ScienceDirect

Chemosphere

Volume 291, Part 2, March 2022, 132675

Detoxification of coir pith through refined vermicomposting engaging *Eudrilus eugeniae*

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https://doi.org/10.1016/j.chemosphere.2021.132675

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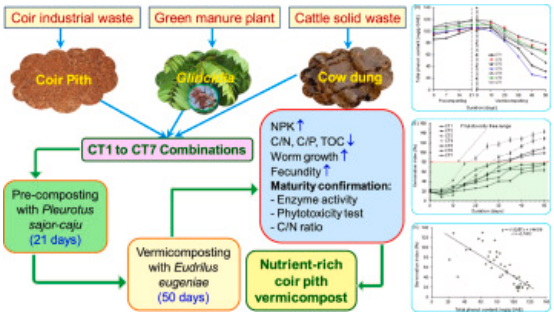
Abstract

Hazardous coir industrial waste, coir pith has been subjected to 50 days vermicomposting with *Eudrilus eugeniae* by amending nitrogenous legume plant, *Gliricidia sepium* together with cattle dung in different combinations, after 21 days precomposting using *Pleurotus sajor-caju* spawn. An increase in electrical conductivity, total NPK and calcium, and a decrease in organic matter, total organic carbon, C/N ratio, C/P ratio and total phenolic content in the final vermicompost were observed. Dehydrogenase, urease and cellulase activity peaked up to 30 days of vermicomposting and then declined. The phytotoxicity studies with *Brassica juncea,* C/N ratio and enzyme activities confirmed the stability and maturity of vermicompost. The results also demonstrated that the 2:3:1 ratio (coir pith+*Gliricidia sepium*+cow dung) is a suitable effective combination for nutrient-rich (N: 2.43%; P: 0.92%; K: 2.09%) vermicompost production. The total phenolic contents declined during the vermicomposting with a lower final content of 21.26mg/g GAE in 2:3:1 combination of substrates from the initial level (105.56mg/g GAE). Besides, the concentration of total phenol contents inversely related to the germination index of *Brassica juncea* (*r=-0.761*), indicating that the phenolic content could also play an important role in phytotoxicity. Growth and fecundity of *Eudrilus eugeniae* in 2:3:1 combination revealed the acceptability and rapid decomposition of coir pith substrate into vermifertilizer.

Graphical abstract



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Introduction

Coconut is cultivated in many countries encompassing 11.8 million hectares of land with the projected output exceeding 61 million tons. According to recent data (2019–2020), in India, coconut is cultivated in 2.173 million hectares of land area with a total production of 20,308.70 million nuts (Coconut Development Board, 2021). During the procurement processing of coconuts generate a large amount of coconut husk, which is the raw material for the coir industries involved in the extraction of coir fibers. During the fiber extraction from the retted or un-retted coconut husks, a sponge-like, light-weighted coir pith (coir dust) is generated in large volumes (Gopal et al., 2016). With the utilization of every 10,000 coconut husks for coir extraction, 1.6 tons of coir pith is generated which accounts for a total estimated production of 7.5 million tons/year (IICF, 2016; Nattudurai et al., 2014). In general, burning is the common way of coir pith disposal which ultimately resulted in environmental pollution risks (Gopal et al., 2016). The leaching of chemical substances, highly complex substances like lignin and cellulose causes soil and water pollution (Swarnam et al., 2016). Apart from this, considerable amounts of plant nutrients present in the huge coir waste biomass are complexed and remain unutilized or wasted. This requires urgent attention of a suitable method of utilizing coir pith into value-added products. However, very low nitrogen content, high C/N ratio and phenolic contents in coir pith make it unfit for composting processes. For overcoming this situation, researchers used nitrogenous amendments for narrowing down the C/N ratio of coir pith to be used as a substrate for the composting process (Gopal et al., 2016).

Vermicomposting is a bioconversion process utilizing earthworms for organic matter decomposition to generate vermicompost for agronomic use (Vicentin et al., 2021). Among the different kinds of earthworms employed for vermiconversion of wastes, *Eisenia fetida, Eudrilus eugeniae* and *Perionyx excavatus* are used in most of the countries (Singh et al., 2020). *Eudrilus eugeniae* is an African earthworm, found suitable for biowaste (including industrial and toxic waste) vermiconversion into vermicompost (Pandit et al., 2020; Paul et al., 2020; Karmegam et al., 2021). In this context, vermicomposting has been tried to enhance the rate of decomposition and nutrient contents of coir pith amending cow dung as bulking material (Biruntha et al., 2020a; Nattudurai et al., 2014). The study by Nattudurai et al. (2014) used graded coir pith in combination with cow dung for vermicomposting; while the study of Biruntha et al. (2020a) used 50% cow dung with coir pith for vermicomposting in comparison with other organic wastes with different C/N ratios. Recent studies revealed that the amendment of nitrogenous legume plants and cow dung with industrial biowastes, such as paper industrial sludge and sugar industry press mud during vermicomposting resulted in nutrient-rich vermifertilizer production (Balachandar et al., 2020; Karmegam et al., 2019). The addition of legume plants and fungal inoculants in vermibed substrates shows promising results in enhancing the rate of bioconversion of wastes and nutrient contents in the final vermicomposts (Karmegam et al., 2021; Singh et al., 2021). The amendment of green manure plants is a newer and greener approach for the transformation of biowastes employing earthworms. The studies on enriching coir pith with legume plants are the least concerned even though the coir pith is abundantly available, a complicated and complex biowaste resource, but with potential environmental hazards. A recent study utilizing the green manure plant, *Sesbania sesban* incorporated with coir pith vermicomposting revealed that the quality of the end product has been increased significantly (Karmegam et al., 2021), where the changes accompanying total phenolic contents has not been addressed. The phenolic contents in the composting substrate largely influence the process as well as the quality of the end product due to slow degradation rate required to be examined (Wang et al., 2022). *Gliricidia sepium* is a fast-growing, resistant to pruning, and ready to use abundant phytomass with potential application as nutrient-rich green manure (Wani, 2012), its amendment with vermicomposting of low-nutrient biowastes like coir pith is highly indispensable. However, the utilization of largely available biomass of the green manure plant, *Gliricidia sepium* for enriching the end product of vermicomposting coir pith is the least studied. Also, the phytotoxicity reduction in the end product of composting system is very important to determine the application of compost (Wang et al., 2022). Considering all these facts, the present study has been carried out with the following objectives: (i) to utilize the coir pith for the vermicomposting process utilizing the biomass of *Gliricidia sepium* in combination with cow dung as amendment materials for the production of nutrient-rich vermifertilizer as this would largely beneficial worldwide; (ii) to assess the physicochemical, total phenolic content (TPHC) and enzymatic changes governing the precomposting with *Pleurotus sajor-caju* followed by vermicomposting with *Eudrilus eugeniae*; (iii) to examine the phytotoxicity of the vermicompost by *Brassica juncea* seed germination assay; (iv) to find out the acceptability of substrate mixture by the earthworm through growth and reproductive performance.

Section snippets

Substrates for vermicomposting and earthworms

The coir pith was collected from a private coir industry located near Tharamangalam, Salem and brought to the laboratory for experimentation. Urine-free fresh cow dung was obtained locally from the cattle-shed and used for the study after shade drying for seven days. The spawn of the mushroom, *Pleurotus sajor-caju* (Oyster mushroom) was obtained from a local mushroom farm and brought to the laboratory. The leaves of the green manure plant, *Gliricidia sepium* was collected locally, shade dried for …

Physico-chemical characteristics

The physicochemical characteristics of different treatments after 50 days are shown in Table 2. The changes in pH of vermicompost over control substrates was very minimum (<4.0%) where the final pH was close to neutral pH (6.41–6.85). The EC changed considerably in vermicompost over respective control treatments. The range of EC in control substrates of different treatments was 1.07–1.31 dS/m while it was 1.52–2.17 dS/m with a range of 33.93–65.12% change. A maximum percentage change of 65.12…

Conclusions

In the present study, TKN, TP, TK and TCa contents in the vermicomposts were significantly higher than the control treatments indicating that the earthworms play a significant role in mineralization. Prominently, the TKN content in coir pith (0.24%) has increased 9.75 folds (2.34%) in CT4 vermibed combination of coir pith+*Gliricidia sepium*+cow dung in a 2:3:1 ratio. The C/N ratio in vermicomposts was well within the range of 20. The reduction of TPHC, higher growth and reproduction of …

Credit author contribution statement

Mani Jayakumar: Methodology, Software, Formal analysis. **Abdi Nemera Emana:** Resources, Formal analysis, Software, Draft editing. **Ramasamy Subbaiya:** Review and Editing, Software, Data curation. **Mohanadoss Ponraj:** Software, Draft Editing, Formal analysis. **Krishna Kumar Ashok Kumar:** Methodology, Software, Formal analysis. **Muthusamy Govarthanan:** Supervision, Methodology, Software, Review and Editing. **Woong Kim:** Supervision, Methodology, Software, Review and Editing. **Natchimuthu Karmegam:**…

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

Acknowledgment

The authors, M. Jayakumar and N. Karmegam sincerely thank Dr. (Mrs.) T. Daniel, Professor (Rtd.), Department of Biology, The Gandhigram Rural Institute, Gandhigram, for constant support encouragement during the investigation. This work was partly supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (MOTIE) (No. 20194110100100, Full-scale feasibility study of the stability and efficiency improvement of a biogas production…

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> ...The amendment of cow dung along with vermicomposting substrates plays a significant role in the shift of pH (Yuvaraj et al., 2021b). Various organic substrates amended with cattle dung in different proportions encourage the growth and activity of microorganisms and earthworms which in turn results in the production of organic acids and by-products attributing to the change of pH in the final vermicompost (Ananthavalli et al., 2019a; Jayakumar et al., 2022). It is very important for soil health to have organic matter that contains organic carbon....

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> ...The declining level of TOC in the substrate between BC-assisted and without BC treatments was statically significant. The reduction in TOC in treatments is due to the mineralization of organically rich materials, which is caused by the combined actions of earthworm species and microorganisms (Jayakumar et al., 2022; Yuvaraj et al., 2021). The increase of the microbial population during the experimental period is also one of the reasons for decreases in TOC (Khwairakpam and Bhargava, 2009)....

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