Int.J.Curr.Res.Aca.Rev.2021; 9(07): 76-82

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 9 Number 07 (July-2021)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2021.907.011

Key Drivers of Vermicomposting and its Multidisciplinary Applications – A Review

R. Sabarish[1,2] and M. Prakash[1*]

[1]Research Department of Microbiology, Kanchi Shri Krishna College of Arts and Science, Kanchipuram-631 551, Tamil Nadu, India
[2]Department of Biotechnology, St.Joseph's College (Arts & Science), Kundrathur Main Road, Kovur, Chennai-600128, India

**Corresponding author*

Abstract

Vermicomposting is described as "oxidation of biological material and stabilization of organic material involving the synergy action of earthworms and microorganisms". Under appropriate maintenance, worms eat agricultural waste and reduce the volume by 40 to 60%. Vermicompost produced by the activity of earthworms is rich in essential nutrients, vitamins, phytohormones, enzymes such as proteases, amylases, lipase, cellulase and chitinase and immobilized microflora. Conventionally vermicompost is used to provide nutrients to the soil and their by enhance the soil fertility and act as a soil conditioner. It is excellent source of humus and plant nutrients, on application of which improve soil physiochemical properties and organic status of soil. Normally vermicomposting in used in the field of agriculture, but this review focusses on the multidisciplinary uses of vermicomposting. This review attempts to increase awareness on waste recycling management to create an ecofriendly environment. The moisture content, bulking materials, precomposting apart from the selection of earthworm species are found to be the key drivers of vermicomposting system, while other factors are peripheral. The amendment of bulking materials with biowastes is also indispensable as the vermicomposting, compost maturity and earthworm growth and reproduction depend on initial C/N ratio and nutrients.

Article Info

Accepted: 20 July 2021
Available Online: 25 July 2021

Keywords

Earthworm, Vermicomposting, Waste Management, Multi-disciplinary Application.

Introduction

In recent years, the disposal of organic wastes from domestic, agricultural and industrial sources has caused increasing environmental and economic problems and many different technologies to address this problem have been developed. The growth of earthworms in organic wastes has been termed as vermiculture and the processing of organic wastes by earthworms is known as vermicomposting (Edwards, 2004). In view of waste recycling with respect to environmental pollution reduction as well as to attain sustainable agriculture, vermicomposting is contemplated as an important eco-technology. The review briefly focuses the process, key factors and applications of vermicomposting technology in a nut-shell.

The earthworms

Earthworms are coelomate animals often referred as farmer's friend with cylindrical body. It is a reddish brown animal without vertebral column. It comes under the Lumbricidae family and to belong to the class Oligochaeta which is included in the phylum of animals having metameric segmented body design (Annelida). More than 1300 species are found around the world

(Gracia, 2006). The worms that produce humus are divided into epigeal and anecic. The epigeal lives on the surface and feed on organic matter and detritus, an instance of them are *E. fetida*, *E. andrei*, *Perionyx excavatus*, *P. sansibaricus*, and *Eudrilus eugenie*. The anecic live in vertical burrows, an instance of them is *Lumbricus terrestris* (Sharma *et al.*, 2005).

Vermicomposting

Vermicomposting is generally defined as the solid phase decomposition of organic residues in the aerobic environment by exploiting the optimum biological activity of earthworms and microorganisms (Garg and Gupta, 2009). Vermicomposting involves the composting of organic wastes through earthworm activity. It has proven successful in processing sewage sludge and solids from wastewater, materials from breweries, paper waste, urban residues, food and animal wastes, as well as horticultural residues from processed potatoes, dead plants and the mushroom industry (Dominguez and Edwards, 2004). As shown in Fig. 1, the interactive effect of earthworms and microorganisms is playing a vital role in decomposition of organic materials, whereas environmental conditions of vermicomposting and maintenance are essential factors without which the production of vermicompost from organic solid waste materials is not productive.

Vermicomposting is a decomposition process involving the joint action of earthworms and microorganisms. Although microorganisms are responsible for the biochemical degradation of organic matter, earthworms are crucial drivers of the process, by fragmenting and conditioning the substrate and dramatically altering its biological activity. Earthworms act as mechanical blenders and by comminuting the organic matter they modify its physical and chemical status, gradually reducing its C:N ratio, increasing the surface area exposed to micro-organisms and making it much more favorable for microbial activity and further decomposition. Greatly during passage through the earthworm gut, they move fragments and bacteria-rich excrements, thus homogenizing the organic material. The end-product, or vermicompost, is a finely divided peat-like material with high porosity and water holding capacity that contains most nutrients in forms that are readily taken up by the plants. These earthworm casts are rich in organic matter and have high rates of mineralization that implicates a greatly enhanced plant availability of nutrients, particularly ammonium and nitrate (Dominguez and Edwards, 2004).

The vermicomposting process different phases during the process are as follows (Garg and Gupta, 2009): (1) Initial pre-composting phase: The organic waste is pre-composted for about 15 days before being fed to earthworms. During this phase, readily decomposable compounds are degraded, and the potential volatile substances are eliminated which may be toxic to earthworms. (2) Mesophilic phase: During this phase, earthworms, through their characteristic functions of breaking up organic matter, combine it with the soil particles and enhance microbial activities and condition organic waste materials for the formation of organic manures. (3) Maturing and stabilization phase.

Among the different phases of vermicomposting, precomposting occupies an important position as the initial temperature build-up and toxicity of organic substrates are eliminated. The initial microbial weathering is essential to make the substrate suitable for vermicomposting. The precomposting of organic substrates favors microbial growth, softens the substrates which makes it suitable for feeding by earthworms during vermicomposting (Karmegam *et al.,* 2021). In addition to this, the cattle dung is very much essential for supplying initial nutrients and microbes that can render successful vermicomposting of organic solid wastes (Yuvaraj *et al.,* 2021b). Similarly, the bulking materials like saw dust, biochar, etc. and enrichment through microbial biofertilizers and nitrogenous green manures improve the process of vermicomposting as well as the quality of final vermicompost (Balachandar *et al.,* 2021; Singh *et al.,* 2020; Yuvaraj *et al.,* 2021a) Moisture, an important determinant of bioconversion process by earthworms and microbes is needed to be maintained optimum (50-70%). The important factors and their functional role during vermicomposting are depicted in Fig. 2.

Microbiology of vermicomposting

The microbial flux during vermicomposting is tremendous. The total population of bacteria, fungi and actinomycetes increase with the progression of the vermicomposting period while the microbial populations start declining towards the end (Prakash and Karmegam, 2010b). Edward *et al.,* (1988) studies the symbiotic interaction between earthworms and microorganisms in the breakdown and fragment organic matter progressively. The role of earthworms as vectors of beneficial soil bacteria and their capacity of influence the population dynamics and impact of microorganisms on soil and plant was studied.

Yasir *et al.*, (2009) showed that changes in bacterial community play a major role during vermicomposting. In addition to bacteria, a fungi especially cellulolytic fungus was found to be increased during vermicomposting of different organic wastes. Cellulose produced by these fungi plays a major role in decomposition of cellulolytic materials of organic wastes.

Biodegradation of industrial waste by vermicomposting

Vermicomposting is also been used in bioremediation it has the ability to remediate different organic wastes produced by paper mill (Negi and Suthar, 2018), palm oil mill (Singh *et al.*, 2011), sugar industrial press mud (Prakash and Karmegam, 2010a), textile mill sludge (Yuvaraj *et al.*, 2020), and other biowastes. The nutrient status of the vermicomposts generated from different biowastes is shown in Table 1. The biodegradable products created by paper mills sludge of paper industries is an alternative growth promoting factors for the vermicompost production as source of organic waste remediation (Negi and Suthar, 2018).

Simao *et al.*, (2018) reported that the waste from paper mill industries can be incorporated as an alternative for the production of compost. To make the PMS suitable for vermicomposting and to produce enriched vermicompost, researchers worldwide have used cattle dung, leaf litter, agricultural residues, etc. For instance, Sahoo *et al.*, (2014) added microbial consortia during pre- vermicomposting and post-vermicomposting mixtures of paper mill waste, including PMS which resulted in the enhanced nutrients with the post-vermicomposting addition of microbial consortia. Negi and Suthar (2018) have proved that the inoculation of brown-rot fungi, *Oligoporus placenta* with the earthworm, *Eisenia fetida* all through vermicomposting of PMS led to accelerated plant nutrients.

Depending on the initial feedstock, heavy metals might be present in the composted material (Swati and Hait, 2017). Heavy metal contents are high in composts originating from animal manure or sewage sludge. During composting and vermicomposting, heavy metals can react with organic matter and their speciation might change. For instance, manure com- posts may contain high levels of Zn, Cd, Pb and Cu and their application on soils may lead to an excessive input of heavy metals (Chen *et al.*, 2010). Using additives during composting is a way to reduce heavy metal availability, resulting in a marketable, safe material. Heavy metal mobility, in particular of Cu, Zn, Cd, Pb and Mn in water-soluble form, can be reduced by organic and mineral additives.

Organic additives like bamboo charcoal, chestnut/leaf litter and biochar are used for this purpose (Chen *et al.*, 2010). Mineral additives favorable to reduce heavy metal mobility are fly ash, Ca-bentonite, phos- phate rock, lime or zeolite. Mixtures of organic and mineral additives in the form of lime and biochar are also effective for reducing heavy metal mobility in composts (Awasthi *et al.*, 2016a).

Application of vermicomposting

Effect of vermicomposting in organic solid waste management

The significance of sewage sludge, biosolids and biomedical waste control via, reasonably economic techniques are in much demand these days. These kinds of biohazard wastes are infectious and need to be disinfected before being entering into the environment. Biosolids additionally incorporate an array of pathogenic microorganisms (Hassen *et al.*, 2001). Bioremediation of these wastes by vermicompost creates biochemical impact in the organic substances and decreases multiplication of virulent microbes (Masciandaro *et al.*, 2000).

Vermicomposting also documented the substantial destruction of disease causing virulent pathogens such as *Vibrio*, *Salmonella* sp., enteric virus and helminth larvae and cyst inside the biosolids (Sidhu *et al.*, 2001). Dominguez (2004) and Edwards (2004), in their work reported that composting of biosolids with earthworms resulted in reduction of coliforms and *Salmonella sp*. from 39,000 MPN/g to 0 MPN/g and < 3 MPN to < 1MPN/g respectively.

Ganesh Kumar and Sekaran (2005), inferred that vermicomposting of municipal sewage sludge with *L. mauritii* removed *Salmonella* and *E. coli*, and the earthworm intestine evaluation additionally proved that *Salmonella sp*. ranging 15–17 × 10^3 CFU/g and *Escherichia sp*. ranging 10–14 × 10^2 CFU/g have been absolutely removed from the inside part of intestine after 70 days of composting period.

Table.1 Physico-chemical characteristics of vermicompost obtained from agricultural, industrial, municipal solid wastes (MSW) and weeds.

Characteristics	Industrial waste			Agro-residues		MSW + CD (1:1)	Weed
	Paper (PMS + CD, 1:1)	**Textile (TMS + CD, 1:1)**	**Sugar (press mud + CD, 1:1)**	**Sugar cane trash + CD (1:1)**	**Paddy straw + CD (1:1)**		***Ipomoea* + CD (1:1)**
pH	7.56	7.49	7.33	7.24	7.32	7.2	7.16
EC (dS/m)	1.21	1.55	2.32	1.87	2.03	2.24	2.07
TOC (g/kg)	389.33	117.7	290.0	292.5	318.0	271.0	300.18
C/N ratio	19.63	16.1	17.89	26.83	27.41	22.03	17.55
TN (g/kg)	19.83	7.3	16.3	10.9	11.6	12.3	17.11
TK (g/kg)	18.6	5.0	31.3	5.7	6.2	6.8	14.08
TP (g/kg)	18.83	9.8	23.8	5.3	4.9	6.5	21.10
Na (mg/kg)	-	-	5.4	0.42	0.37	4.9	6.45
Ca (g/kg)	-	-	29.1	8.7	8.9	9.0	12.33
Iron (ppm)	-	-	214.5	-	-	-	-
Zn (mg/kg)	-	59.16	0.045	-	-	-	212.42
Reference	(Karmegam *et al*., 2019)	(Yuvaraj *et al*., 2020)	(Prakash and Karmegam, 2010a)	(Biruntha *et al*., 2020)		(Biruntha *et al*., 2020)	(Balachandar *et al*., 2021)

(CD = cow dung; PMS = Paper mill sludge; TMS = Textile industrial sludge)

Fig.1 Interactive success of vermicomposting. (a) Combined action of earthworms and microorganisms is the key role in bioconversion of organic solid wastes; (b) and (c) Perfect maintenance conditions are very essential for the success of establishing growth and multiplication of earthworms and microbial agents involved in vermicomposting; (d) The production of quality vermicompost relies on the maintenance based joint action of earthworms and microorganisms.

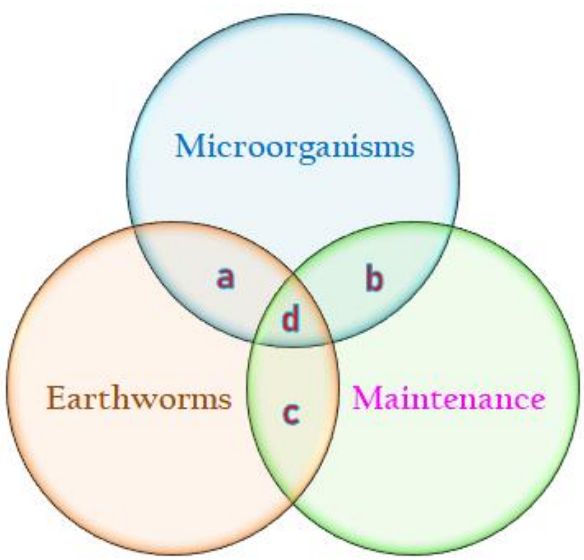
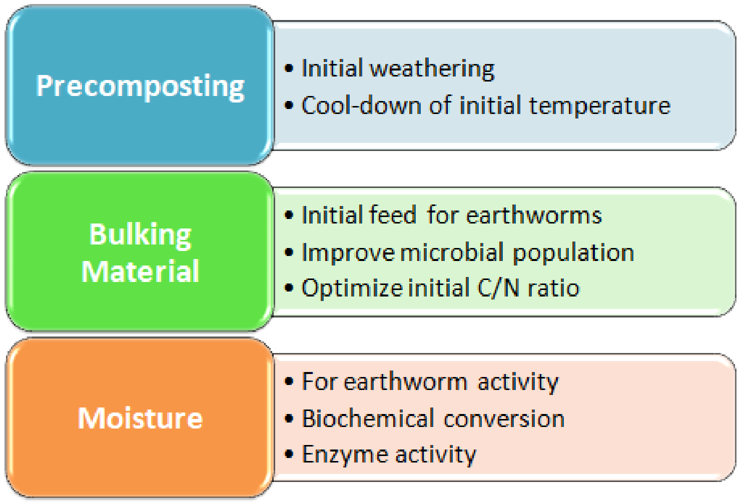


Fig.2 Key drivers of vermicomposting and their prime role.



Not only in sludge management earthworms also utilized in sewage water treatment. In the sewage effluent earthworms supports the multiplication of 'environmental friendly bacteria' and servers as agitators, aerators and helps in the fragmentation of chemicals (Sinha *et al.*, 2002). Also, the vermiwash (vermicompost leachate) is known to possess positive influence on plant growth (Deepthi *et al.*, 2021). Vermiwash is also reported to improve plant growth and yield, disease suppressive activity (Gudeta *et al.*, 2021).

Bio-control action of vermicomposting against plant pathogens

Apart from the conventional uses vermicompost has also been documented to have an array of the non-directional impact on growth of plants by possessing a germicidal effect on plant pathogens. Numerous studies proved that use of vermicompost manure on soil reduced the risk of exposing the plants to pathogens (Trillas *et al.*, 2006).

Few studies have been proved that earthworm composting have inhibited the growth of the plant pathogenic helminthes. In the work done by Orlikowski (1999) vermicompost has got fungicidal properties, also he stated that an application vermicompost extracts to 3 decorative plant species stopped the sporulation of the pathogen *Phytophthora cryptogea*. Nakasone *et al.*, (1999) inferred that Watery extracts of vermicompost were capable of suppress the growth of disease fungi such as *Botrytis cinerea*, *Sclerotinia sclerotiorum*, *Corticium rolfsii*, *Rhizoctonia solani* and *Fusarium oxysporum*. In the past years the role of the vermicomposting was restricted only in few areas, but the recent research has focused on the multiple uses of the vermicomposting in waste management, bio-control action of vermicomposting against plant pathogens, the biodegradation of different biowastes by vermicomposting. Conclusively, type of earthworm, precomposting, moisture and maintenance are playing crucial role in vermicomposting as well as the quality of end product, vermicompost. The current review summarized that the vermicomposting act as the best tool for the bioremediation of organic wastes by making a pollution less environment.

References

Awasthi, M K., Q, Wang., H, Huang., R Li, F Shen., 2016. Effect of biochar amendment on greenhouse gas emission and bio-availability of heavy metals during sewage sludge co-composting. J. Clean. Prod., 135, 829-835.

Balachandar, R., Biruntha, M., Yuvaraj, A., Thangaraj, R., Subbaiya, R., Govarthanan, M., Kumar, P., Karmegam, N., 2021. Earthworm intervened nutrient recovery and greener production of vermicompost from *Ipomoea staphylina* – An invasive weed with emerging environmental challenges. Chemosphere 263, 128080.

Biruntha, M., Mariappan, P., Karunai Selvi, B., John Paul, J. A., Karmegam, N., 2020. Vermiremediation of urban and agricultural biomass residues for nutrient recovery and vermifertilizer production. Waste Biomass Valor., 11, 6483–6497.

Chen, X., G, Chen., L, Chen., Y, Chen., 2010. Adsorption of copper and zinc by biochars produced from pyrolysis of hardwood and corn straw in aqueous solution. Bioresource Technology, 102, 8877-8884.

Deepthi, M. P., Nivethitha, S., Saminathan, K., Narendhirakannan, R. T., Karmegam, N., Kathireswari, P., 2021. Effect of vermiwash prepared from livestock biowaste as vermiponics medium on the growth and biochemical indices of *Amaranthus viridis* L. Environ. Technol. Innov. 21, 101300.

Dominguez, J., Edwars, C. A., 2004. Vermicomposting organic wastes: A review. – In: Soil Zoology for Sustainable Development in the 21st Century (Eds. S. H. Shakir Hanna and W. Z. A. Mikhatl). – Cairo, pp. 369–395.

Edwards, C. A., 2004. Earthworm Ecology (2nd Edition). CRC Press, Boca Raton, FL, London, New York, Washington. 448 pp.

Edwards, C A, Mccay and Lofty J R., 1988, Nitrogenous fertilizers and earthworm population in agricultural soil, *Soil Biology and Biochemistry*, 14, 515-521.

Ganesh kumar, A., Sekaran, G., 2005. Enteric pathogen modification by anaecic earthworm, Lampito Mauritii. J Appl Sci Environ Mgt 9:15–17.

Garg, V. K., Gupta, R., 2009. Vermicomposting of agro-industrial processing waste. In: Biotechnology for Agro-Industrial Residues Utilisation. – Springer, Dordrecht, pp. 431–456, doi: 10.1007/978-1-4020-9942-7_24.

Gracia, H., 2006. Presence of Exotic and Native Earthworms in Principal Agro- and Natural Systems. Caribbean Journal of Science, Vol. 42, No. 3, 359-365.

Gudeta, K., Julka, J. M., Kumar, A., Bhagat, A., Kumari, A., 2021. Vermiwash: An agent of disease and pest control in soil, a review. Heliyon 7, e06434.

Hassen, A., Belguith, K., Jedid, I N., Cherif, A., Boudabous, A., 2001. Microbial characterization during composting of municipal solid waste. Bioresour. Technol 80: 217–225.

Karmegam, N., Jayakumar, M., Govarthanan, M., Kumar, P., Ravindran, B., Biruntha, M., 2021. Precomposting and green manure amendment for effective vermitransformation of hazardous coir industrial waste into enriched vermicompost. Bioresour. Technol. 319, 124136.

Karmegam, N., Vijayan, P., Prakash, M., John Paul, J. A., 2019. Vermicomposting of paper industry sludge with cowdung and green manure plants using *Eisenia fetida*: A viable option for cleaner and enriched vermicompost production. J. Clean. Prod. 228, 718–728

Masciandaro, G., Ceccanti, B., Gracia C., 2000. `*In situ*' vermicomposting of biological sludges and impacts on soil quality. Soil Biol Biochem 32:1015–1024.

Nakasone, A. K., Bettiol, W., and de Souza, R. M.,1999. The effect of water extracts of organic matter on plant pathogens. Summa Phytopathologica, 25, 330-335.

Negi, R., Suthar, S., 2018. Degradation of paper mill wastewater sludge and cow dung by brown-rot fungi Oligoporus placenta and earthworm (*Eisenia fetida*) during vermicomposting. J Clean Prod 201:842–852

Orlikowski, L. B., 1999. Vermicompost extract in the control of some soil borne pathogens. International Symposium on Crop Protection, 64, 405-410.

Prakash, M., Karmegam, N., 2010a. Vermistabilization of pressmud using *Perionyx ceylanensis* Mich. Bioresour. Technol. 101, 8464–8468.

Prakash, M., Karmegam, N., 2010b. Dynamics of nutrients and microflora during vermicomposting of mango leaf litter (*Mangifera indica*) using *Perionyx ceylanensis*. Int. J. Glob. Environ. Issues 10, 339–353.

Sahoo, S., Harichandan, A. K., Rath, S. P., 2014. Improvement of the quality of vermicompost from paper mill waste. Pollut. Res. 33, 451e454.

Sharma, S., Kaviraj. P., Santosh, S., Padma V., 2005. Potentiality of Earthworms for Waste Management. The Journal of American Science, (1)1.

Sidhu, J., Gibbs, R A., Ho G E., Unkovich, I., 2001. The role of indigenous microorganisms in suppression of Salmonella regrowth in composted biosolids. Water Res 35:913–920.

Simao, L., Hotza, D., Raupp-Pereira, F., Labrincha, J. A., Montedo, O. R. K., 2018. Wastes from pulp and paper mills - a review of generation and recycling alternatives. Cer^amica 64, 443e453.

Singh, A., Karmegam, N., Singh, G. S., Bhadauria, T., Chang, S. W., Awasthi, M. K., Sudhakar, S., Arunachalam, K. D., Biruntha, M., Ravindran, B., 2020. Earthworms and vermicompost: an eco-friendly approach for repaying nature’s debt. Environ. Geochem. Health, 42: 1617–1642.

Singh, R., Embrandiri, A., Ibrahim, M., & Esa, N., 2011. Management of biomass residues generated from palm oil mill: Vermicomposting a sustainable option. Resources, Conservation and Recycling, 55(4), 423-434.

Sinha, R K., Heart, S., Agarwal, S., Asadi, R., Carretero, E., 2002. Vermiculture technology for environmental management: study of the action of the earthworms, *Eisenia foetida*, *Eudrilus euginae* and Perionyx excavatus on biodegradation of some community wastes in India and Australia. The Environmentalist 22:261–268

Swati, A., and S Hait., 2017. Fate and bioavailability of heavy metals during vermicomposting of various organic wastes—A review. Process safety and environment protection. 109, 30-45.

Trillas, M I., Casanova E., Cotxa rrera L., Or dovás J., Borrero C, Avilés M 2006. Composts from agricultural waste and the *Trichoderma asperellum* strain T-34 suppress *Rhizoctonia solani* in cucumber seedlings. Biological Control 39, 32-38

Yasir, M., Aslam, Z., Kim Lee S W., and Chung, Y R., 2009. Bacteria community composition and chitinase gene diversity of vermicompost with antifungal activity. *Bioresource Technology*.100,4396-4403.

Yuvaraj, A., Karmegam, N., Tripathi, S., Kannan, S., Thangaraj, R., 2020. Environment-friendly management of textile mill wastewater sludge using epigeic earthworms: Bioaccumulation of heavy metals and metallothionein production. J. Environ. Manage. 254, 109813.

Yuvaraj, A., Thangaraj, R., Karmegam, N., Ravindran, B., Chang, S. W., Awasthi, M. K., Kannan, S., 2021a. Activation of biochar through exoenzymes prompted by earthworms for vermibiochar production: A viable resource recovery option for heavy metal contaminated soils and water. Chemosphere 278, 130458.

Yuvaraj, A., Thangaraj, R., Ravindran, B., Chang, S. W., Karmegam, N., 2021b. Centrality of cattle solid wastes in vermicomposting technology – A cleaner resource recovery and biowaste recycling option for agricultural and environmental sustainability. Environ. Pollut. 268, 115688.

How to cite this article:

Sabarish, R. and Prakash, M. 2021. Key Drivers of Vermicomposting and its Multidisciplinary Applications – A Review. *Int.J.Curr.Res.Aca.Rev.* 9(07), 76-82. doi: https://doi.org/10.20546/ijcrar.2021.907.011