Vermicomposting Water Hyacinth: Turning Fisherman's Nightmare into Farmer's Fortune

Philip Ariya Ogutu

Department of Biological Sciences, Masinde Muliro University of Science and Technology, School of Natural Sciences, P.O. Box 190, Post Code 50100, Kakamega, Kenya.

***Abstract:*-Water hyacinth (*Eichhornia crassipes*) in Lake Victoria has caused water loss through evapotranspiration, provided a breeding ground for mosquitoes and interfered with fishing and navigation. The weed contains macronutrients such as nitrogen (2.5%), phosphorus (1.0%) and potassium(5.3%) which can be made available to plants by using earthworms to convert the plants into compost. The worm cast and vermicompost obtained is a better source of organic manure than other aerobically or anaerobically degraded compost and has a lower environmental impact than chemical fertilizers. This study investigated the vermicomposting of water hyacinth by the fast-growing composting worm *Perionyx excavatus* and determined the concentrations of macronutrients. It was found that the vermicompost contained 47% more nitrogen, 60% more phosphorus and 40% more potassium than compost produced without worms. This suggests that vermiculture could be a means of reducing water hyacinth in Lake Victoria or other water bodies while producing a valuable agricultural product.**

***Keywords*: Waterhyacinth, vermicompost, macronutrients, *Perionyx excavatus*, microorganisms, farmer**

I. INTRODUCTION

Water hyacinth, *Eichhornia crassipes* is one of the most widespread, persistent, troublesome and harmful aquatic weeds [1]. It causes enormous losses of water through evapotranspiration, provides a breeding ground for obnoxious insects like mosquitoes, and prevents light penetration into the water below. This inhibits photosynthesis of submerged aquatic plants and phytoplankton, which can contribute to deoxygenation. The weed, which invaded Lake Victoria in 1989 [2], spread to cover about 17,000 ha in Kenya by November 1998 but this declined to about 400 ha in 2001. The decline was attributed to biological control by weevils (*Neochetina* spp.) and mechanical control [3]-[5]. Beaches covered by hyacinth mats varied in size but when they were totally covered there was a significant impact on communities by reducing economic and recreational activities on the lake. These included swimming and washing, boating and navigation, and fishing, with fish catchability decreasing by as much as 45%. [6]- [7].

The weed has some beneficial uses, however, especially as a source of macronutrients such as nitrogen, phosphorus and potassium that are essential for plant nutrition [8]-[10] and it can be used to improve soil fertility and increase crop yields [11]-[12].It is therefore a potentially valuable resource in a region where continuous land cultivation has led to reduced soil fertility and crop productivity [13]. These macronutrients are only available in bound forms, and their conversion into forms available to plants is enhanced by the activity of earthworms [14]-[16].

Vermicomposting involves the biodegradation of organic wastes into an amorphous, dark brown, microbially active, humus-rich substance under conditions of optimum temperature, moisture and aeration. It is environmentally sound, requires little energy, capital or equipment, and does not involve intensive management [17].

The resultant material, vermicompost, provides a base for the establishment of beneficial microorganisms such as nitrogen-fixers, actinomycetes, fungi and free-living microbes whose activity is essential for the release of diverse nutrients to plants [18]. Such beneficial microbes include soil bacteria that produce vitamins, growth hormones, enzymes, antibiotics, and immobilized microflora that promote plant growth [15]-[16] and increase yields[15]-[19].

Growth hormones such as gibberrellins, cytokinins and auxins are released by metabolic activity in vermiculture while it contains antibiotics and actinomycetes which contribute to the control of pests and diseases [15] while the application of vermicompost to fields improves the physico-chemical and biological properties of soil [18], [20].

Inorganic fertilizers are expensive and are not readily accessible to many small-scale farmers [21]. Furthermore, an increase in the use of inorganic fertilizers has been linked to increased health hazards in humans and livestock, and severe environmental problems like water and soil pollution, [18],[22],[23].This highlights the importance of organic composts such as those produced by earthworms, and this paper discusses the role of vermiculture in utilising water hyacinth. In particular, it compares the concentrations of selected macronutrients (N, P and K) in the vermicompost with that of natural composting.

II. METHODS

The earthworm *Perionyx excavatus* was used in this study.It matures rapidly(24) and starts producing cocoons at 8-12 weeks and has a wide range of temperature (8-35°C) and moisture tolerance. Being a non-burrower, it leaves its

excrement as loose mounds on the surface and it can be recovered to use as compost.

Twelve jute bags of water hyacinth were collected from ponds on the campus of Annamalai University, Chidambaram, India, and dried in the sunlight for 20 days. The water hyacinth was then chopped into small pieces and buried in a pit (1.8 x 1.5 x 1.2 m) and moistened by sprinkling it with water daily for two weeks to enable semi-decomposition to occur.

The experiment was carried out at a temperature of 25 $\pm 2^{o}$C and at a 75% moisture content. Six cement cisterns measuring 50 x 30 x 20 cm were used as worm bins for this study, with three serving as experimental bins and the other three as the controls. Semi-decomposed water hyacinth was put in the cisterns and 200 adult worms were introduced in each of the experimental cisterns. Water was sprinkled daily in all the cisterns to ensure a moisture content of 70-80%, and the experiment lasted for 25 days.

The concentrations of nitrogen, phosphorus and potassium in the water hyacinth were determined in samples taken at the time of the worm introduction, and after 25 days, from both the experimental bins and controls. Nitrogen (N) was determined by the macrokjeldahl method (25), phosphorus (P) by the vanadomolybdate yellow colour method (26) and potassium (K) by flame photometry (25). The crude protein content was estimated by the formula N x 6.25 where N = nitrogen content (27).

Table I. Comparative Values of N, P, K and Crude Protein in Natural Compost (control) and Vermicompost (experimental), both made from Water hyacinth.

Treatment	Initial	Control	Experimental
Day	0	25	25
N (%)	1.27	1.58	2.32
P (%)	0.98	1.70	2.30
K (%)	2.02	2.08	2.90
Protein (%)	7.9	9.9	14.5

III. RESULTS

The nitrogen concentration increased by 24% and by 82% in the experimental bins (Table I) and the difference between the control and experimental was highly significant (t-test, $p < 0.01$). The phosphorus content increased by 73% and 134% in the control and experimental samples respectively, and the differences between treatments was also highly significant (t-test, $p< 0.01$). Potassium increased by 3% in the controls but by 43% in the experimental treatments which is also a highly significant increase ($p < 0.001$).

IV. DISCUSSION

Earthworms, known to man from the time of Aristotle, who called them the "intestines of the earth" have been recognized as the most important soil invertebrates for their contribution to the fertility and productivity of the soil. Earthworms have been used to compost different forms of organic waste, such as animal and plant waste, sewage sludge, sugar factory wastes, cow and horse dung, pig and cattle slurries and the droppings of poultry and rabbits (28). In all cases, the materials were turned into NPK-rich vermicompost. Earthworm vermicompost, with continous application, releases the nutrients slowly and at a constant rate and protects plants (15). Increased concentrations of nitrogen,phosphorus, potassium and crude protein are well documented in vermicompost (15),(24). The present results, showing that nitrogen, phosphorus, potassium and crude protein were from 14-46% higher in vermiculture than in the wormless, natural compost clearly establishes the role of *P. excavatus* as a good composter. Thus, vermiculture offers a means of converting waste from water bodies into a rich manure.

Fishing is the major industry on the lake and water hyacinth mats may invade fishing grounds causing loss of fishing nets and blocking waterways, thus delaying access to markets. It was estimated that fish catches decreased by 5-45% (with the most severe effects being recorded in Kenya) during the period when the lake was most severely affected by water hyacinth [7],[29]. To the farmer however, this weed could be a fortune since it is very rich in plant nutrients, and with vermitechnology, these nutrients can be released much faster than the natural decomposition process.

V. CONCLUSION

Water hyacinth is thus not just an enemy but also a friend of the lakeshore communities.

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REFERENCES

[1]. Wilson, J.R., Holst, N. and Rees, M., (2005). Determinants and patterns of population growth in water hyacinth. *Aquatic Botany* **81**:51-67.

[2]. Twongo, T., (1991). Status of Water hyacinth in Uganda. *In*: A.Greathead and P. de Groot (eds). *Control of Africa's Floating Water Weeds, Proceedings of a Workshop, Harare, June 1991*. Commonwealth Science Council, London: pp. 55-57.

[3]. Albright, T.P., Moorhouse, T.G. and McNabb, T.J., (2004). The rise and fall of water hyacinth in Lake Victoria and the Kagera River basin. *Journal of Aquatic Plant Management* **42**:73-84.

[4]. Williams, A.E., Hecky, R.E. and Duthie, H.C., (2007). Water hyacinth in Lake Victoria: why did it vanish so quickly and will it return? *Aquatic Botany* **87**:94-96.

[5]. Wilson, J.R.U., Ajuonu,O.,Center, T.D., Hill, M.P.,Julien, M.H., Katagira, F.F., Neuenschwander,P., Njoka, S.W.,Ogwang, J., Reeder, R. H. and Van, T.,(2007). The decline of water hyacinth in Lake Victoria was due to biological control by *Neochetina spp*. *Aquatic Botany* **87**: 90-93.

[6]. Opande, G.O., Onyango, J.C. and Wagai S.M., (2004). Lake Victoria: The water hyacinth (*Eichhornia crassipes*[Mart]Solms), its socio-economic effects, control measures and resurgence in Winam Gulf. *Limnologica* **34**:105-109.

[7]. Kateregga, E. and Sterner, T., (2009). Lake Victoria fish stocks and the effects of water hyacinth. *Journal of Environment and Development* **18**: 62-78.

[8]. Center, T.D., Hill, M.P., Cordo, H. and Julien, M.H., (2002). Water hyacinth. *In*: R. van Driesche (ed.). *Biological control of invasive plants in Eastern U.S*. FHTET: USDA Forest Service Publication: pp. 41-46.

[9]. Sahu, A.K., Sahoo, S.K. and Giri, S.S., (2002). Efficacy of water hyacinth compost in nursery pond for larval rearing of Indian major carp, *Labeo rohita*. *Bioresearch and Technology* **85**:309-311.

[10]. Woomer, P.L., Muzira, R., Bwamiki, D., Metutikka, D., Amoding, A. and Bekunda, M.A., (2000). Biological Management of water hyacinth in Uganda. *Biological Agriculture and Horticulture***17**:181-196.

[11]. Amoding, A., Muzira, N.R., Bekunda, M.A. and Woomer, P.L., (1999). Bioproductivity and decomposition of water hyacinth in Uganda. *African. Crop Science. Journal* **7**:433-439.

[12]. Osoro, N., Muoma, J.O., Amoding, A., Mukaminega, D., Muthini, M., Ombori, O. and Maingi, J., (2014). Effects of water hyacinth (*Eichhornia crassipes* [Mart.] Solms) compost on growth and yield of maize (*Zea mays*). *British Journal of Applied Science and Technology* **4**:617- 633.

[13]. Ojiem, J.O, Mureithi, J.G., Okousa, E.A., (2000). Integrated Management of Legume green manure, farmyard manure and inorganic nitrogen for soil fertility improvement in Western Kenya. Participatory technology development for management of small holders in Kenya. Kenya Agricultural Research Institute, Nairobi: pp. 97-102.

[14]. Chaoui, H.I., Zibislke, L.M. and Ohno, T., (2003). Effects of earthworm casts and compost on soil microbial activity and plant availability. *Soil Biology and Biochemistry* **35**:295-302.

[15]. Sinha, R., Herat, S., Valani, D. and Chauhan, K., (2009). Earthworms vermicompost: a powerful crop nutrient over the conventional compost and protective soil conditioner against the destructive chemical fertilizers for food safety and security. *American-Eurasian Journal of Agriculture and Environmental Sciences* **5**(S): 14-55.

[16]. Sridevi, S., Prabu, M. and Tamilselvi, N.G., (2016). Bioconversion of water hyacinth into enriched vermicompost and its effect on growth and yield of peanut. *International Journal of Current Microbiology and Applied Sciences* **5**:675-681.

[17]. Hénault-Ethier,L., Martin, V.J.J. and Gélinas, Y., (2016). Persistence of *Escherichia coli* in batch and continuous vermicomposting systems. *Waste Management* **56**: 88-91.

[18]. Moradi,H.,Fahramand,M.,Sobhkhizii,A.,Adibian,M.,Noori, M., Abdollahi, S.and Rigi, K., (2014)Effect of vermicompost on plant growth and its relationship with soil properties.*International Journal of Farming and Allied Sciences* **3**:333-338.

[19]. Oroka, F.O.,(2012). Water hyacinth-based vermicompost on yield, yield components and yield advantage of cassava plus groundnut intercropping system. *Journal of Tropical Agriculture* **50**:49-52.

[20]. Azarmi, R.,Gilou, M.T. and Shmikail, R.D.T., (2008). Influence of vermicompost on soil chemical and physical properties in tomato field. *African Journal of Biotechnology* **7**:2397-2401.

[21]. Chianu, J.N., Chianu, J.N. and Mairura, F., (2012). Mineral fertilizers in the farming systems of sub-SaharanAfrica. A review. *Agronomy for Sustainable Development* **32**:545-566.

[22]. Alam, M.N., Jahan, M.S., Ali, M.K., Islam, M.S. and Khandaker, S.M.A.T., (2007). Effect of vermicompost and NPKS fertilizers on growth, yield and yield components of red amaranth. *Australian Journal of Basic and Applied Science* **1**:706-716.

[23]. Savci, S., (2012). Investigation of effects of chemical fertilizers on environment. *APCBEE Procedia* **1**:287-292.

[24]. Pattnaik, S. and Reddy, M.V., (2010). Nutrient status of vermicompost of urban green waste processed by three earthworm species - *Eisenia fetida*, *Eudrilus eugeniae*, and *Perionyx excavatus*. *Applied and Environmental Soil Science*. Volume 2010, Article ID 967526, 13 pages.

[25]. Jackson, N.L., (1973).*Soil Chemical Analysis.* Prentice Hall India: New Delhi.

[26]. Piper, C.S., (1966). *Soil plant Analysis*. Hars Publication, Bombay.

[27]. Association of Official Agricultural Chemists., (1960). *Methods of Analysis*. Association of Official Agricultural Chemists: Washington DC.

[28]. Orozco, F.H., Cegarra, J., Trujillo, L.M. and Roig, A., (1996). Vermicomposting of coffee pulp using the earthworm *Eisenia fetida*: effect on C and N contents and the availability of nutrients. *Biology and Fertility of Soils* **20**:162-166.

[29]. Ngeno E.K., Langat B.K. and Kipsat M.K., (2010). Econometric analysis of the effects of Water hyacinth on the fish catches in Lake Victoria, East Africa. *Journal of Development and Agricultural Economics*.**2**: 277-280.