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SUSTAINABLE DECENTRALIZED VERMI-COMPOSTING SYSTEM INTEGRATED WITH ORGANIC FRACTION OF WET WASTE & WASTEWATER

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ABSTRACT

The increasing global population generates a substantial amount of liquid and solid waste, posing a significant challenge for safe disposal and effective management. Vermicomposting, utilizing earthworms to decompose organic waste, emerges as a promising solution. This method not only transforms organic waste into nutrient-rich compost but also mitigates the risk of pathogenic contamination and leachate formation. The vermicompost produced, enriched with essential plant nutrients, proves valuable for farmers, offering an eco-friendly alternative to chemical fertilizers. The process involves specific earthworm species, such as Eisenia fetida, and a combination of organic materials like cow manure, dry grass clippings, and rice straw. Various methods of vermicomposting station construction, such as bin composting and expandable worm towers, are explored. Physico-chemical analysis during vermicomposting, including pH, moisture content, COD, nitrogen, phosphorus, potassium, total carbon, and C/N ratio, reveals the dynamic nature of the process. The benefits of vermicomposting extend to soil improvement, increased nutrient availability for plants, and potential bioremediation applications. The study emphasizes the eco-friendly nature of vermicomposting, showcasing its role in recycling waste and enhancing soil fertility for sustainable agricultural practices.

KEYWORDS

Vermicomposting , Eisenia fedtida , fertilizer.

INTRODUCTION

A variety of liquid and solid waste are produced in world wide due to increase in population .It become a serious problem that requires strategies for safe disposal and effective management. municipal solid waste is highly organic in nature , so vermicomposting is one of the best method for the safe disposal and effective management of it [1]. Most of the organic waste are highly infectious as they contain a variety of pathogenic microorganisms. Dumping of solid wastes at a particular site may lead to the formation of leachates during rains, which may seep down and contaminate the ground water. Vermicomposting process decomposition of organic waste with the help of earthworm to turn the organic waste into enrich nutrient compost [Ismail 2005; Devi and Prakash 2015]. Vermicompost contains important plant nutrients N P K which are more soluble and excellent growth promotor [2]Recently, may studies are carried out to improve the quality of vermicompost by different organic substitutes [kitchen waste , sugar cane , rice straw , Agro-residues] to establish vermicomposting is one of the alternative to chemical fertilizers .

The vermicompost produced can be of significant value to the end users like farmers for replacement of chemical fertilizers and procuring better prices for the organic produce using such composting material locally available at much lower cost.

VERMICULTURE

Vermi means worms [earthworms] Culture means forming. Forming of earthworms is known vermiculture. which converts the organic solid waste into usefull byproduct [3].

EARTHWORMS

Earthworms are vertebrates belong to the phylum Annelida and class Oligochaeta. Generally epigeic earthworms such as [Eisenia fetida or Eisenia Andrei] [4],are used for vermicomposting process (Bouché 1977; Lee 1985) The earthworms are known for their creepy look but they are useful to save the environment as well. People burn down the waste or use the chemical to destroy the waste but the vermicomposting culture is simply the best and you want to take the example of it then look at the rural areas where literally feed these worms to help decompose the waste naturally and save the natural air.

Panfish worm is also called as Eisenia Fetida and with Red wigglers, there are not available on the garden soil. They may look thick but they are best to play the role of earthworm in the vermicomposting concept. They are really good at easing your life by eating your waste from home.

Earthworms choiced base on characteristic of earthworms like length, weight and reproduction rate and population density are the important characteristic for the progress of vermicomposting. Earthworms should be adjust for various environmental changes like temperature and moisture condition .[5]

VERMIWASH

Varmiwash is a liquid obtained during vermicomposting process. Which is rich in plant growth promoting hormones, enzyme, macronutrients and micronutrients[6]. Vermiwash of 60 ml was collected per day from 10kg of organic waste , which was vermicomposted[7].

- For vermiwash required plastic tub filled with gravel about 25cm from the bottom and plastic gate valve should be provided to collect vermitea.
- Vermiwash + water with proper ratio (60:40%), (50:50%), (40:60%) can be used as a foliar spray.
- Foliar spray is a foliar feeding is a technique in which liquid fertilizer directly sprayed / applied on leaves.
- Plants are able to absorb essential elements through their leaves.`[8]
- This method is suitable for vegetable crops like chilli (capsicum annuum), tomato. It promotes the root growth , and also enhance the root volume and length when compared to use of chemical fertilizers.[9]
- Varmiwash (buffalo dung) + neem oil + liquid extract from garlic helps plant growth and early flowering and enhances the productivity of gram[10].

MATERIALS AND METHODS

Vermicomposting is done by using cow manure, dry grass clippings and rice straw. The combination of cow manure and dry grass clipping/ rice straw waste in ratio of 5:1. At the end result, the combination cow manure and grass clipping gives the high yielding[[11].

Sewage water is collected then it is filtered through sand filter unit, the sludge remained at the top is used for vermicomposting experiment. The washed water obtained from the filtration used for moisten the vermibed. The combination of sludge and sugarcane trash are used , the sugarcane trash can reduce the characteristics smell of putrescible substances and bio toxic compounds[12].

- Organic waste collected, including kitchen waste, fruit scraps, rice straw, dry grass clippings, and sewage, is used for vermicomposting .
- Segregate the non-putricible waste from organic kitchen waste.
- In vermicompost plant materials such as leaves, grass, vegetable peelings are used.
- Organic waste should be free from tobacco leaves.
- Organic waste should not contains any chicken droppings, bones, meat and eggshells etc.
- The mixture should be kept under the moisture condition for 10 to 15 days. So that can allows the initial thermophilic condition of organic materials to moderate the tolerable level for the earthworms.
- It can be increase in temperature in organic material during primary period of decomposition. Also it will kill the mesophilic pathogens in waste material and gives good resultant compost to agricultural applications[13]

Waste Materials Preferably to be Avoided for Vermi-composting

- Organic waste with excess of citrus content like orange and lemon peel and onion wastes are avoided (it may reduce pH and effect worms activity).
- Heavy salted products are not preferable for vermicomposting.
- Feces of pets are not preferable because it contains viral or bacterial toxins
- Fresh green grass is also avoided because it requires high temperature it may harm worms.[14]

CONSTRUCTION OF THE VERMICOMPOSTING STATION

Earthworms are used to convert the organic waste material into nutrient rich humus that is a good source of manure for plants. Vermicompost required container of suitable dimensions, always container height will be lesser than length for proper aeration and also provide proper drainage holes for drain out excess water to maintain suitable moisture content. Generally the vermicomposting method or construction having various method, such are: pit composting, pile composting and bin composting.

- Bin composting: This is the most common method and also used for small scale composting. The bin will construction by various materials like wooden/plastic/recycled containers etc. It as different size and shape, the bin as dimensions of 45x30x45cmhaving with 10 holes for proper aeration and drainage [15].
- Expandable worm tower is also an type of composting method, in this method expandable tower is automatically separates the organic waste from finished compost. They placed in layers and very simple to assemble [3].

The concrete unit of 150x100x60cm^3 were built as container for culturing the earthworm. It should have drainage holes to drain out excess water. Here plastic container used of dimensions 200 cm * 150 cm * 75 cm [16].

- The vermicomposting container is includes the first layer of vermibed, which is prepared by using broken bricks, about 3-4cm.
- The moisture layer of soil should follows 15cm and by giving proper drainage. After the settling include earthworms. Water should be sprayed till 30 days to maintain the moisture content. The organic waste can added on 31st day, the processes of spraying water and adding wastes will continue for twice a week. At the end of 45 days the compost will be ready to use as fertilizer[17].

- The container should be in darkness or shaded area by covering with moist jute bag. so that the worms will protect from birds, rat , termites and also to maintain the stability of temperature of current environment, allows proper aeration and moisture[18] .

- The entire unit is covered with banana leaves to protect from birds and sunlight.

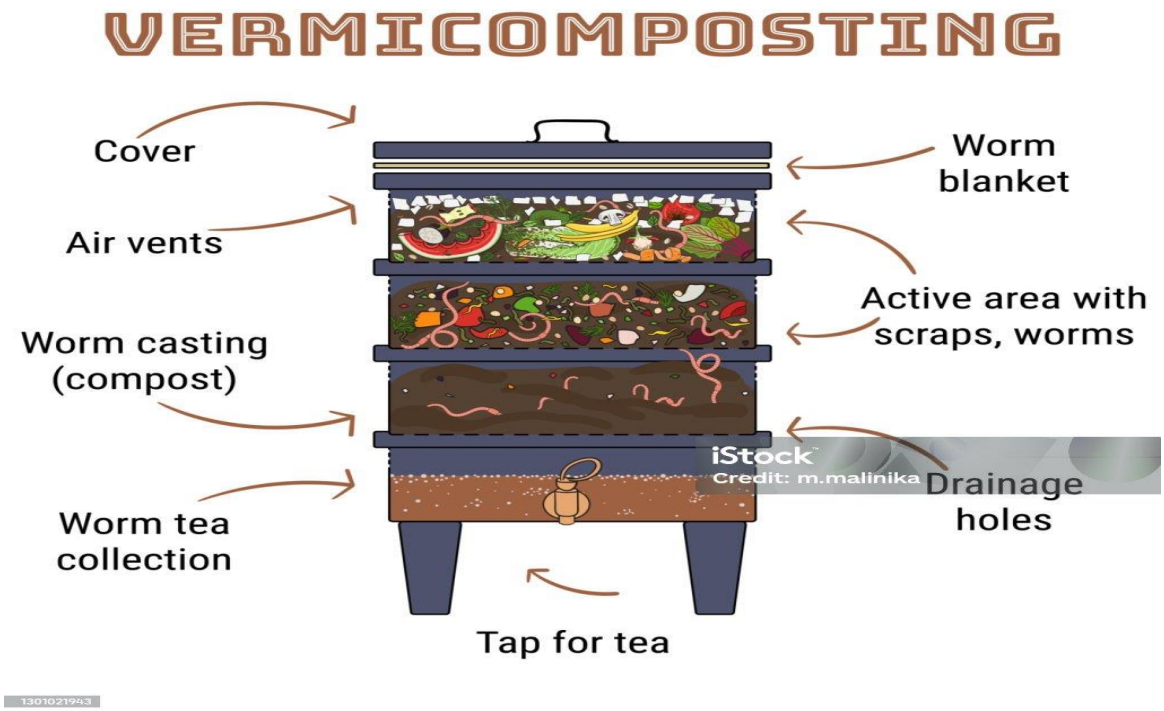
VERMICOMPOSTING
Cover
Air vents
Worm casting (compost)
Worm tea collection
Worm blanket
Active area with scraps, worms
Drainage holes
Tap for tea
iStock
Credit: m.malinika

FIG .1

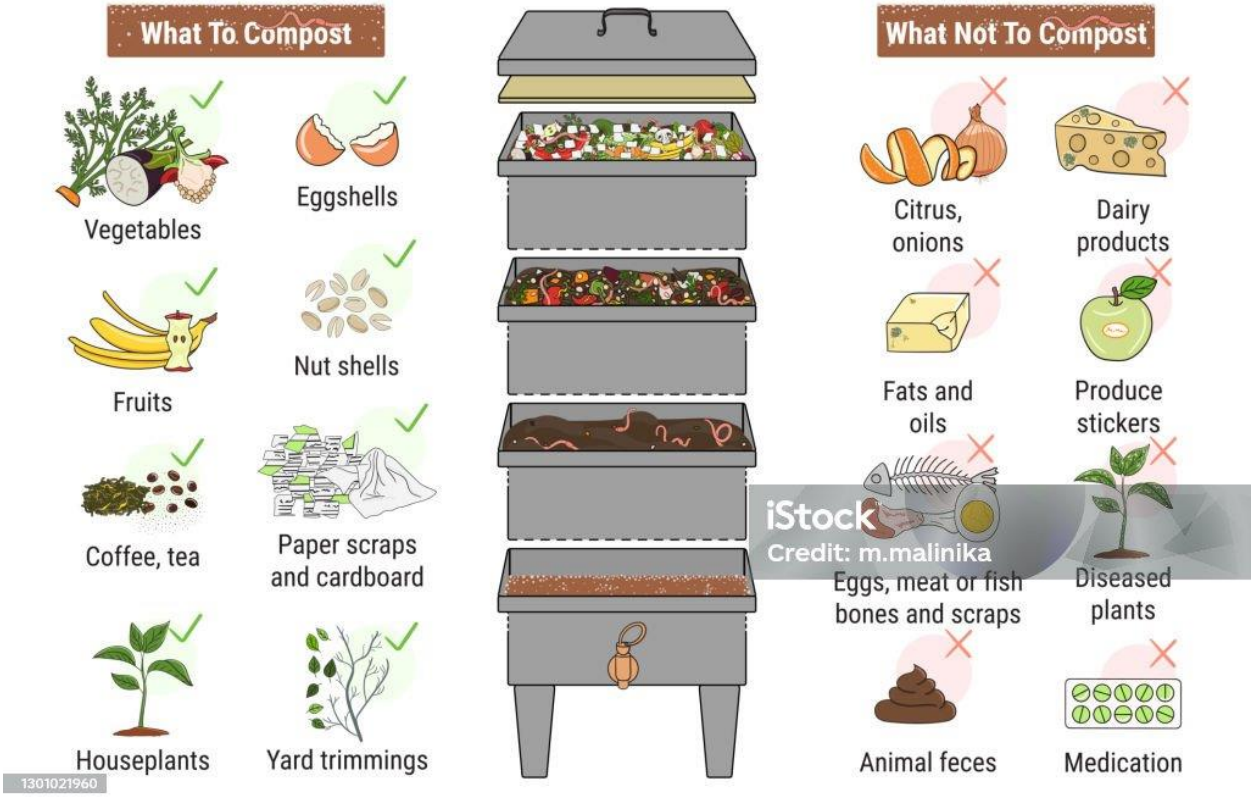
What To Compost
Vegetables
Eggshells
Fruits
Nut shells
Coffee, tea
Paper scraps and cardboard
Houseplants
Yard trimmings
What Not To Compost
Citrus, onions
Dairy products
Fats and oils
Produce stickers
Eggs, meat or fish bones and scraps
Diseased plants
Animal feces
Medication
iStock
Credit: m.malinika

FIG.2

PHYSICO-CHEMICAL ANALYSIS

pH ,Moisture content ,COD nitrogen ,phosphorus , potassium , total carbon content and C/N ratio were noted for every week during vermicomposting .

Moisture content can be measured by gravimetric method [19]. Moisture content of manure increases with time,it independent of presence or absences of earthworms [20].

pH can be measured by using pH meter [19] . pH increases in initial days due to increase of microbial activity and also increase of organic matter [20]. After few days decrease in PH value due to increase of ammonia led to nitrification and attain the carbon dioxide and organic acids [16].

COD of the vermicompost can be determined by using closed reflux trimetric method.

Temperature for the survival of Eisenia fetida was 0-35 c [19] , but ideal temperature of 25 c [domigues and Edwards , 2016] , by daily sprinkling water can maintain the favorable temperature for the survival of earthworms .

Nitrogen can be determined by kjeldhal method [8]. Micronutrients [Ca , K , Mg] and macronutrients [heavy metals] were determined by atomic absorption spectroscopy [21] .There is a great proportion of the crop nutrient input in the process of cultivation come back in the form of plant residues, for crops residues and food crops is 30-35 % applied N&P 70 -80% of K[[22].

Electrical conductivity of vermicompost is the soluble salt level is an organic and is a good indicator for the use of applicability of vermicompost for field purpose[23].

C/N ratio mainly impact on quality of the vermicompost , earthworms growth and reproduction [24] . By the addition of activated sludge to fruit and vegetable waste reduces C/N ratio , but increase in Nitrogen and Phosphorus content in generated vermicompost [24] . Lower the C/N ratio ,is more suitable for use of as soil amendment [25] .

Availability of Potassium [K] is increased by vermicomposting , the total amount of K is not altered by earthworms , but through the action of earthworms the rate of nutrient recycling is increased [25] .

The total amount of vermicompost produced was calculated by the formula productivity of vermicompost (%) = $\frac{\text{Harvested vermicompost}}{\text{total mass feed}} \times 100$

Total population of earthworms can be determined by manually separation of vermicast and earthworms, then by counting earthworms we can get the population of earthworms increased.

BENEFITS OF VERMICOMPOST

- Vermicompost can minimize the environmental pollution and provides good organic fertilizer[26].
- Vermicompost is the best organic fertilizer or material to increase the crop yield. It is having bio-oxidation and stabilization[27].

- Vermicompost and vermiwash are rich in NPK, and trace elements has been studied. Their potential use as bio fertilizers has been investigated as well as their impact on soil properties.
- The vermi-products can be used as bio-fertilizers whilst the earthworms can be used for further vermicomposting and other technologies like vermifiltration and vermi-remediation[28].
- Earthworms reduces 40to60% of volume by consuming various organic waste.
- It plays an important role in improving growth and yield of different fields like crops and vegetables.
- It provides all nutrients in readily available form and also enhances the uptake of nutrients by plants.
- It can also be used for bioremediation of high volume contaminated soil. It is thus found to improve soil physio-chemical and biological properties.
- Vermicomposting metal contaminated soil may help in soil remediation and improving its quality[29].

- Earthworm castings have a higher ammonium concentration and water-holding capacity than bulk soil samples, and they constitute sites of high dentrification potential.
- The perceived, sometimes demonstrated benefits include improvement in the water retention capability of the soil, and better plant availability of the nutrients in the vermicast compared to the 'parent' (pre-vermicomposted) materials[30].

CONCLUSION

Vermicomposting is an ecofriendly, which turns the wet solid waste and wastewater into nutrient rich soil. It recycles the organic waste and produce valuable nutrients. Vermicomposting can increase the soil fertility physically, chemically and biologically. Vermicomposting is a method used to assemble the earthworms together and to remove the toxic substances and convert the various waste materials into a product that can be used for agricultural process. Vermicomposting encourages the development of the soil with plant growth hormones (such as auxins and gibberllic acid etc.). Vermicomposting improves aeration of soil, texture, porosity, bulk density, water retention and organic matter content for better crop yield. Vermicomposting maintains the colour, shape and size of the flowers and leaves by providing the nutrients for plants. Vermicompost is rich in nitrogen, phosphorous, potassium and micro nutrients.

REFERENCE :

[1] Kaviraj and S. Sharma, "Municipal solid waste management through vermicomposting employing exotic and local species of earthworms," *Bioresour. Technol.*, 2003, doi: 10.1016/S0960-8524(03)00123-8.

[2] K. Huang, F. Li, X. Fu, and X. Chen, "Feasibility of a novel vermitechnology using vermicast as substrate for activated sludge disposal by two epigeic earthworm species," *Agric. Sci.*, 2013, doi: 10.4236/as.2013.410071.

[3] K. Janagan, V. Sathish, and A. Vijayakumar, "A Sustainable System for Solid Waste Treatment - Vermiculture," *System*, 2003.

[4] R. M. Atiyeh, S. Subler, C. A. Edwards, G. Bachman, J. D. Metzger, and W. Shuster, "Effects of vermicomposts and composts on plant growth in horticultural container media and soil," *Pedobiologia (Jena).*, 2000, doi: 10.1078/S0031-4056(04)70073-6.

[5] R. Gupta and V. K. Garg, "Potential and possibilities of vermicomposting in sustainable solid waste management: A review," *Int. J. Environ. Waste Manag.*, 2011, doi: 10.1504/IJEWM.2011.039465.

[6] S. I. Akazawa *et al.*, "The Growth-Promoting Effect of Earthworm Vermiwash on House Tomato Plants," *Sustain.*, 2023, doi: 10.3390/su151310327.

[7] M. M. Manyuchi, T. Chitambwe, A. Phiri, P. Muredzi, and Q. Kanhukamwe, "Effect of Vermicompost , Vermiwash and Application Time on Soil Physicochemical Properties," *Int. J. Chem. Environ. Eng.*, vol. 4, no. 4, pp. 216–220, 2013, [Online]. Available: http://warponline.org/uploads/contents/221-content-3-Effect-of-Vermicompost,-Vermiwash-and-Application-Time-on-Soil-Physicochemical-Properties.pdf

[8] K. Sundararasu, "International Journal of Advanced Research in Biological Sciences Effect of vermiwash on growth and yielding pattern of selected vegetable crop Chilli, Capsicum annuum)," *Int. J. Adv. Res. Biol. Sci*, 2016.

[9] C. Makkar, J. Singh, and C. Parkash, "Vermicompost and vermiwash as supplement to improve seedling, plant growth and yield in Linum usitassimum L. for organic agriculture," *Int. J. Recycl. Org. Waste Agric.*, 2017, doi: 10.1007/s40093-017-0168-4.

[10] S. Verma *et al.*, "Significance of vermiwash on crop production: A review," *~ 297 ~ J. Pharmacogn. Phytochem.*, 2018.

[11] 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.*, 2019, doi: 10.1007/s40093-018-0225-7.

[12] S. Suthar, "Vermistabilization of municipal sewage sludge amended with sugarcane trash using epigeic Eisenia fetida (Oligochaeta)," *J. Hazard. Mater.*, 2009, doi: 10.1016/j.jhazmat.2008.06.106.

[13] G. N. Chattopadhyay, "Use of vermicomposting biotechnology for recycling organic wastes in agriculture," *International Journal of Recycling of Organic Waste in Agriculture*. 2012. doi: 10.1186/2251-7715-1-8.

[14] R. K. Sinha *et al.*, "Vermiculture technology for recycling of solid wastes and wastewater by earthworms into valuable resources for their reuse in agriculture (organic farming) while saving water and fertilizer," in *Waste Management: Challenges, Threats and Opportunities*, 2015.

[15] T. Kaur, "Vermicomposting: An Effective Option for Recycling Organic Wastes," in *Organic Agriculture*, 2020. doi: 10.5772/intechopen.91892.

[16] S. Suthar, "Vermicomposting of vegetable-market solid waste using Eisenia fetida: Impact of bulking material on earthworm growth and decomposition rate," *Ecol. Eng.*, 2009, doi: 10.1016/j.ecoleng.2008.12.019.

[17] A. Aalok, A. K. Tripathi, and P. Soni, "Vermicomposting: A Better Option for Organic Solid Waste Management," *J. Hum. Ecol.*, 2008, doi: 10.1080/09709274.2008.11906100.

[18] R. K. Sinha, S. Herat, S. Agarwal, R. Asadi, and E. Carretero, "Vermiculture and waste management: Study of action of earthworms Elsinia foetida, Eudrilus euginae and Perionyx excavatus on biodegradation of some community wastes in India and Australia," *Environmentalist*, 2002, doi: 10.1023/A:1016583929723.

[19] M. N. Acquah, H. M. K. Essandoh, S. Oduro-Kwarteng, E. Appiah-Effah, and P. A. Owusu, "Degradation and accumulation rates of fresh human excreta during vermicomposting by Eisenia fetida and Eudrilus eugeniae," *J. Environ. Manage.*, 2021, doi: 10.1016/j.jenvman.2021.112817.

[20] A. Rajpal *et al.*, "Co-treatment of organic fraction of municipal solid waste (OFMSW) and sewage by vermireactor," *Ecol. Eng.*, 2014, doi: 10.1016/j.ecoleng.2014.09.012.

[21] G. Masciandaro, B. Ceccanti, and C. Garcia, "Soil agro-ecological management: Fertirrigation and vermicompost treatments," *Bioresour. Technol.*, 1997, doi: 10.1016/S0960-8524(96)00142-3.

[22] A. Aynehband, A. Gorooei, and A. A. Moezzi, "Vermicompost: An Eco-Friendly Technology for Crop Residue Management in Organic Agriculture," in *Energy Procedia*, 2017. doi: 10.1016/j.egypro.2017.11.090.

[23] S. L. Lim, T. Y. Wu, and C. Clarke, "Treatment and biotransformation of highly polluted agro-industrial wastewater from a palm oil mill into vermicompost using earthworms," *J. Agric. Food Chem.*, 2014, doi: 10.1021/jf404265f.

[24] M. C. Enebe and M. Erasmus, "Vermicomposting technology - A perspective on vermicompost production technologies, limitations and prospects," *Journal of Environmental Management*. 2023. doi: 10.1016/j.jenvman.2023.118585.

[25] S. L. Lim, T. Y. Wu, P. N. Lim, and K. P. Y. Shak, "The use of vermicompost in organic farming: Overview, effects on soil and economics," *J. Sci. Food Agric.*, 2015, doi: 10.1002/jsfa.6849.

[26] S. Sheela, S. K.-R. J. of A. and Forestry, and undefined 2013, "Vermicompost to save our agricultural land," *Isca.Me*, vol. 1, no. 4, pp. 18–20, 2013, [Online]. Available: http://isca.me/AGRI_FORESTRY/Archive/v1/i4/3.ISCA-RJAFS-2013-028.pdf

[27] Ebrahim Azarpour, "Effects of vermicompost application and seed inoculation with biological nitrogen fertilizer under different plant densities in soybean [Glycine max (L.) cultivar, Williams]," *AFRICAN J. Agric. RESEEARCH*, 2012, doi: 10.5897/ajar11.1767.

[28] M. Manyuchi and A. Phirri, "Vermicomposting in Solid Waste Management: A Review," *Int. J. Sci. Eng. Technol.*, 2013.

[29] S. Piya, I. Shrestha, D. Gauchan, and J. Lamichhane, "Vermicomposting in organic Agriculture: Influence on the soil nutrients and plant growth," *Int. J. Res.*, 2018.

[30] S. Gajalakshmi and S. A. Abbasi, "Earthworms and vermicomposting," *Indian Journal of Biotechnology*. 2004.