International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Vermi Composting with Water Hyacinth (Eichhornia Crassipes) and African Night Crawller (Eudrilus Eugeniae) for Heavy Metal Reduction

Archie P. Urbiztondo[1], James M. Dumaguit[2]
[1]College of Teacher Education, Surigao State College of Technology, Surigao City, Philippines-8400
[2]College of Technology, Surigao State College of Technology, Surigao City, Philippines-8400

***Abstract*— *This study aimed to investigate the reduction process of heavy metals specifically iron, Nickel, Copper, and Lead, which were phytoacummulated by the water hyacinth (Eichhornia crassipes) prior to its bioavailability status on its biomass, through direct composting using African Night Crawlers (Eudrilus eugeniae). Two bin setups were prepared based on the sampling location to obtain their average. Each setup had 3 sets of replication and each replicate had 100 kg of water hyacinth with 2 kg of African Night Crawlers (ANC). The setups underwent direct vermicomposting phase for 33 days. Vermicast samples were collected on the 12th day and 33rd day for the analysis of their metal content- Iron (Fe), Nickel (Ni), Copper (Cu), and Lead (Pb), and NPK composition with regards to the fertilizer property. The results showed that all heavy metals specified have indicated reduction at the end of the direct composting phase. Fe- 63.95%; Ni-63.63%; Cu- 63.85%; Pb-51.26%. Meanwhile, Pb had fluctuated to 10.65 ppm from its Below Detection Limit (BDL) status possibly due to translocation of heavy metals by the ANC from the control group based on the first-post analysis, but it was still feasible for organic fertilizer property. Therefore, direct vermicomposting of water hyacinth using ANC for more than 30 days is highly recommended in regrads to effective heavy metal content reduction, but in terms of organic fertilizer property, the 12th day had nearly satisfied the required standard.*

***Keywords*— *African Night Crawler (ANC), Heavy Metal Reduction, Organic fertilizer property, Vermicomposting, Water Hyacinth.*

I. INTRODUCTION

Water hyacinth is an aquatic plant common to freshwater system such as lakes, rivers and pond known for its fast growth thus tagging it as an evasive species of plant.[1] Water hyacinth is said to have the ability to phytoaccumulate heavy metals. Consequently, water hyacinth absorbs the heavy metals present in the water of its habitat, presenting a hazard to the ecosystem as it interacts with other organism .[2][3]

While finding a way to dispose of the hyacinth is then critical for environment health, the ability of water hyacinth to phytoaccumulate heavy metals somehow provides beneficial effects to the environment because the chances of exposure to the heavy metals are lessened as they are absorbed by the hyacinth.[4]

Instead of direct disposal, this study put the good use of the water hyacinth in metal reduction using African Night Crawlers and its feasibility as organic fertilizer.[5][6][7] Vermicomposting is already a known practice in which annelid worms are cultured to compost biodegradable materials and several studies have consequently been made to assess the changes in the heavy metal content of the vermicompost.[8][9] This provide the basic foundation of the study.

II. MATERIALS AND METHODS

Fig. 1. Framework

A. Collection of samples.

Lake water samples were collected from lake Mainit Surigao del Norte, a liter of water sample was obtained from Brgy. Quezon and one from Brgy. Hacienda.

Fig. 2. Site

Water hyacinths used for pre-analysis and treatment were also collected from Brgy. Quezon and Brgy. Hacienda, both are within the vicinity of the lake. Morethan 300kg of the plant were collected from each location.

The cultured African Night Crawlers *(Eudrilus eugeniae)* were obtained from the Vermiculture House. Two(2)kg of which were placed on each replicate. Therefore, there were 6 kg of ANCs on each set-up.

B. Identification and authentication of Species.

The water hyacinth specimen was brought to the National Museum –Botany Division in Manila city for certifying identification of species and its scientific name validation.

C. Preliminary Analysis of Samples

The collected samples were preserved in an iced bucket and brought to University of San Carlos (USC) Water laboratory-Talamban Campus in Cebu City for the analysis metal content (Fe, Ni, Cu, and Pb) and Turbidity. The collected plant samples from Brgy. Hacienda and Brgy. Quezon were air-dried for about 7 days and eventually brought to the USC Water Laboratory for metal content (Fe, Ni, Cu, and Pb) Analysis.

D. Control Sample

The vermibed (consisted of decomposed substrates of kitchen waste, coconut fibers, other domestic wastes) as a control group which was used for the Direct Composting Phase was brought to the Department of Agriculture Regional Soils Laboratory in Taguibo, Butuan City for analysis of NPK composition and metal content (Fe, Ni, Cu, and Pb).

E. Direct Composting Phase

The collected water hyacinths were brought to the City Agriculture-Vermiculture House located in Brgy. Canlanipa, Surigao City. The plants from the two separate locations were shredded and placed in two separate bins. Set-up A was for Brgy. Hacienda and the other for Brgy. Quezon. Each set-up was divided into three replicates. Therefore, each replicate had 100kg of shredded water hyacinths both set-ups were placed with vermibeds which were beneath the shredded hyacinths and surrounding the three replicates to signify the control group.

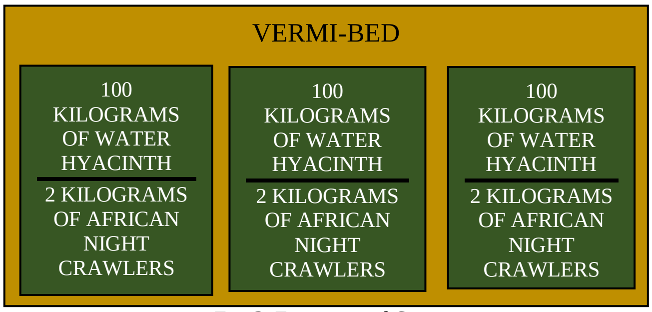

Fig. 3. Experimental Set-up

F. Post Analysis of Vermicast

On the 12th day since the start of the Direct Composting Phase using African Night Crawlers, 3 kg. of vermicast was obtained from each replicate of each set-up for analysis. [10][11][12]The samples were brought to the Regional Soils Laboratory (RSL)in Taguibo, Butuan City for analysis of NPK Composition and Metal Content (Fe, Ni, Cu, and Pb). Then, on the 33rd day, a 3kg. of vermicast was obtained from each replicate of each set-up for final analysis and brought to RSL for analysis of NPK and Metal content. Along with the vermicast samples, the control group of each set-up was also analyzed with the same parameters.

III. Results and Discussion

The study covered around 65 days since the start of the collection of samples until the final analysis and interpretation of data.

Based on the results shown in table 1, a direct composting process using ANC is effective in the content reduction of Iron (Fe), Nickel (Ni), and Copper (Cu) in water Hyacinth biomass except for Lead (Pb) which fluctuated based on the first post-analysis result, but is still tolerable in regards to standard organic fertilizer property.

TABLE 1. Pre and Final analysis of metal content of two set-ups using Atomic Emission Spectrum Method.

Set-ups	Metal Content							
	Iron(Fe)		Nickel(Ni)		Copper(Cu)		Lead(Pb)	
	Pre	Final	Pre	Final	Pre	Final	Pre	Final
Set-up A:Hacienda	3.276	1.196	212.18	59.160	75.376	26.446	10.65	BDL
Set-up B:Quezon	2.816	1.000	82.703	48.076	60.366	22.606	27.60	16.25

Nickel content on the vermicast showed a significant reduction on the first and final analysis but is not tolerable considering the standard requirement of heavy metal content for organic fertilizer based on the Bureau of Agriculture and Fisheries Product Standard[13][14][15][16]. Meanwhile, the NPK composition of the vermicast analyzed on the 12th day of direct composting which was 4.59% nearly satisfied the required standard for organic fertilizer's NPK composition of 5-7% compared to the results on the 33rd day which is less than 1%. [17]

TABLE 2. Avearge and percentage decrease of Pre and Final Analysis of heavy meatals.

Heavy Metals	Pre-Analysis	Final Analysis	Percentage Decrease
Iron (ppm)	3.0467	1.0983	63.95%
Nickel(ppm)	147.443	53.6183	63.63%
Copper(ppm)	67.87166	24.5267	63.86%
Lead(ppm)	19.125	8.125	57.16%

The table shows the heavy metals specifically Fe,Ni,and Cu have shown almost the same high percentage decrase ranging from 63.63% to 63.95%while Lead had 57.26% deacrease.

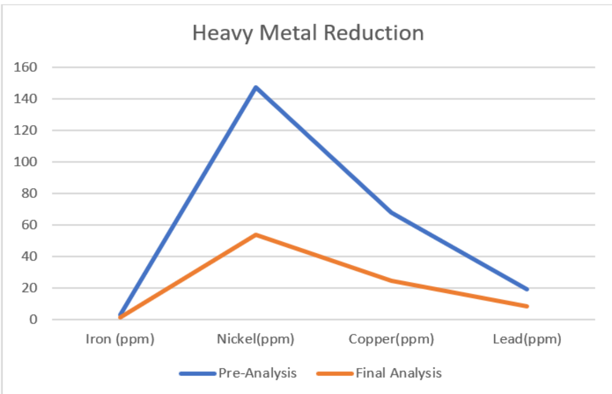

Fig. 4. Graph showingreduction of heavy metals during direct composting

Using Atomic Emission Spectrum Method, taking the average amount of heavymetals in ppm [18][19][20]. It shows that vermicomposting with the aid of bioaccumulation of water hyacinth and biodegradation through African Night Crawler has indeed reduced the heavy metal concentration.[21][22]

IV. CONCLUSION

The study shows that in terms of metal reduction, direct composting has an exceptional and significant effect. Moreover, with regards to the organic fertilizer, we categorize the vermicast based on the Bureau of Agriculture and Fisheries Product Standards as plant supplement and soil enhancer with 0.5-2.5% of standard NPK.

REFERENCES

[1] E. Funnell, M. Heaton, F. MacDonald, and B. Brownson, "The aquarium and horticultural industry as a pathway for the introduction of aquatic invasive species—outreach initiatives within the great lakes basin," *Biodiversity*, vol. 10, no. 2–3, pp. 104–112, 2009, doi: 10.1080/14888386.2009.9712852.
[2] S. Mishra *et al.*, "Heavy Metal Contamination: An Alarming Threat to Environment and Human Health," *Environ. Biotechnol. Sustain. Futur.*, pp. 103–125, 2019, doi: 10.1007/978-981-10-7284-0_5.
[3] Z. Abbas, F. Arooj, S. Ali, … I. Z.-I. J., and undefined 2019, "Phytoremediation of landfill leachate waste contaminants through floating bed technique using water hyacinth and water lettuce," *Taylor Fr.*, vol. 21, no. 13, pp. 1356–1367, Nov. 2019, doi: 10.1080/15226514.2019.1633259.
[4] S. Sharma and A. Bhattacharya, "Drinking water contamination and treatment techniques," *Appl. Water Sci.*, vol. 7, no. 3, pp. 1043–1067, Jun. 2017, doi: 10.1007/S13201-016-0455-7.
[5] R. Gupta, V. G.-C. D. in B. and, and undefined 2017, "Vermitechnology for Organic Waste Recycling," *Elsevier*, Accessed: Mar. 29, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B978044463664500058
[6] Lirikum, L. N. Kakati, L. Thyug, and L. Mozhui, "Vermicomposting: an eco-friendly approach for waste management and nutrient enhancement," *Trop. Ecol.*, 2022, doi: 10.1007/S42965-021-00212-Y.
[7] S. M. Faheem and M. A. Khan, "Waste management methods and sustainablity," *Adv. Bioprocess Technol.*, pp. 57–78, Jan. 2015, doi: 10.1007/978-3-319-17915-5_4.
[8] A. Singh, E. S. E. Omran, and G. S. Singh, "Vermicomposting Impacts on Agriculture in Egypt," *Springer Water*, pp. 181–203, 2020, doi: 10.1007/978-3-030-30375-4_9.
[9] A. Singh *et al.*, "Earthworms and vermicompost: an eco-friendly approach for repaying nature's debt," *Environ. Geochem. Health*, vol. 42, no. 6, pp. 1617–1642, Jun. 2020, doi: 10.1007/S10653-019-00510-4.
[10] R. Mohee, N. S.- Resources, C. and Recycling, and undefined 2014, "Comparison of heavy metals content in compost against vermicompost of organic solid waste: past and present," *Elsevier*, Accessed: Mar. 29, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0921344914001475
[11] S. Datta, J. Singh, S. Singh, and J. Singh, "Earthworms, pesticides and sustainable agriculture: a review," *Environ. Sci. Pollut. Res.*, vol. 23, no. 9, pp. 8227–8243, May 2016, doi: 10.1007/S11356-016-6375-0.
[12] C. S. Binoya, "Climate Smart Farmers' Field School as Extension Modality for Climate Change Adaptation in Rice Farming: Bicol, Philippines," *apaari.org*, Accessed: Mar. 29, 2022. [Online]. Available: http://www.apaari.org/web/wp-content/uploads/downloads/2018/Climate Smart Farmer-Success Story_10-8-2018_Final.pdf
[13] R. Singh, P. Bhunia, R. D.-J. of E. Management, and undefined 2017, "A mechanistic review on vermifiltration of wastewater: design, operation and performance," *Elsevier*, Accessed: Mar. 29, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0301479717303900
[14] A. Embrandiri, S. Quaik, … P. R.-W. management, and undefined 2015, "Sustainable utilization of oil palm wastes: opportunities and challenges," *academia.edu*, Accessed: Mar. 29, 2022. [Online]. Available: https://www.academia.edu/download/53522554/Waste_management_Threat_opportunities_and_challenges_book_v1.pdf#page=231
[15] B. Ravindran, N. Karmegam, … A. Y.-B., and undefined 2021, "Cleaner production of agriculturally valuable benignant materials from industry generated bio-wastes: A review," *Elsevier*, Accessed: Mar. 29, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0960852420315558
[16] A. Mudhoo, V. K. Garg, and S. Wang, "Heavy metals: Toxicity and removal by biosorption," *Environ. Chem. a Sustain. World*, vol. 2, pp. 379–442, Jan. 2012, doi: 10.1007/978-94-007-2439-6_10.
[17] Y. I. Ramnarain, A. A. Ansari, and L. Ori, "Vermicomposting of different organic materials using the epigeic earthworm Eisenia foetida," *Int. J. Recycl. Org. Waste Agric.*, vol. 8, no. 1, pp. 23–36, Mar. 2019, doi: 10.1007/S40093-018-0225-7.
[18] S. Sehar, I. Naz, N. Ali, S. A.-E. monitoring and, and undefined 2013, "Analysis of elemental concentration using ICP-AES and pathogen indicator in drinking water of Qasim Abad, District Rawalpindi, Pakistan," *Springer*, vol. 185, no. 2, pp. 1129–1135, Feb. 2013, doi: 10.1007/s10661-012-2620-2.
[19] D. Malizia, A. Giuliano, G. Ortaggi, and A. Masotti, "Common plants as alternative analytical tools to monitor heavy metals in soil," *Chem. Cent. J.*, vol. 6, no. SUPPL.2, May 2012, doi: 10.1186/1752-153X-6-S2-S6.
[20] Y. Lee, S. W. Oh, and S. H. Hanb, "Laser-induced breakdown spectroscopy (LIBS) of heavy metal ions at the sub-parts per million level in Water," *Appl. Spectrosc.*, vol. 66, no. 12, pp. 1385–1396, 2012, doi: 10.1366/12-06639R.
[21] S. Das, L. Goswami, S. B.-C. D. in, and undefined 2020, "Vermicomposting: earthworms as potent bioresources for biomass conversion," *Elsevier*, Accessed: Mar. 29, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B978044464309400039
[22] S. Pascal-Lorber and F. Laurent, "Phytoremediation Techniques for Pesticide Contaminations," *Altern. Farming Syst. Biotechnol. Drought Stress Ecol. Fertil.*, pp. 77–105, 2011, doi: 10.1007/978-94-007-0186-1_4.