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A Review on Potential of Vermicomposting Derived Liquids in Agricultural Use

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Abstract- Rising demand on fertilizer is closely related with the rising demand of crop as the population increases. Land available to be used for agricultural purposes is limited. With the increase of health awareness of people, organically cultured fruits and vegetables are getting attention and in demand. Although chemical fertilizers are still in extensive use these days, people are getting more aware of the effects brought by these chemicals. Environmental as well as health problems have raised the alarm on the effects of usage of chemical fertilizer and consuming of heavily chemically fertilized crops. Vermicomposting has been getting attention due to its environmental friendly approach. Beside the compost produced, recent interest has been brought up due to the possible use of the liquid by products from this green technology. Several terms have been used to describe the liquids derived from the vermicomposting process. This paper reviews the common terms used for vermicompositng derived liquids, its potential in agricultural use as well as its pros and cons.

Index Terms- Vermicomposting, vermiwash, vermicomposting leachate, vermicompost extract, agricultural use

I. INTRODUCTION

With the drastic increase in population globally, there is no doubt that food supply will have to be increased at the same pace in order to meet the demand. All forms of fertilizers are playing a vital role as maximizing yield of crops has became one of the priorities of the farmers these days. Asia consumed of 61% of world total fertilizer. This makes Asia region the largest consumer of fertilizer in the world, FAO, 2010 [1]. Environmental friendly approach of producing high quality organic fertilizer is one of the major concerns of researchers lately. Vermicomposting technology is a simple technology that has been under the spotlight of sustainable technology in the past decades. With the help of the earthworms' feeding behavior, vermicomposting has the ability to process wastes through degradation and decomposition. Several terms have been defined and coined by researchers to explain the vermicomposting derived liquids based on their preparation method. This environmental friendly approach and the rising demand of the naturally derived fertilizer have brought the interest of preparing this review, as well as to clear the confusion of terms that used to describe these liquids.

II. VERMICOMPOSTING DERIVED LIQUIDS

The beauty of vermicomposting if compared with conventional composting process is that the time span for stabilizing and processing the waste is shorten, even though it does not undergo thermophilic phase of composting. The half digested material that after being processed by earthworm, will later being further decomposed by gut associated microbes and converted into mature compost, Dominguéz and Edwards, 2004 [2]. Earthworms ingest soil, burrow and excrete casts and urine to the soil. In vermicomposting process, earthworms will ingest the substrate introduced into the reactor. There are few terms that can be found in describing vermicomposting derived liquids. The common ones are like vermiwash, vermicomposting leachate /vermi-leachate, worm bed leachate and worm tea. The term vermiwash was coined by Ismail, 1997 [3]. Leachate is generated along with vermicomposting process commonly referred to as vermicomposting leachate or worm-bed leachate, Gutiérrez-Miceli *et al*, 2011 [4] Extract from vermicompost is known as vermicompost extract, AP Pant *et al*, 2009 [5]. The preparations of these vermicomposting derived liquids are different.

A. Vermiwash

In vermiwash production, as introduced by Ismail, 1997 [3], cow dung was used as the substrate for vermicomposting. No garbage or other wastes were suggested to be used. Water percolated through the column of worm actionwill collect excretory products and mucus secretions of earthworms, as well as the micronutrients from the soil organic molecules, Ismail, 1997 [3]. This produces the liquid (vermiwash) that washed away the valuable plant nutrients and microorganism present in drilosphere. Drilosphere, as defined by Brown *et al*, 2000 [6], is the environment made up of microenvironment in earthworm gut, surface that earthworm in contact with

soil, surface and below ground of the vermicasts, middens, burrows and diapause chambers.Earthworms prefer to consume a mixture of soil and organic matter over pure organic matter. They feed selectively and Judas, 1992 [7] confirmed it by observing its gut content. Earthworms' ability in digesting organic matter and assimilating nutrients from ingested organic matter is varies in species and ecological categories. Lattaud *et al*, 1998, 1999 [8][9]

Concept of the design of vermiwash reactor is well defined and coined by Ismail, 1997 [3]. Various substrates were used in the same design by others as the modification. Vermiwash collects the nutrients as well as microorganism present in the drilosphere through water percolation Ismail, 1997 [3]. Figure 1 shows the earthworm activities and its benefits in vermicomposting process.

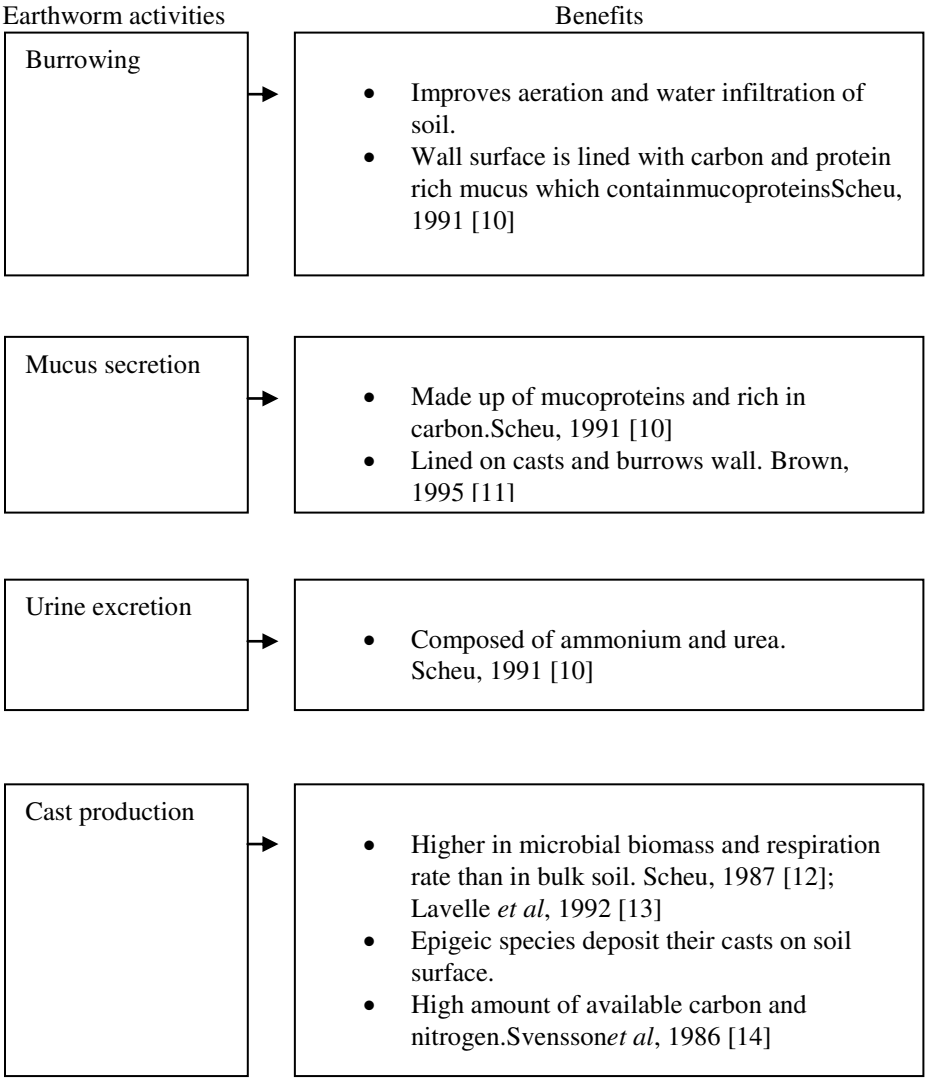

Figure 1: Earthworm activities and its benefits in vermicomposting process.

Table 1 shows a summary of studies on vermiwash carried out from various wastes and the findings when applied to plants. Improvement in growth and higher concentration of chlorophyll and carotenoids were observed. Vermiwash contain valuable plant nutrients as well as indoleacetic acid (IAA).

Table 1: Summary of vermiwash as liquid fertilizer in agricultural use from different types of substrates.

Substrate used for vermiwash	Plant	Findings	Reference
Cow dung and leaf litter	Rice	Maximum leaf and root length, number of leaves and plant height were recorded from pot applied with vermicompost and vermiwash.	Tharmaraj *et al*, 2011 [15]

Cow dung and coconut leaf litter	Cowpea, Maize and Okra	High concentration of P, K, Caand Mg were found in vermiwash. Vermiwash from pure cow dung showed highest in N, P, Ca, Mg and indoleacetic acid (IAA) concentration. Seedling vigour index were highest in 1:10 dilution for cowpea.	Gopal *et al* , 2010 [16]
Animal waste and kitchen waste	-	Results showed potential as a bio-fertilizer for particular nutrient deficient soil by using combination of substrate.	Nath *et al*, 2009 [17]
Cow manure	Indian Borage (*Plectranthusambionicus)*	High concentration of potassium (K) concentration was determined. Diluted vermiwash (10%) shows highest in germination percentage, root and shoot length, total chlorophyll and carotenoids content.	Quaik *et al*, 2012a [18]

B. Vermicomposting leachate

Water was constantly applied to the vermicomposting reactor to ensure the moisture level and excess water in the reactor will be leached out. The concept of the preparation of vermicomposting leachate is that nutrients that have been mineralized and assimilated by earthworms and microorganism during the vermicomposting process will be leached out along side with leachate. Table 2 is a summary of studies carried out on vermicomposting leachate/worm bed leachate. It showed high germination percentage and improvement in growth indices.

Table 2: Summary of studies on vermicomposting leachate/worm bed leachate. Modified from Quaik*et al*, 2012b [19]

Substrates used for vermicomposting leachate	Plant used	Findings	Reference
Sheep manure	Radish (Raphanus sativus *L.*)	Germination(%), number of leaves, plant height (cm), and shoot dry weight (g) are highest in leachate of 10% dilution. Whereas root dry weight(g) is highest in leachate of 15% dilution	Gutiérrez-Miceli *et al*, 2011 [4]
Cow dung, vegetable waste and mixture of cow dung and vegetable waste (1:2)	Strawberry (*Fragaria x ananassa Duch*.)	High leaf area and dry weight of plants were obtained for leachate from cow dung, vegetable waste and mix waste. Foliar application of leachate obtained from mixture of cow dung and vegetable waste showed supremacy in plant growth. Significantly higher fruit yield were obtained if compared to control.	Singh *et al*, 2010 [20]

Cow manure	Sorghum (*Sorghum bicolor* (L.) Moench)	Germination index of vermicomposting leachate for crest was 65 ±7 %. For maximum growth, NPK fertilization is required.	Gutiérrez-Micel i*et al*, 2008 [21]
Cow manure	Maize (*Zea Mays* L.)	Vermicomposting leachate has to be diluted to 50% to 500ml to get maximum plant growth.	García-Gómez *et al*, 2008 [22]
Cow dung and green forage	Tomato (Lycopersicum esculentum cv. Momotaro)	Hewitt solution was used as control. Both leachates were used as foliar fertilizer with dilution of 1ml in 500 ml. Treatment with green forage leachate showed highest chlorophyll content as well as plant height. N, P and K content of fruits are highest in the plant fertilized with green forage leachate, followed by cow dung leachate and control.	Tejada *et al*, 2008 [23]

C. Vermicompost aqueous extract

According to Pant et al, 2009 [5], vermicompost aqueous extracts (vermicompost teas) can be extracted through employing non-aerated or aerated method. Non-aerated or passive extraction of extract was by placing vermicompost into a fix amount of volume of water with occasional stirring and allowed to sit for 7 days. For aerated extraction, air was pumped and oxygen level was maintained to above $5mgL^{-1}$. Sugar, grain, fish emulsion, kelp tea, humic acid and other products are often added during the process to further enhance the microbial activity of the end-product, Ingham, 2005 [24]. Welke, 2005 [25] reported that compost tea extracted through both aerated and non-aerated method from animal manure showed positive effect on strawberry yield as well as suppression of *Botrytis cinerea*.

III. PROS AND CONS

Vermicomposting technique has been used as one of the environmental friendly technology for waste management as several approaches have been done on stabilizing wastes generated from agricultural activities as well as from other industries. Studies are showing that besides vermicompost, vermicomposting process also produces another eco-friendly by product in liquid form. Potential of these vermicomposting derived liquids has been shown in several studies mentioned above. The chemical-free method of preparation for these liquids is in favor as an approach of producing environmental friendly biofertilizer. One of the advantages of vermicomposting derived liquids is that nutrients present are completely soluble in water due to its preparation method. Hence, it has the potential to be used as a foliar fertilizer. To be used as foliar spray, the nutrient should be water soluble and the salt concentration in it should not be too high till it causes scorching on leaves when sprayed. From the summary of studies carried out with vermiwash, vermicomposting leachate and vermicompost aqueous extract, these biofertilizers showing promising result in various dilutions. Therefore, it showed the potential of using vermicomposting derived liquids as foliar fertilizer (Table 1 and Table 2). On the other hand, foliar fertilizing compensates the loss of fertilizing effect of conventional soil-applied fertilizer through the prevention of leaching. Rate of leaching is different with different composition of soil. For example higher composition of clay present in the soil will have lower leaching rate. Soil water holding capacity will also determine the significance of leaching losses. Certain nutrients such as sodium and magnesium are more prone to leaching in soil with high clay concentration, Mengel and Kirkby 2001 [26]. Leaching not only will cause nutrients loss before being absorbed by plants, it may also cause ground water pollution if the planting site happen to be nearby groundwater source. Despite ground water pollution, run-off may also bring nutrients into nearby stream and river. Nutrients such as nitrates and phosphates will cause eutrophication to nearby water body.

Vermicomposting derived liquids may be added to irrigation system to provide extra nutrients to plant through fertigation which is a technique of combining fertilizing and irrigation. Nutrients that completely soluble in water will have no risk of clogging up the sprayer.

Available plant nutrients that present in these liquids are valuable and have the potential to be used as nutrients solution in hydroponics culture. Quaik *et al*, 2012 [18] reported that diluted vermiwash and vermicomposting leachate when used as nutrient

solution for *Plectranthus ambionicus,* chlorophyll and carotenoids content were higher if compared to control. Hydroponics culture has the advantage of being carried out in space limited area. Hydroponics culture is a soilless cultivation method which is a contribution for crop production in area where lands are inadequate for crop production. By using these plant nutrients rich liquids in hydroponics culture, soil borne diseases and pests can be controlled, Jensen, 2002 [27].Usage of other fertilizer can be also reduced. However, very limited research has been reported on using these bioliquids in hydroponics culture.

The downside of these liquids is that the nutrient contents of end product are strongly depending on the substrates that were used. Substrates high in heavy metals content may produce liquids that contain high value of heavy metals. One of the concerns about these so called biofertilizers is types of substrates the liquid derived from as it will directly affect the content of the product. On the other hand, the nutrient content presence in these liquids is high but may not be completely enough as study has suggested that NPK fertilizer may have to be added for better yield, Gutiérrez-Miceli *et al*, 2008 [20]. Therefore, using these liquid alone for plant fertilizing may not be enough for promising growth.

The limitation for applying liquid fertilizer directly to soil may not be as efficient as applying solid fertilizer as it may be leached away easily. Soil composition and texture are playing vital role in rate of leaching. The quantity of liquid fertilizer required in order to achieve the result that on par with conventional solid fertilizer may be much higher due to its concentration. Besides that,storage of liquid fertilizers may require larger space if compared.

IV. CONCLUSION

Vermicomposting derived liquids contain valuable nutrients that promote plant growth. Substrates that have been used in these liquids production are mainly animal and agricultural waste. Different terms are used in describing these liquids as there are some differences in preparation. However, controversy is still exists as these liquids are produced from waste substrates especially industrial waste that may contain heavy metals and other harmful elements. Chances of transferring harmful substances from the substrate to the liquids are still unknown. Therefore, further studies are strongly needed especially liquid preparation method as well as on relationship between the substrates and the vermicomposting derived liquids.

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