	0.22
19	San Jorge, Samar	3.17	3.88	3.46	3.50	0.35
20	Mike Pedroso Farm, Carayman, Calbayog, Samar	3.11	4.06	3.64	3.60	0.47
21	AOVR Allen, N.Samar	BDL	BDL	BDL	BDL	BDL
22	MIDOFSFA Mckinley, Catarman, N. Samar	1.00	1.29	0.87	1.05	0.21
23	Milagrosa Galutan, Catarman, N.Samar	0.80	1.01	0.59	0.80	0.21
24	Enderio's Farm Borongan, E.Samar	2.28	3.12	2.70	2.70	0.42
25	BACCFA Balangkayan, E.Samar	0.05	1.39	0.97	0.80	0.68
26	LEFFA Marabut, Samar	5.29	6.04	5.62	5.65	0.38
27	Bontay, Calbayog, Samar	3.11	5.33	4.91	4.45	1.18
28	BUERMI Victoria, N.Samar	BDL	BDL	BDL	BDL	BDL
29	Gen.Macarthur, Calutan, E.Samar	1.03	1.27	0.85	1.05	0.21
30	Hernani, E.Samar	41.98	43.05	42.63	42.55	0.54
31	San Jose, Ormoc City, Leyte	BDL	BDL	BDL	BDL	BDL
32	P.S. Eamiguel, Naval Biliran	BDL	BDL	BDL	BDL	BDL
33	Capiñahan, Naval Biliran	BDL	BDL	BDL	BDL	BDL
34	Caibiran, Biliran	BDL	BDL	BDL	BDL	BDL
35	Cabatuan, Dulag, Leyte	BDL	BDL	BDL	BDL	BDL
36	San Jose, Dulag, Leyte	BDL	BDL	BDL	BDL	BDL
37	Manalog Hinunangan So.Leyte	BDL	BDL	BDL	BDL	BDL
38	Buac Gamay, Sogod So. Leyte	0.82	1.00	0.58	0.80	0.21
39	Cabulisan, Inopacan, Leyte	0.94	0.49	0.07	0.50	0.44
40	Canaan Hills Farm Canaan, Caibiran, Biliran	BDL	BDL	BDL	BDL	BDL

Table 6. The copper content of the different Vermicast from the Visayas Region, Philippines

	Region 6	Copper (ppm)				
		R1	R2	R3	Average	STDEV
1	Bongloy, Dingle, Iloilo	97.83	98.32	98.00	98.05	0.25
2	Silagon, Ajuy, Iloilo	95.54	94.21	95.10	94.95	0.68
3	Astorga, Dumarao, Capiz	58.89	59.13	59.22	59.08	0.17
4	Bangon-bangon, Sigma, Capiz	144.25	145.40	145.20	144.95	0.61
5	Malapad Cogon, Sigma, Capiz	76.30	76.50	76.10	76.30	0.20
6	Alaguisoc, Jordan, Guimaras	56.11	56.71	57.13	56.65	0.51
7	Magcalon, San Jose, Antique	46.22	46.00	46.02	46.08	0.12
8	Enclaro, Binalbagan, Negros Occidental	44.97	43.35	43.98	44.10	0.82
	Region 7					
9	LGU- Alegria, Cebu	108.59	108.23	108.23	108.35	0.21
10	Sibulan, Negros Oriental	108.99	108.00	108.06	108.35	0.56
11	Montesuerte, Carmen, Bohol	169.68	169.18	169.19	169.35	0.29
12	Dimiao, Bohol	67.93	67.26	67.46	67.55	0.34
13	Caipilan, Siquijor, Siquijor	BDL	BDL	BDL	BDL	BDL
14	Cabal-asan, Maria, Siquijor	37.82	37.00	37.83	37.55	0.48
15	Cabal-asan, Maria, Siquijor	29.75	29.50	28.50	29.25	0.66
16	Bonga, Maria, Siquijor	23.91	22.12	23.12	23.05	0.90
17	Olang, Maria, Siquijor	24.63	24.28	24.89	24.60	0.31
	Region 8					
18	Santa Margarita, Samar	51.93	50.05	51.02	51.00	0.94
19	San Jorge, Samar	26.77	25.90	25.78	26.15	0.54
20	Mike Pedroso Farm, Carayman, Calbayog, Samar	49.12	50.23	50.50	49.95	0.73
21	AOVR Allen, N.Samar	21.28	20.72	21.00	21.00	0.28
22	MIDOFSFA Mckinley, Catarman, N. Samar	27.31	27.90	27.89	27.70	0.34
23	Milagrosa Galutan, Catarman, N.Samar	60.74	61.18	61.98	61.30	0.63
24	Enderio's Farm Borongan,E.Samar	39.66	39.57	39.57	39.60	0.05
25	BACCFA Balangkayan, E.Samar	36.15	35.85	36.00	36.00	0.15
26	LEFFA Marabut, Samar	373.28	374.00	373.52	373.60	0.37
27	Bontay, Calbayog, Samar	49.21	49.14	50.00	49.45	0.48
28	BUERMI Victoria, N.Samar	126.91	126.00	126.44	126.45	0.46
29	Gen.Macarthur, Calutan, E.Samar	19.55	18.65	18.65	18.95	0.52
30	Hernani, E.Samar	38.79	38.20	38.81	38.60	0.35
31	San Jose, Ormoc City, Leyte	44.28	45.00	45.12	44.80	0.45
32	P.S. Eamiguel, Naval Biliran	37.98	36.18	36.99	37.05	0.90
33	Capiñahan, Naval Biliran	31.31	31.30	31.44	31.35	0.08
34	Caibiran, Biliran	33.78	34.01	32.41	33.40	0.87
35	Cabatuan, Dulag, Leyte	73.98	72.81	72.81	73.20	0.68
36	San Jose, Dulag, Leyte	13.05	11.70	13.50	12.75	0.94
37	Manalog Hinunangan So.Leyte	294.73	293.16	293.96	293.95	0.79
38	Buac Gamay, Sogod So. Leyte	36.82	35.69	35.49	36.00	0.72
39	Cabulisan, Inopacan, Leyte	49.07	48.67	48.96	48.90	0.21
40	Canaan Hills Farm Canaan, Caibiran, Biliran	25.15	26.00	24.30	25.15	0.85

Table 7. The zinc content of the different Vermicast from the Visayas Region, Philippines

	Region 6	Zinc (ppm)				
		R1	R2	R3	Average	STDEV
1	Bongloy, Dingle, Iloilo	155.17	155.27	156.66	155.70	0.83
2	Silagon, Ajuy, Iloilo	134.76	135.84	135.60	135.40	0.57
3	Astorga, Dumarao, Capiz	219.78	219.06	219.00	219.28	0.43
4	Bangon-bangon, Sigma, Capiz	178.22	179.56	178.65	178.81	0.68
5	Malapad Cogon, Sigma, Capiz	125.75	125.92	125.58	125.75	0.17
6	Alaguisoc, Jordan, Guimaras	70.35	71.95	69.95	70.75	1.06
7	Magcalon, San Jose, Antique	83.13	83.77	84.14	83.68	0.51
8	Enclaro, Binalbagan, Negros Occidental	155.99	155.15	155.16	155.43	0.48
	Region 7					
9	LGU- Alegria, Cebu	280.00	280.27	281.68	280.65	0.90
10	Sibulan, Negros Oriental	280.32	280.81	280.82	280.65	0.29
11	Montesuerte, Carmen, Bohol	222.98	222.37	222.00	222.45	0.49
12	Dimiao, Bohol	232.10	232.30	233.10	232.50	0.53
13	Caipilan, Siquijor, Siquijor	BDL	BDL	BDL	BDL	BDL
14	Cabal-asan, Maria, Siquijor	115.85	115.45	116.80	116.03	0.69
15	Cabal-asan, Maria, Siquijor	120.28	120.00	120.02	120.10	0.16
16	Bonga, Maria, Siquijor	97.88	97.32	97.00	97.40	0.45
17	Olang, Maria, Siquijor	117.35	118.10	118.40	117.95	0.54
	Region 8					
18	Santa Margarita, Samar	175.10	176.00	176.60	175.90	0.75
19	San Jorge, Samar	148.22	146.19	146.59	147.00	1.08
20	Mike Pedroso Farm, Carayman, Calbayog, Samar	113.10	113.90	112.60	113.20	0.66
21	AOVR Allen, N.Samar	89.25	88.05	89.85	89.05	0.92
22	MIDOFSFA Mckinley, Catarman, N. Samar	79.21	79.07	80.07	79.45	0.54
23	Milagrosa Galutan, Catarman, N.Samar	214.74	212.50	212.51	213.25	1.29
24	Enderio's Farm Borongan, E.Samar	160.54	160.81	160.00	160.45	0.41
25	BACCFA Balangkayan, E.Samar	129.71	129.02	130.82	129.85	0.91
26	LEFFA Marabut, Samar	1108.92	1107.79	1108.19	1108.30	0.57
27	Bontay, Calbayog, Samar	187.27	187.61	187.62	187.50	0.20
28	BUERMI Victoria, N.Samar	257.45	257.65	256.05	257.05	0.87
29	Gen.Macarthur, Calutan, E.Samar	171.50	171.87	171.28	171.55	0.30
30	Hernani, E.Samar	137.21	137.65	137.64	137.50	0.25
31	San Jose, Ormoc City, Leyte	174.15	173.98	173.57	173.90	0.30
32	P.S. Eamiguel, Naval Biliran	126.45	127.00	127.70	127.05	0.63
33	Capiñahan, Naval Biliran	195.25	194.52	196.88	195.55	1.21
34	Caibiran, Biliran	294.11	294.64	294.00	294.25	0.34
35	Cabatuan, Dulag, Leyte	203.00	203.98	204.57	203.85	0.79
36	San Jose, Dulag, Leyte	217.44	218.53	218.78	218.25	0.71
37	Manalog Hinunangan So.Leyte	947.28	946.73	946.39	946.80	0.45
38	Buac Gamay, Sogod So. Leyte	115.98	114.60	115.47	115.35	0.70
39	Cabulisan, Inopacan, Leyte	266.84	267.26	267.05	267.05	0.21
40	Canaan Hills Farm Canaan, Caibiran, Biliran	131.32	130.68	129.95	130.65	0.69

Table 8. The iron content of the different Vermicast from the Visayas Region, Philippines

	Region 6	Iron (ppm)				
		R1	R2	R3	Average	STDEV
1	Bongloy, Dingle, Iloilo	38676.00	38677.15	38681.15	38678.10	2.70
2	Silagon, Ajuy, Iloilo	9069.00	9065.15	9063.25	9065.80	2.93
3	Astorga, Dumarao, Capiz	19486.00	19490.38	19490.02	19488.80	2.43
4	Bangon-bangon, Sigma, Capiz	37170.50	37170.28	37169.22	37170.00	0.68
5	Malapad Cogon, Sigma, Capiz	38422.20	38422.00	38420.00	38421.40	1.22
6	Alaguisoc, Jordan, Guimaras	6087.85	6089.39	6087.36	6088.20	1.06
7	Magcalon, San Jose, Antique	17633.50	17638.17	17635.43	17635.70	2.35
8	Enclaro, Binalbagan, Negros Occidental	34955.87	34957.59	34954.53	34956.00	1.53
	Region 7					
9	LGU- Alegria, Cebu	12222.00	12224.40	12223.20	12223.20	1.20
10	Sibulan, Negros Oriental	12224.12	12223.71	12221.79	12223.21	1.24
11	Montesuerte, Carmen, Bohol	9952.89	9951.66	9949.66	9951.40	1.63
12	Dimiao, Bohol	20816.00	20815.10	20813.90	20815.00	1.05
13	Caipilan, Siquijor, Siquijor	BDL	BDL	BDL	BDL	BDL
14	Cabal-asan, Maria, Siquijor	17094.28	17093.18	17091.54	17093.00	1.38
15	Cabal-asan, Maria, Siquijor	10385.00	10389.15	10389.25	10387.80	2.43
16	Bonga, Maria, Siquijor	12478.00	12481.24	12480.46	12479.90	1.69
17	Olang, Maria, Siquijor	7114.99	7115.17	7114.69	7114.95	0.24
	Region 8					
18	Santa Margarita, Samar	31233.28	31235.26	31233.46	31234.00	1.09
19	San Jorge, Samar	18826.25	18826.12	18824.73	18825.70	0.84
20	Mike Pedroso Farm, Carayman, Calbayog, Samar	38293.98	38293.23	38291.79	38293.00	1.11
21	AOVR Allen, N.Samar	6357.85	6358.37	6356.88	6357.70	0.76
22	MIDOFSFA Mckinley, Catarman, N. Samar	30975.00	30979.20	30977.70	30977.30	2.13
23	Milagrosa Galutan, Catarman, N.Samar	21648.14	21650.63	21649.13	21649.30	1.25
24	Enderio's Farm Borongan, E.Samar	26483.11	26482.79	26481.30	26482.40	0.97
25	BACCFA Balangkayan, E.Samar	32643.55	32647.67	32646.18	32645.80	2.09
26	LEFFA Marabut, Samar	18760.58	18762.71	18761.21	18761.50	1.09
27	Bontay, Calbayog, Samar	44066.69	44070.30	44068.81	44068.60	1.81
28	BUERMI Victoria, N.Samar	66013.10	66017.90	66016.40	66015.80	2.46
29	Gen.Macarthur, Calutan, E.Samar	19660.21	19660.49	19659.00	19659.90	0.79
30	Hernani, E.Samar	96175.08	96178.86	96177.36	96177.10	1.90
31	San Jose, Ormoc City, Leyte	18502.17	18506.86	18505.37	18504.80	2.40
32	P.S. Eamiguel, Naval Biliran	36237.22	36241.39	36239.89	36239.50	2.11
33	Capiñahan, Naval Biliran	64220.07	64219.06	64217.57	64218.90	1.26
34	Caibiran, Biliran	74355.20	74360.60	74359.10	74358.30	2.79
35	Cabatuan, Dulag, Leyte	47021.09	47021.11	47019.61	47020.60	0.86
36	San Jose, Dulag, Leyte	1146587.00	1146592.25	1146590.75	1146590.00	2.70
37	Manalog Hinunangan So.Leyte	43427.00	43427.60	43426.10	43426.90	0.75
38	Buac Gamay, Sogod So. Leyte	22678.00	22675.75	22674.25	22676.00	1.89
39	Cabulisan, Inopacan, Leyte	46376.82	46380.54	46379.04	46378.80	1.87
40	Canaan Hills Farm Canaan, Caibiran, Biliran	70380.00	70380.15	70378.65	70379.60	0.83

Iron concentrations were also observed to be the highest of all the metals analyzed in this study. In fact, in Region 6 (Table 6), vermicast collected in Dingle, Iloilo had the highest concentration of iron having a value of 38676.05 ppm with a substrate composed of kakawate, cow manure, banana stalk, mud press, and other waste materials in the vermicast production. Vermicast from Alaguisoc, Jordan, Guimaras had the lowest iron concentration with a value of 6088.20 ppm using chicken dung, carabao manure, cow manure, rice straw, banana stalk as substrates. Kakawate as substrate had the lowest iron concentration at 6357.10 ppm.

CONCLUSION AND RECOMMENDATIONS

The nutritional content of vermicast is determined by the kind of substrate used in the vermicomposting process. The majority of the samples have a neutral pH, dark-colored, high percent organic matter, and within the range of percent moisture content. All of the vermicast do not qualify as organic fertilizer, instead as soil conditioner since their % total N, P_2O_5, and K_2O were below 5 %, lower than the required criteria set by the PNS-BAFS (2016). On the other hand, vermicast from Santa Margarita, Samar (4.32), Balangkayan, E. Samar (4.35), and Gen. Macarthur, Calutan, E. Samar (4.36) had a promising total N, P_2O_5, and K_2O. Regarding heavy metals, all except for Zn and Copper, were within acceptable levels.

A study focusing on reformulation should be conducted since the values for nitrogen, phosphorus, potassium and heavy metals are already quantified. For biochemical characterization, it must include microbial analysis and identification of microorganisms present in the vermicast. There must also be efficacy testing on crops to assess their growth and yield performance. The data generated from this study could be a great help to farmers, consumers, and researchers in informing them about the safety of the soil organic fertilizer. While most of the heavy metals found in the samples were within acceptable levels, some exceeded these.

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