Environmental Research, Engineering and Management 4(70): 80–86
Aplinkos tyrimai, inžinerija ir vadyba 4(70): 80–86
http://dx.doi.org/10.5755/j01.erem.70.4.8552
ISSN 1392-1649 (print)
ISSN 2029-2139 (online)
© 2014 EREM

Vermicomposting of *Mucuna bracteata* – a Fast Spreading Troublesome Weed in Kerala, India

Sruthi S. N., Sibin A., Ramasamy E. V.
School of Environmental Sciences, Mahatma Gandhi University, Kottayam, Kerala, India

Corresponding author:
E.V. Ramasamy, School of Environmental Sciences, Mahatma Gandhi University, PD Hills PO, Kottayam - 686 560, Kerala, India
E-mail: evramasamy@rediffmail.com

Mucuna bracteata DC. is one among the common weeds spreading rapidly in Kerala. The spread of this weed becomes an environmental nuisance and a threat to the local biodiversity. Conversion of this troublesome weed into nutrient rich manure through vermicomposting with native earthworm species of *Perionyx ceylanensis* was attempted in this study. The phytomass of *M. bracteata* was subjected to precompost along with cattle dung in the ratio of 6:1 for a period of 15 days. The resulting precompost – partially decomposed phytomass – was fed into vermireactors. The vermireactors fed with 37.5 g (dry weight) precomposted weed mass and 10 adult earthworms were operated for 15 days. These experiments were repeated for six times. The vermireactors performed with 14–21.3% recovery of vermicast with a C/N ratio of 23.7, which is comparable with the reported values in the literature. The findings of this study indicate that the earthworm species *P. ceylanensis* is potential enough to convert the phytomass of *M. bracteata* into nutrient rich manure. Also, the worms multiplied and grew well by gaining weight. Hence, these reactors with precomposted phytomass of *M. bracteata* can be operated sustainably.

Keywords: *Perionyx ceylanensis, weed management, vermicast, earthworms, nutrient recycle.*

1 Introduction

Weeds are usually introduced species in an area (Smith et al. 2010) and by most of the definitions weeds are plants growing where they are not wanted. Weeds may decrease the crop yield or quality of the crop or even harm the health of animals that ingest them (Janick et al., 1981). *Mucuna bracteata* a leguminous plant found mostly in humid tropics was introduced in rubber plantations of Kerala as a cover crop for improving the nitrogen content of soil. The cover crop has recently become a weed when it escaped from rubber plantations and spread across the surrounding areas. Like most other weeds *M. bracteata* is also bestowed with an excellent growth potential, due to which it has extensively spread in natural environment and trigger the replacement of native plant species damaging the local biodiversity. As most of the weed control methods are accompanied with certain disadvantages, weed utilisation has been reported in the literature as an alternate weed management strategy (Bindu and Ramasamy, 2008; Kurian and Ramasamy, 2006). Out of the several utilisation options available, bioconversion of this weed into vermicompost – a natural manure using earthworm – has been attempted in this study.

Vermicompost often referred to as ‘vermicast’ is considered as good ‘soil conditioners’ with multitude of nutrients and plant growth hormones in addition to the potential to enhance water retention capacity of soil and encourage the function of root system of plants (Gajalakshmi et al., 2001). Bioconversion of *M. bracteata* into vermicompost, which, in turn, can be used in the rubber plantation itself, is an efficient and environmentally sound way of recycling of nutrients.

There exists a vast literature on vermicomposting of different substrates into vermicasts (Hanc and Pliva, 2013; Suthar, 2009; Bindu and Ramasamy, 2008; Kurian and Ramasamy, 2006; Gajalakshmi et al., 2001) and impacts of vermicasts on growth and yield of many plants (Sangwan et al., 2010; Gandhi and Sundari, 2012; Atiyeh et al., 2001). However, reports on vermicomposting of this weed using native earthworm species *Perionyx ceylanensis* are scarce, or perhaps none. Hence, in the present study, the precomposted phytomass of this plant was used as substrate in the vermireactors inoculated with epigeic earthworm species *P. ceylanensis*. This study mainly aims to check whether the phytomass is suitable for vermicomposting and to assess the quality of vermicompost in terms of nutrients. The viability of the vermiconversion of this weed into vermicast was also assessed by studying the reproduction rate and growth potential of the worms in this reactor along with mortality during the study period.

2 Materials and methods

Earthworm species

P. ceylanensis, classified as epigeic or humus-feeder earthworm (Ismail, 1997), typically inhabit humus-laden upper layer of garden earth and manure pits. *P. ceylanensis* being native earthworms (Shylesh et al., 2012; Julka et al., 2007; Julka, 2008) and available abundantly were used in the present study. *P. ceylanensis* worms were obtained from the stock culture maintained in the laboratory.

Substrate

M. bracteata, whole plant biomass, was subjected to precomposting prior to feeding the vermireactors. *M. bracteata* belongs to the family *fabacea* of order fables in the kingdom plantae. It is a climbing shrub, young parts grey pubescent. Leaves alternate, *trifoliolate* up to 25 cm long. Racemes up to 16 cm long; flowers blackish purple 3.5–4.5 cm long (Sasidharan, 2011). For this study, *M. bracteata* was collected from rubber plantations located close to Mahatma Gandhi University campus, Kottayam. While precomposting, whole plant biomass was chopped into 2–3 cm size bits and mixed with cow dung slurry in 6:1 (weed to cow dung) ratio (weight per volume) and placed in a precomposting container with slits on the walls. The cow dung slurry was prepared by mixing cow dung with water 1:2 (Cowdung to water, weight per volume) ratio. The water used in preparing the slurry was supernatant water obtained by mixing tap water with garden soil in 2:1 (volume per weight) ratio and was allowed to settle in a glass column for 1 hour. With appropriate moisture the precomposting was continued for 15 days with intermittent stirring or mixing of the content for aeration. After 15 days the precomposted biomass of *M. bracteata* was used as feed in the experimental vermireactors.

Vermireactor

Plastic containers of four litre volume were used as vermireactors. These reactors were filled from bottom up with successive layers of broken country burned bricks, river sand and garden soil of the depth of 2 cm, 2 cm and 4 cm, respectively (Kurian and Ramasamy, 2006; Gajalakshmi et al., 2001; Ismail 1997). The earthworm used in these reactors was *P. ceylanensis*.

Experimental methods

Four vermireactors were used in this study with precomposted phytomass of *M. bracteata* as feed, which was placed over the top layer of the soil bed. In each reactor 10 healthy, clitellated worms of *P. ceylanensis* were introduced. All reactors were run with 37.5 g (dry weight) of feed per reactor. The average moisture content of the vermireactors was maintained at $60 \pm 2\%$ by periodic sprinkling of adequate quantities of water. After 15 days of operation, the vermicasts from the surface layer of soil bed of the reactors were harvested, then the reactors were started once again with 37.5 g of fresh feed, and the experiment was repeated. The harvested vermicasts have been quantified and analysed for their nutrient status. Earthworm biomass was also assessed during the initial day and on the 30th, 60th and 90th day of the experiment (Kurian and Ramasamy, 2006). Earthworms were washed and blotted with tissue paper before weighing. The growth rate of earthworms as a change in biomass and reproduction rate in terms of juvenile number per reactor were also assessed at 30-day intervals of the experiment.

These vermireactors were protected with a thin nylon mesh covering in order to avoid the entry of insects and rodents. These experiments were repeated thrice, which implies that the recovery of casts was estimated six times, while the earthworm biomass and reproduction rates were assessed thrice.

Analytical methods

Vermicasts were analysed for various parameters like moisture content, organic carbon, total nitrogen, available phosphorus, sodium, exchangeable potassium, calcium and magnesium as per the procedure of Maiti (2011).

3 Results and discussion

The study has examined the potential of a native, epigeic earthworm species *P. ceylanensis* in bio-converting the phytomass of the weed *M. bracteata* into vermicast. The potential of the earthworm species was assessed in terms of recovery of vermicast and the survival of these earthworm species in the vermireactor by gaining or losing weight, their reproductive potential and rate of mortality, etc. The quality of the earthworm casts was also assessed.

3.1 Vermicast recovery

The vermireactors operated with precomposted feed of *M. bracteata* were recorded with less vermicast recovery (14 ± 0.64%) as the fraction of feed mass during the initial period of operation. This low profile of vermicast recovery indicates that the earthworms which have been cultured with cattle dung as the principal feed have started acclimatising with the changeover to new feed. Similar observations on attempts with new substrates have been reported in the literature (Kurian and Ramasamy, 2006; Gajalakshmi et al., 2001). The per cent recovery of vermicasts improved subsequently indicating that the acclimatisation of the worms with this new feed has also increased. The vermicast recovery has steadily improved and reached 21.3 ± 0.6% towards the end of this study (Fig. 1). The increasing trend of vermicast yield indicates that these vermireactors can be operated successfully with the phytomass feed of *M. bracteata* along with *P. ceylanensis*.

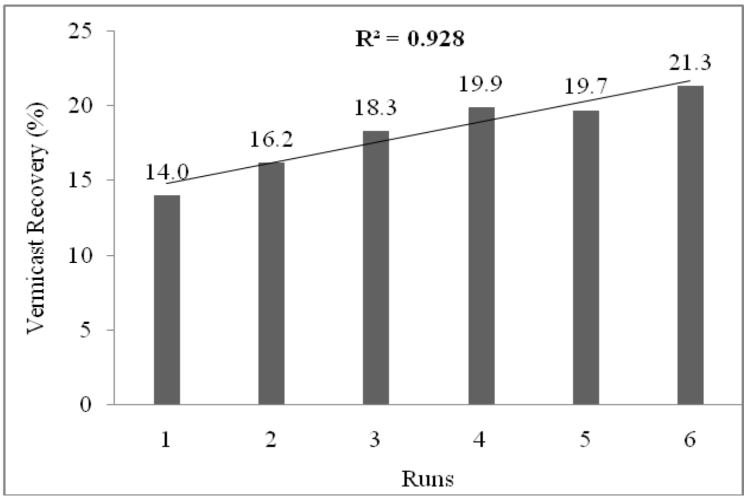

Figure 1 Vermicast recovery (%) at different runs of the experiment along with trend line analysis.

The statistical analysis of the vermicast recovery data was carried out. Based on the coefficient of variation analysis, vermicast recovery of Run 5 (R5) and Run 6 (R6) seems to be more stable than the vermicast recovery observed between Run 1 (R1) and Run 2 (R2). Student's t-test was also used to find out the statistical significance of higher per cent recovery of casts obtained in R6 with that in R1 ($P < 0.01$) (Table 1). As per the result of the statistical analysis (ANOVA-two way), there is a significant difference observed between runs ($F = 28.2$), whereas no significant difference was observed between reactors of this experiment (Table 2). Linear trend analysis (regression) indicated that except the cast recovery at R2, all other runs showed either higher (R3, R4) or lower (R1, R5 and R6) than the average result of vermicast recovery – as expressed in the trend line.

Table 1. Statistical analysis of recovery percentage of vermicast in Run 1 and 2; Run 5 and 6.

χ_1 (R1 and R2)	χ_2 (R5 and R6)	t	Probability	Degree of freedom	Coefficient of variation (R1 and R2), %	Coefficient of variation (R5 and R6), %
15.1	20.5	3.5	P<0.01	10	9.0	6.6

Table 2. ANOVA table (two way) of recovery percentage of vermicast during the experiment.

Source of variation	SS	df	MS	F	P-value	F crit
Between runs	109.0	5	21.8	28.2	1.4	3.3
Between reactors	2.7	2	1.3	1.7	0.2	4.1
Error	7.7	10	0.7			

3.2 Nutrient status

The vermicasts generated during the three months long study were analysed for the nutrient content. The results indicate a gradual increase in nutrient contents of the vermicast. For instance, the total nitrogen concentration of vermicast ranged from 0.1% to 0.3% having an average concentration of 0.2 ± 0.05%. 0.1% of nitrogen content observed during the 15th day has doubled to 0.3% on the 90th day (Fig. 2). Similar trend of increase in nutrient status of vermicompost was reported in the literature (Hanc and Pliva, 2013). Earthworm activity in the soil enhances the nitrogen content during vermicomposting through the process of microbial transformation of nitrogen and by the addition of nitrogenous waste secreted by earthworms (Suthar, 2009; Kale, 1998).

The carbon to nitrogen (C/N) ratio of the manure is considered as an important indicator of the quality of vermicast. The preferable range of the C/N cited in the literature varies between 18 and 25 (Kurian and

Ramasamy, 2006; Abbasi and Ramasamy, 2001). When the ratio exceeds 25, the assimilation of nitrogen from the manure by the plants becomes difficult. The C/N ratio obtained from the vermicasts of the present study was in the range from 22.2% to 26.9% (average concentration, 23.7 ± 3.9%) which is well within the preferable range of the C/N ratio reported in the literature. Earthworm activity including respiration and the respiration of soil microbes can reduce the carbon content of the soil leading to the lowering of the C/N ratio of the soil (Ronald and Donald, 1977). Similar observations of reduction in the C/N ratio have been reported in the literature (Daniel and Karmegam, 2000; Edwards and Lofty, 1976; Kaushik and Garg, 2003; Bansal and Kapoor, 2000; Levi-Minzi, 1986; Chauhan and Joshi, 2010). Edward and Lofty (1976) have clearly stated that the plant roots can easily assimilate nitrogen from soil when the carbon nitrogen ratio is 20 or less. The carbon nitrogen ratio of the casts from the present study (Table 3) is very close to 20 and there are studies which also report the casts with 16.5 to 26.45% of C/N ratios (Kaushik and Garg 2003). Thus, from the perspective of the C/N ratio, the vermicasts obtained in this study have comparable nutrient status of the reported studies in the literature.

Both available phosphorus and exchangeable potassium content of the cast was fluctuating. Phosphorus concentration was in the range of 0.2–0.5% with an average of 0.4 ± 0.12. An increase in phosphorus content from 0.2 on the 15th day to 0.54 on the 30th day was noticed, after that the values were fluctuating (Fig. 2). The fluctuation of phosphorus content may be due to the activity of microbial community present in the earthworm gut or due to the presence of phosphatase and p-solubilising microbial load of the vermicast (Khwairakpam and Bhargava, 2009). Similarly the potassium content of the cast also fluctuates during the experiment having an average value of 0.7 ± 0.11%. The overall nutrient content (average of six run) of casts including N, P, K, Na, Ca, and Mg (Table 3) obtained in this study is comparable with the values reported in the literature. Hence, the manure derived from this weed through vermicomposting is suitable for plants as a fertilizer.

Table 3. Nutrient status (average of 6 runs) of vermicast.

Parameters	Concentration (%)
Organic carbon	4.5 ± 0.63
Total nitrogen (N)	0.2 ± 0.05
Available phosphorus (P)	0.4 ± 0.12
C/N ratio	23.7 ± 3.9
Sodium (Na)	0.8 ± 0.33
Potassium (K)	0.7 ± 0.11
Calcium (Ca)	0.1 ± 0.04
Magnesium (Mg)	0.2 ± 0.05

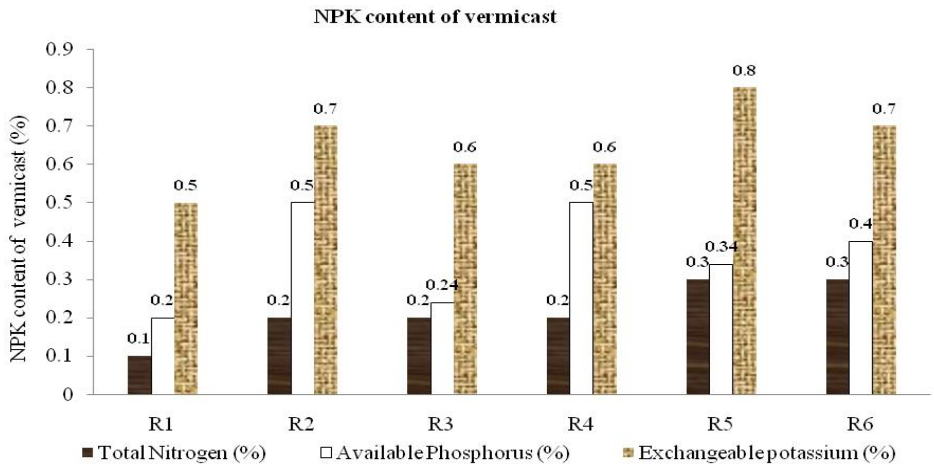

Figure 2. NPK (Nitrogen, Phosphorus and Potassium) content of vermicast.

3.3 Earthworm biomass change and reproduction

In all vermireactors the earthworms gained weight and reproduced well (Fig. 3). The average net increase in worm biomass of 23.1%, 35.4% and 45.3% was observed on the 30th day, 60th day and 90th day of vermireactor operation, respectively. Similarly an increase in the number of juveniles and cocoons was also recorded. Towards the end of the 3 months long experiments, an average of 38 cocoons and 53 juveniles per reactor was recorded. Besides worm reproduction, only a single mortality of earthworm was recorded during the experiment. The earthworm biomass has increased during the experimental period and attained 23.1% at the end of 30 days, subsequently reached 45.3% (90 days) increase in biomass with respect to the initial biomass of the worm at the beginning of the experiment.

The gradual increase in earthworm biomass as observed in the present study was also noticed by many researchers during their vermicomposting experiments (Hanc and Pliva, 2013; Garg and Gupta, 2011; Gupta and Garg, 2008). The increase in worm number with negligible rate of mortality and worm biomass increase during this 3-month study indicate that the weed mass (*M. bracteata)* is an acceptable feed to the earthworm *P. ceylanensis.* The 15 days precomposting process subjected prior to vermicomposting perhaps made the weed biomass as more palatable to the earthworms.

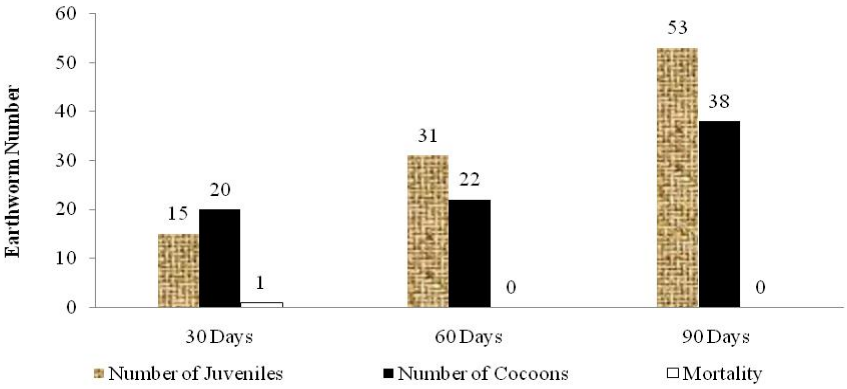

Figure 3. Increase in earthworm number (average of 4 vermireactors) during the course of experiment.

4 Conclusions

The phytomass of *M. bracteata* used in this study as feed for earthworms could be successfully bio-processed by earthworm *P. ceylanensis* into nutrient rich vermicast. The native epigeic earthworm *P. ceylanensis* grew and reproduced well in the vermireactors fed with the precomposted phytomass of *M. bracteata*. The findings of this study reveal that the precomposted phytomass of *M. bracteata* can be used as a suitable substrate for vermicomposting without any adverse effects on earthworm species *P. ceylanensis.* This approach may also serve as a suitable weed management option with recycling of nutrients, which, in turn, help to solve the issue of weed menace.

Acknowledgement

The authors are grateful to Kerala State Council for Science Technology and Environment (KSCSTE), Department of Environment and Climate Change (DoECC), Government of Kerala and Department of Science and Technology (DST) – FIST and DST-PURSE programmes – for all the financial and infrastructure support. The support of Mrs. P. Padma (Advanced Centre of Environmental Studies and Sustainable Development – ACESSD) in the statistical analysis of the data is gratefully acknowledged.

References

Abbasi S.A. and Ramasamy, E.V. (2001). *Solid Waste Management with Earthworms*, pp. 192. New Delhi, India: Discovery publishing hous.

Atiyeh, R.M., Arancon, N.Q., Edwards, C.A., and Metzger, J.D. (2001) The influence of earthworm-processed pig manure on the growth and productivity of marigolds. *Bioresource Technology* 81(2): 103-108. doi: http://dx.doi.org/10.1016/S0960-8524(01)00122-5.

Bansal, S. and Kapoor K.K. (2000) Vermicomposting of crop residues and cattle dung with Eisenia foetida. *Biores. Technol.*73: 95-98. doi: http://dx.doi.org/10.1016/S0960-8524(99)00173-X.

Bindu, T. and Ramasamy, E.V. (2008) Recovery of energy from Taro (Colocasia esculenta) with solid feed anaerobic digesters (SOFADs). *Waste management* 38: 396-405. doi: http://dx.doi.org/10.1016/j.wasman.2006.12.016.

Chauhan, A. and Joshi, P.C. (2010) Composting of Some Dangerous and Toxic Weeds Using Eisenia foetida. *Journal of American Science* 6(3): 1-6.

Edwards, C.A. and Lofty, J.R. (1976). *Biology of Earthworms*. Crawfordsville, Indiana: Bookworm Publishing Company (ISBN 0-916302-20-2).

Gajalakshmi, S., Ramasamy, E.V., and Abbasi S.A. (2001) Screening of four species of detritivorous earthworms for sustainable vermicomposting of paper waste. *Environmental Technology*, 22: 678-685. doi: http://dx.doi.org/10.1080/09593332208618240.

Gandhi, A. and Sundari, U.S. (2012) Effect of Vermicompost Prepared from Aquatic Weeds on Growth and Yield of Eggplant (Solanum melongena L.). *J Biofertil Biopestici* 3: 128. doi: 10.4172/2155-6202.10000128.

Garg, V.K. and Gupta R. (2011) Optimization of cow dung spiked pre-consumer processing vegetable waste for vermicomposting using Eisenia foetida. *Ecotoxicol. Environ. Saf* 74: 19- 24. doi: http://dx.doi.org/10.1016/j.ecoenv.2010.09.015.

Gupta, R. and Garg, V.K. (2008) Stabilization of primary sewage sludge during vermicomposting. *J Hazard Mater* 153: 1023- 1030. doi: http://dx.doi.org/10.1016/j.jhazmat.2007.09.055.

Hanc, A. and Pliva, P. (2013) Vermicomposting technology as a tool for nutrient recovery from kitchen bio waste. *J Mater Cycles Waste Manag* 15: 431- 439. doi: http://dx.doi.org/10.1007/s10163-013-0127-8.

Ismail, S.A. (1997). *Vermicology: the biology of earthworms*, pp. 192. Chennai, India: Orient Longman.

Janick, J., Sherry, R.W., Woods, F.W., and Ruttar, V.W. (1981). *Plant Science: Introduction to World Crop*. New York, USA: W.H. Freeman & Co.

Julka J.M. (2008) *Know your earthworms.* Solan, Himachal Pradesh, India: Shoolini Institute of Life sciences and Management.

Julka, J.M., Paliwal, R., and Kathireswari, P. (2007) Biodiversity of Indian earthworms – an overview. In: Edwards, C.A., Jeyaraaj, R., and Jayaraaj, I.A. (Eds.). (2009). *Proceedings of Indo-US workshop on Vermitechnology in human welfare*, Coimbatore, India.

Kale, R.D. (1998) Earthworm: Nature's gift for utilization of organic wastes. In: Edwards, C.A. (Ed.). *Earthworm Ecology* (pp. 355- 376). New York, USA: St. Lucie Press (ISBN 1884015-74).

Karmegam N., and Daniel, T. (2000) Effects of bio-digested slurry and vermicompost on the growth and yield of cow pea [Vigna unguiculata (L)]. *Environment and Ecology* 18(2): 367-370.

Kaushik, P. and Garg, V.K. (2003) Vermicomposting of mixed solid textile mill sludge and cow dung with epigeic earthworm Eisenia foetida. *Bioresour Technol* 90: 311–316. doi: http://dx.doi.org/10.1016/S0960-8524(03)00146-9.

Khwairakpam, M. and Bhargava, R. (2009) Vermitechnology for sewage sludge recycling. *J Hazard Materials* 161: 948- 954. doi: http://dx.doi.org/10.1016/ j.jhazmat.2008.04.088.

Kurian, J. and Ramasamy, E.V. (2006) Vermicomposting of Taro (Colocasia esculenta) with two epigeic earthworm species. *Bioresource technology* 97: 1324-1328. doi: http://dx.doi.org/10.1016/j.biortech.2005.05.018.

Levi-Minzi, R., Riffaldi, R., and Saviozzi, A. (1986) Organic matter and nutrients in fresh and mature farmyard manure. *Agricultural Wastes* 16: 225–236. doi: http://dx.doi.org/10.1016/0141-4607(86)90068-5.

Maiti, S.K. (2011). *Handbook of methods in environmental studies*. Jaipur, New Delhi, India: Oxford book company.

Ronald, E.G. and Donald, E.D. (1977). *Earthworms for ecology and profit: Scientific Earthworm Farming.* Ontario: Bookworm Publishing Company.

Sangwan, P., Garg, V.K., and Kaushik, C.P. (2010) Growth and yield response of marigold to potting media containing vermicompost produced from different wastes. *Environmentalist.* doi: 10.1007/s10669-009-9251-3. doi: http://dx.doi.org/10.1007/s10669-009-9251-3.

Sasidharan, N. (2011). Flowering plants, Biodiversity documentation for Kerala, version 2 (CD ROM). Kerala state Forest Research Institute (KFRI), Peechi, Trissure, Kerala.

Shylesh, C.M.S., Sujatha, S., Mohan, M., Julka, J.M., and Ramasamy, E.V. (2012) Earthworm diversity at Nilgiri biosphere reserve, Western Ghats, India. *Biodiversity conservation* 21: 3343- 3353. doi: http://dx.doi.org/ 10.1007/s10531-012-0365-4.

Smith, R.G., Mortensen, D.A., and Ryan, M.R.A. (2010) New hypothesis for the functional role of diversity in mediating resource pools and weed–crop competition in agro-ecosystems. *Weed Research* 50: 37-48. doi: http://dx.doi.org/10.1111/j.1365-3180.2009.00745.x.

Suthar, S. (2009) Vermistabilization of municipal sewage sludge amended with sugarcane trash using epigeic Eisenia fetida (Oligochaeta). *J.Hazard.Mater* 163: 199-206. doi: http://dx.doi.org/10.1016/j.jhazmat.2008.06. 106.

Greitai plintančios, probleminės piktžolės *Mucuna bracteata* kompostavimas naudojant sliekus Keraloje, Indijoje

Sruthi S. N., Sibin A., Ramasamy E. V.
Aplinkos mokslų fakultetas, Mahatma Gandhi universitetas, Kottayam, Kerala, Indija.

Mucuna bracteata DC. – tai viena iš dažnai Keraloje pasitaikančių ir sparčiai plintančių piktžolių. Šios piktžolės plitimas tampa aplinkos apsaugine problema ir kelia grėsmę vietos biologinei įvairovei. Tyrime buvo pabandyta paversti šias problemines piktžoles į maistingų medžiagų turtingą trąšą kompostuojant kartu su vietinių sliekų rūšimi *Perionyx ceylanensis.* Prieš kompostuojant *M. bracteata* fitomasė 15 dienų buvo laikoma sumaišyta su galvijų mėšlu santykiu 6:1. Gauta iš dalies suskaidyta fitomasė buvo paduota į vermireaktorius. Į juos buvo įdėta 37,5 g (sauso svorio) dalinai suskaidytos piktžolės masės ir 10 suaugusių sliekų, ir viskas buvo palikta 15 dienų. Šie eksperimentai buvo kartojami 6 kartus. Nustatyta vermireaktorių komposto išeiga siekė 14–21,3 %, o C/N santykis – 23,7, kuris yra palyginamas su kitomis literatūroje pateikiamomis reikšmėmis. Tyrimo rezultatai parodė, kad *P. ceylanensis* sliekų rūšis turi pakankamai potencialo paversti *M. bracteata* fitomasę į maistingų medžiagų turtingą trąšą. Taip pat paaiškėjo, kad sliekai dauginosi ir augo gerai, o jų svoris didėjo. Taigi šie reaktoriai su dalinai suskaidyta *M. bracteata* fitomase gali veikti darniai.

Raktiniai žodžiai: *Perionyx ceylanensis, piktžolių tvarkymas, kompostas, sliekai, maistingųjų medžiagų reciklas.*