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MICROBIAL DEGRADATION OF ORGANIC WASTE THROUGH VERMICOMPOSTING

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ABSTRACT

Every habitation produces a considerable amount of biodegradable waste that is discarded via dumping at various sites, in landfills, being burnt or is dumped in the river systems. Guyana is no exception - the water ways are polluted with plants, grass is constantly mowed from lawns, huge amounts of market refuse on a daily basis – contributes to unsightly land pollution. Vermicomposting is the best solution to getting rid of these biodegradable waste materials. Composting of grass, water hyacinth and a combination of grass with water hyacinth were successful. Final compost yields were at least 30%. This represents a huge decrease in compost volume. Therefore, vermiculture is an efficient method to reduce biodegradable solid waste. By using earthworms, waste is rapidly turned into vermicompost. Vermicompost has higher microorganism content and the activities of microorganisms (Actinomycetes, Azotobacter, Nitrobacter, Nitrosomonas and Aspergillus) is responsible for enhanced plant productivity much more than would be possible from the mere conversion of mineral nutrients into more plant-available forms. Also, during this period, there is a reduction of Gram negative cocci bacteria and corresponding increase in Gram positive bacilli as time progresses towards the maturity of the vermicompost in all three compost samples. This would indicate a healthier finished product that is highly beneficial to plant growth.

Keywords: Vermicomposting, Biodung compost, Microorganisms, Plant growth, Earthworms, Plant productivity.

Contribution/ Originality

This study is one of very few studies which have investigated the contribution of microbes in the process of large scale biodung mediated vermicomposting. The contribution is significant in the area of organic waste recycling that is necessitated towards clean environment.

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1. INTRODUCTION

All human habitations produce huge quantities of solid biodegradable waste that range from domestic to agricultural and industrial. Management of these wastes and their disposal is a major problem. Many countries, both developed and underdeveloped, opt for landfills and burning. These methods of waste disposal result in valuable resources which can otherwise be recycled. Wastes if not managed scientifically pose a sequel of environmental and health hazards. In Guyana, solid waste is a major problem especially in towns. Recycling of organic waste is beneficial towards environmental management as well as economically helpful in municipal composting with sustainable costing. Also, recycling the composts back on national parks, in local gardens, on farms, or for reforestation of disturbed lands, also can make such entities more sustainable. Our agricultural lands also yield solid wastes in the form of weeded grass, paddy straws and so on. Also, huge amounts of vegetable wastes are left over from the markets throughout Guyana. These wastes can be collected and bio-composted (Ansari, 2011).

Vermitechnology is a method of converting all the biodegradable wastes into useful product i.e. vermicompost, through the action of earthworms (Ansari, 2011). Vermicompost is a sustainable bio-fertilizer regenerated from organic wastes using earthworm which contains 1.2 to 6.1% more nitrogen, 1.8 to 2.0% more phosphate and 0.5 to 0.75% more potassium compared to farm yard manure. It also contains hormones like auxins and cytokinins, enzymes, vitamins and useful microorganisms like bacteria, actinomycetes, protozoans, fungi etc (Ansari and Ismail, 2001). This process of decomposition results in the production of vermicompost. Vermicompost, or castings, is worm manure. It is considered by many in farming arena to be the very good soil improver. The nutrient content of castings is dependent on the material fed to the worms-and worms are commonly fed materials with high nutrient content (Ismail, 1997; 2005). It is the worm castings that provide these nutrients in a form that is readily available to plants. The biology of the worm's gut facilitates the growth of fungus and bacteria that are beneficial to plant growth.

The organic waste basically contains two important elements, carbon and nitrogen, should be mixed in such a way that ratio is 30:1 and during the process of composting becomes suitable for growth of microbes like bacteria, active during initial phase of composting. Raw materials high in carbon (such as grass) should be combined with raw materials high in nitrogen (such as manure) to obtain the appropriate 30:1 ratio for optimum composting conditions. For most composting, a ratio of between 20 and 30:1 is recommended. When C content rises above 30, heat production drops and the rate of composting slows (Kale, 1998; Ansari, 2012). During composting C: N ratio is reduced to 20:1 resulting in increased pH (los of nitrogen as ammonia) that may affect the functioning of some microorganisms. Oxygen is an essential component for aerobic composting that is aided by porosity required for circulation of oxygen in the composting material. Insufficient oxygen results in anaerobic conditions and the production of objectionable odors from chemicals such as hydrogen sulfide, methane, and organic acids (Dickerson, 1999). A good compost should be moist with moisture content ranging between 40-60% that tends to facilitate the growth of

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microorganisms and maintains the microbial activity at optimal level. Moisture levels above 60 percent result in anaerobic conditions (Dickerson, 1999).

Temperature plays an essential role in the process of composting. As temperatures rise and fall in the compost, different bacterial species will become more or less active. Psychrophilic, mesophilic and thermophilic bacteria each operate best within specific temperature ranges. The psychrophiles are the first to start the process. They can work at temperatures below 0 ^{o}C (as low as -18 ^{o}C), but are most active around 13 ^{o}C. The heat generated makes the conditions suitable for the growth of mesophiles. Most decomposition work is done by mesophilic bacteria (Ansari, 2012). These are the midrange bacteria that operate in temperatures between 15 ^{o}C and 40 ^{o}C, but thrive when temperatures are closest to 21 to 32 ^{o}C. Heat generated as a by-product of the mesophiles work raises the temperature in the pile even more, creating conditions suitable for thermophilic composting. The thermophiles do "hot" composting. They start to take over when temperatures reach 40 to 45 ^{0} C and will continue to work in temperatures up to about 70 ^{o}C when their numbers start to decline. The rate of activity of thermophiles is faster but they survive for 3 to 5 days. Turning of composting material helps in providing sufficient aeration necessary for maintaining the activity of thermophiles. As temperatures drop and thermophiles reduce in number, the compost moves into a more mature stage. Mesophiles and psychrophiles, which may have been working in a reduced capacity around the cooler edges of the decomposing organic material, become more active. The final stage of decomposition is carried out by Actinomycetes that produce antibiotics. Production of antibiotics inhibit the growth of bacteria. They work on tough organic material and give compost its pleasant, earthy smell. They are especially important in the formation of humus. They liberate carbon (C), nitrate (NO_3^-) and ammonium (NH_4^+), making nutrients available to plants. They produce Actinomycetes that are very important in the formation of humus (Ansari and Rajpersaud, 2012). Actinomycetes may work near the surface or many feet below the ground. While decomposing animal and vegetable matter, actinomycetes liberate carbon, nitrogen, and ammonia, making mineral nutrients available for higher plants.

Final stages of composting also facilitate the growth of fungi that prefer acidic conditions prevailing in the late stages of composting. Plant nutrients present in decomposed organic material is released slowly into the soil ecosystem. Some fungi form mycorrhizae associations with plant roots - plants provide the fungi with food (sugars and other root exudates) and the mycorrhizae provide the plants with enhanced availability of plant nutrients (Ansari, 2012; Ansari and Ismail, 2012).

Earthworms from the beginning have been recognized for contributing to soil fertility. Although so much has been said about the effects of these almost invaluable creatures to soil fertility and vitality for centuries not much has been done so far to harness to maximize the benefits (Ansari, 2012). Microorganisms are the main component responsible for the recycling of organic matter both in natural and artificial systems. Vermicompost has high microorganism content and the activities of these microorganisms is thought to be responsible for enhanced plant productivity

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much more than would be possible from the mere conversion of mineral nutrients into more plant-available forms (Simpson and Martin, 2004).

1.1. The Present Research Work was carried out with the Following Objectives

- To recycle water hyacinth (*Eichhornia crassipes*), Bermuda grass (*Cynodon dactylon)* and vegetable wastes by vermitechnology.
- To conduct microbial analyses (*Nitrobacter, Nitrosomonas, Azotobacter, Actinomycetes, Aspergillus,* Total microbial count) of vermicompost samples.
- To provide the knowledge and skills developed in this investigation to farmers throughout Guyana.

2. MATERIALS AND METHOD

The vermicomposting units were set up at the University of Guyana – Turkeyen campus compound next to the garden. The microbial analysis of the composted samples was carried out at the science laboratory at the University of Guyana – John's campus.

2.1. Method Used in Setting up Vermicomposting Units (Ansari and Ismail, 2001)

Three tanks made from hollow blocks (1.5 m x 1 m x 1m each) were used as the set up units for vermicomposting. In each unit* (see details below), there was added a bottom layer of crushed stones (4 cm) followed by a layer of white sand (4 cm) followed layer of loamy soil (4 cm). These layers were then moistened but not completely soaked. A layer of grass was then placed over the foundation followed by cattle dung (see appendix for diagrams). This was repeated until the height reached 1 metre. In each container approximately 60 locally collected species of earthworm, *Eisenia foetida*, were placed. These units were then sprinkled with water to keep the contents moist so that the earthworms would have a suitable habitat to live and multiply. Tanks were covered so as to prevent direct sunlight unto the compost. Watering was done every three to four days as needed to maintain the compost in a moist but not wet state. After every 10 days, samples of ½ kg were collected, air dried and labeled and put up in a safe place for microbial analyses. A total of 30 samples were collected. (Also, there was a concurrent processing of biodung composting for 30 days of the fresh grass). After about 60 days the composts were harvested from each unit.

The vermicomposting unit plan was carried out as follows (in triplicates):

Unit 1	Bermuda grass with cattle dung.
Unit 2	Water hyacinth, grass and cattle dung.
Unit 3	Water hyacinth and cattle dung.

The compost samples were then quantitatively analyzed for microbes (*Azotobacter, Actinomycetes, Aspergillus,* Total heterotrophic count and Total fungal count) present at different stages of the composting.

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3. RESULTS

Figure 1 indicated that the maximum productivity in Unit 3 (T3) in which the organic waste was in the form of water hyacinth + grass clippings. The organic waste in T3 is mixture of water hyacinth and grass clippings in comparison to T1 and T2, that enhances the activity of earthworms in organic waste conversion to vermicompost.

Figure 2 indicated that the heterotroph count is greater in T2 followed by T4 and T3 (PDYEA media). Figure 3 indicates that the heterotroph count is greater in T2 followed by T3 and T4 (PDA media). Figure 4 showed that the fungal growth was greater in T3 followed by T4 and T2 (PDYEA media). Figure 5 indicated that the fungal count was greater in T3 followed by T2 and T4 (PDA media). Colony count of Bacilli was greater in T3 followed by T4 and T2 whereas Cocci were greater in T2 followed by T4 and T3 (Figure 6). Figure 7 indicated that *Aspergillus* growth was greater in T2 followed by T4 and T3. *Nitrobacter* population was maximum in T2 followed by T4 and T3 (Figure 8). Figure 9 showed that *Nitrsomonas* count was greater in T4 followed by T2 and T3. *Actinomycetes* population was greater in T3 followed by T4 and T2 (Figure 10).

4. DISCUSSION

The vermicompost obtained after processing through vermicomposting differs in quantity (reduced) compared to the organic waste inputs added to Vermitech units at the start of the process. The earthworms process the organic waste by mixing it with mucous, gut flora and excrete as vermicast enriched with micronutrients and essential microbes (Ismail, 1997; 2005; Ansari, 2011). The bio-composting method is made up of two phases (breakdown and buildup phase). In the breakdown phase biodegradable wastes are decomposed into smaller particles. Proteins are broken down into amino acids and finally to ammonia, nitrates and free nitrogen. Similarly, urea, uric acids and other non-protein nitrogen-containing compounds are reduced to form different plant nutrients. In the build-up phase, there is the re-synthesis of simple compounds into complex humic substances. *Azotobacter*, *Nitrosomonas* and *Actinomycetes* play an important role in transforming the raw organic material to humus like sweet smelling fine composted material. Heat, water vapor, and carbon dioxide released during the composting process reduce the overall size of the compost pile by as much as 50 %. Both fungi and actinomycetes tend to feed on more resistant materials, such as cellulose and lignins, which are left over after the composting process. Curing is considered complete when the pile remains at or near ambient air temperatures and the respiration rate (rate of oxygen consumed) is less than 200 mg O_2 per kg of compost per hour. The compost can then be screened for various agronomic and horticultural uses.

Composted urban refuses were studied as organic fertilizers (Villar *et al.*, 1993). These were found to be containing Ca, Na, K, Mg and P. However NH_4 was higher in concentration than NO_3 indicating unbalanced availability of major nutrients. Total C contents and C/N ratios in the three non-amended composts were in the range for stabilized composts; however, the NH_4 content seemed to point to the presence of non-stabilized substances (Villar *et al.*, 1993).

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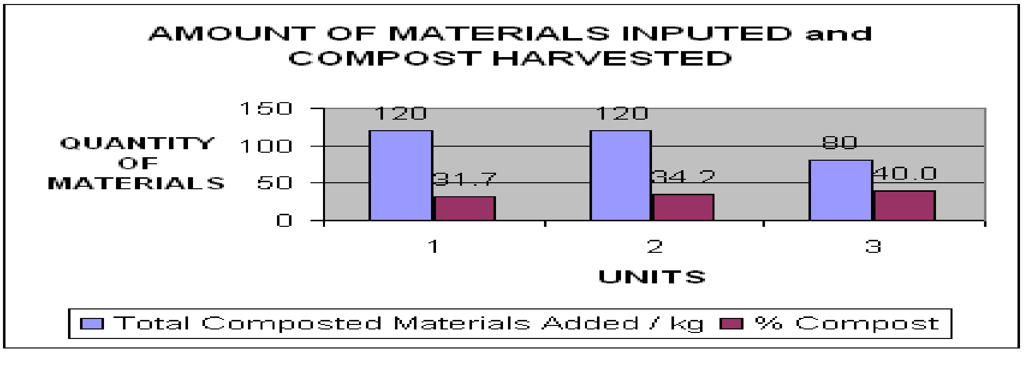
A higher plant growth was observed in the presence of worms (Edwards and Bohlen, 1996; Edwards and Arancon, 2004). Birch seedlings planted in soil with earthworms had 33% and 24% more leaf and stem biomass respectively than in those grown in pots without earthworms. Root biomass was slightly lower in the earthworms than in the bare soil treatment and N content of leaves was twice higher in the treatment with earthworms. This was only partially explained by earthworm mortality. N uptake increases in the presence of earthworms and is correlated (r = 0.85) with the increase in CO_2 production (Ruz-Jerez *et al.*, 1992). The soil productivity is indicated not only by enriched mineral nutrients but also by organic matter that is derived from organic compost added to the soil. This is the so-called "organic matter effect" suggests that mechanisms other than simple nutrient supply can contribute to plant growth (Galli *et al.*, 1992). Edwards and Bohlen (1996) studied the effects of nutrient enrichment processes (i.e. allowing the passage of organic residues from the surface of the soil to below the surface) and those of gut associated process.

It can be concluded that growth parameters for chemical grown crops and organically grown crops are comparable. Chemical fertilizers, especially nitrogen based, shown spectacular growth and productivity in the field but this is short lived. The high level of these chemical added to the soil are not usually absorbed completely by the plants. The balance cannot remain in the soil for the next season. They are either leached or formed complexes with high levels of metal ions to form undesirable complexes (Ansari and Rajpersaud, 2012). Constant use of chemical fertilizer increases leaching because of depletion of organic carbon (Stoffella and Kahn, 2000; Ansari and Sukhraj, 2010).

5. CONCLUSION

Composting of grass, water hyacinth and a combination of grass with water hyacinth were successful. Final compost yields were at least 30%. This represents a huge decrease in compost volume. Therefore, Vermitech is a very efficient method to reduce biodegradable solid waste. By using earthworms, waste is rapidly turned into vermicompost. Vermicompost forms fine stable granular organic matter that assist in the aeration, released mucus that are hygroscopic absorbs water and prevents water logging and improves water holding capacity. Vermicompost contains nutrients, microbes and plant growth promoters that are released slowly due to combined effect of fine humus present as component of organic matter.



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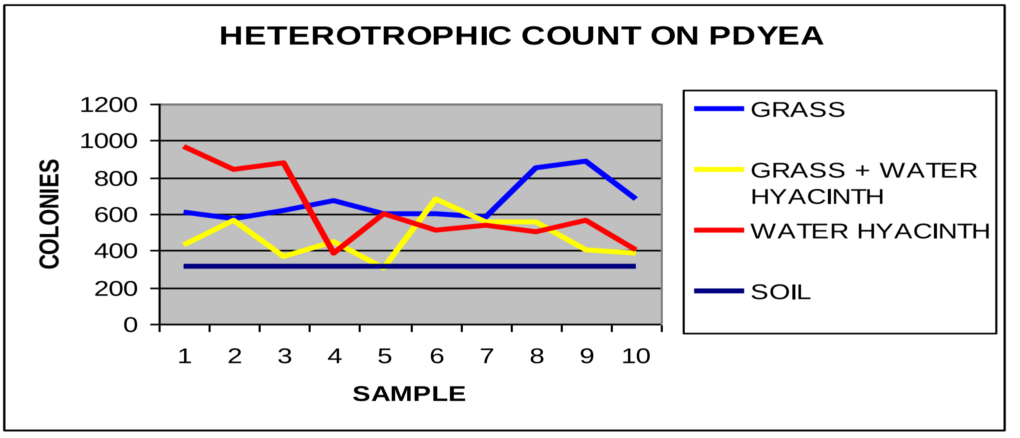

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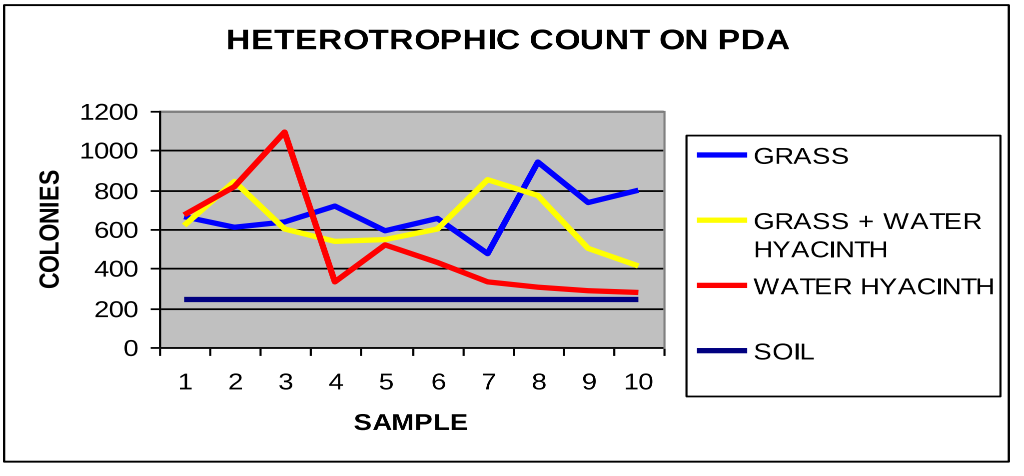

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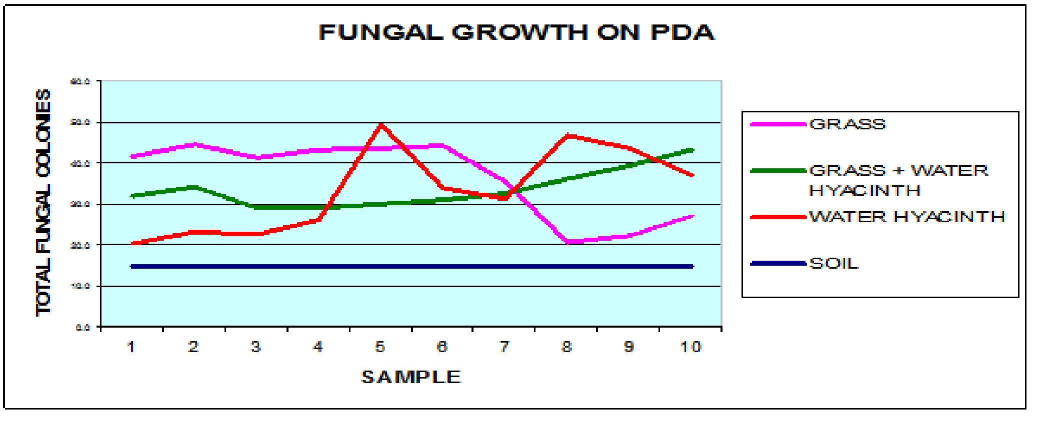

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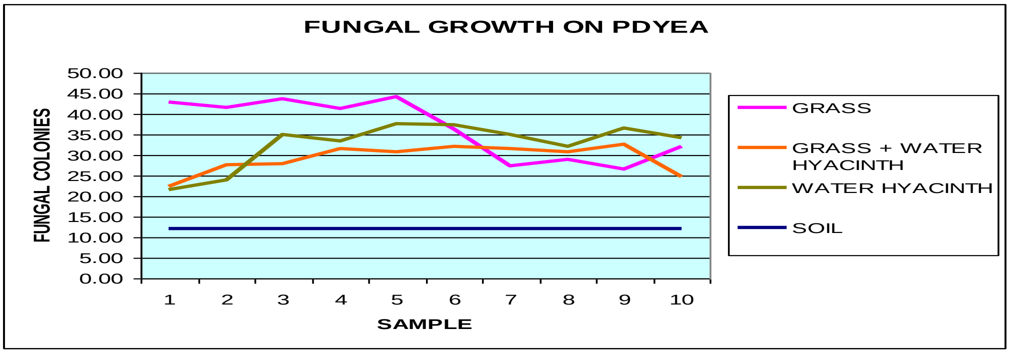

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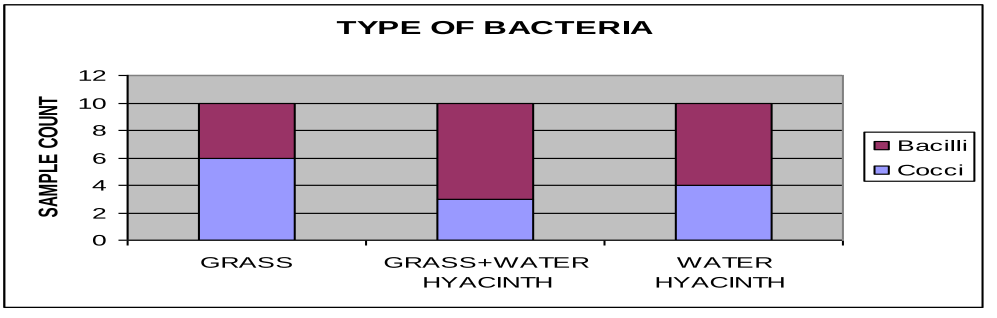

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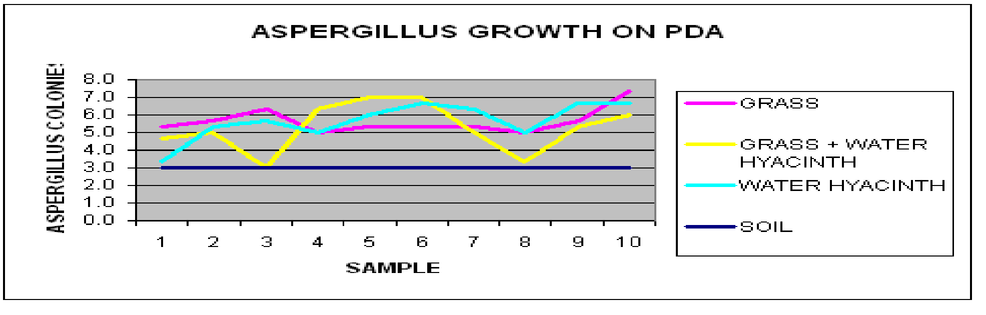

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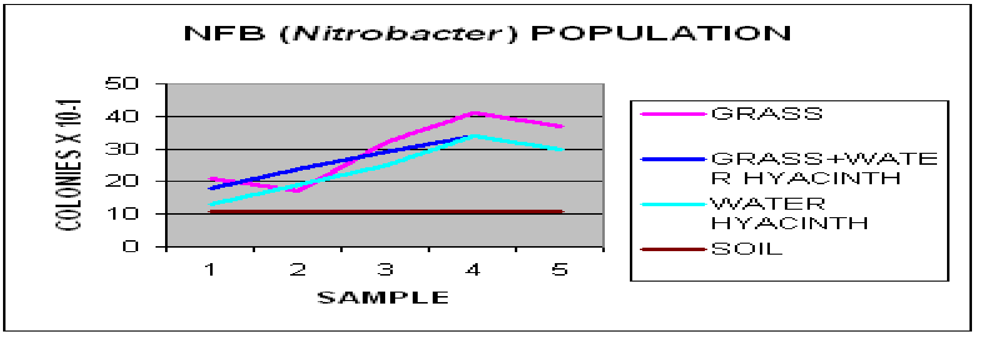

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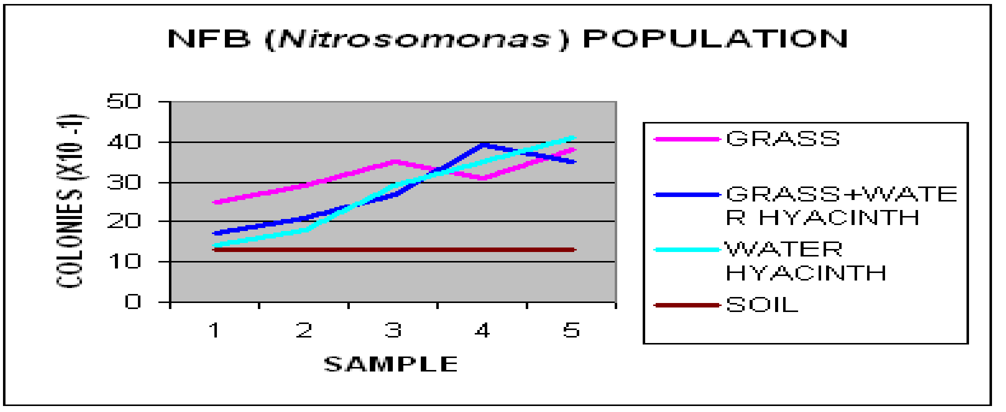

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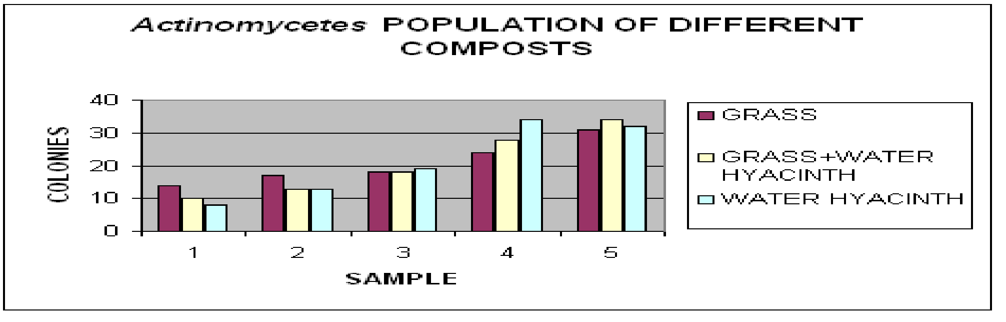

Figure-10.

REFERENCES

Ansari, A.A., 2011. Worm powered environmental biotechnology in organic waste management. International Journal of Soil Science, 6(1): 25-30.

Ansari, A.A., 2012. Vermitechnology-permutations and combinations of organic waste. Germany: Lambert Academic Publishing GmbH & Co. KG. pp: 68.

Ansari, A.A. and S.A. Ismail, 2001. Vermitechnology in organic solid waste management. Journal of Soil Biology and Ecology, 21(1&2): 21-24.

Ansari, A.A. and S.A. Ismail, 2012. Earthworms and vermiculture biotechnology. (In Management of Organic Waste, Eds) by Sunil Kumar and Ajay Bharti, ISBN 978-953-307-925-7). Chapter 5: 87-96. Available from: www.intechweb.org.

Ansari, A.A. and J. Rajpersaud, 2012. Management of water hyacinth (Eichhornia Crassipes) and grass clippings through biodung mediated vermicomposting. Research Journal of Environmental Sciences, 6(1): 36-44.

Ansari, A.A. and K. Sukhraj, 2010. Effect of vermiwash and vermicompost on soil parameters and productivity of Okra (Abelmoschus Esculentus) in Guyana. Pakistan Journal of Agricultural Research, 23(3-4): 137-142.

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Dickerson, G.W., 1999. Description and use of municipal solid waste composts in New Mexico. Circular 562. College of Agriculture and Home Economics New Mexico State University.

Edwards, C.A. and N.Q. Arancon, 2004. The use of earthworms in the breakdown of organic waste to produce vermicomposts and animal protein. Earthworm Ecology, (Ed: Edwards, C.A). 2nd Edn., Boca Raton: CRC Press. pp: 345-438.

Edwards, C.A. and P.J. Bohlen, 1996. Biology and ecology of earthworms. 3rd Edn., London: Chapman and Hall. pp: 426.

Galli, E., J.C. Rosique, D. Tomati and A. Roig, 1992. Effect of humidified material on plant metabolism. Proceedings of the 6th International Meeting of the International Humic Substances Society.

Ismail, S.A., 2005. The earthworm book. Mapusa, Goa: Other India Press. pp: 101.

Ismail, S.A., 1997. Vermitechnology: The biology of earthworms. Chennai, India: Orient Longman Ltd. pp: 92.

Kale, R.D., 1998. Earthworm Cinderella of organic farming. Bangalore, India: Prism Book Pvt Ltd. pp: 88.

Ruz-Jerez, B.E., P.R. Ball and R.W. Tillman, 1992. Laboratory assessment of nutrient release from a pasture soil receiving grass or clover residues, in the presence or absence of lumbricus rubellus or eisenia fetida. Soil Biology & Biochemistry, 24(12): 1529-1534.

Simpson, L.A. and R.D. Martin, 2004. Studies on vermiculture and organic vegetable production in Jamaica. Workshop on: Sustainable Organic Agricultural Development. University of Guyana, Turkeyen, 6 - 10th September, 2004.

Stoffella, P.J. and B.A. Kahn, 2000. Compost effects on crop growth and yield in commercial vegetable. Compost utilization in horticultural cropping systems. London: CRC Press. pp: 123-134.

Villar, M.C., M.C. Beloso, M.J. Acea, A. Cabaneiro, S.J. Gonzalez-Prieto, M. Carballas, M. Diaz-Ravina and T. Carballas, 1993. Physical and chemical characterization of four composted urban refuses. Bioresource Technology, 45(2): 105-113.

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