St. Joseph's Journal of Humanities and Science (Volume 4 Issue 1 January 2017) 58-63

St. Joseph's Journal of Humanities and Science
ISSN: 2347 - 5331

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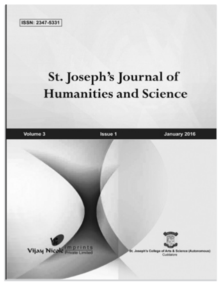

FEASIBILITY STUDIES ON THE USE OF AQUATIC WEED SALVINIA AS AN EARTHWORM FEEDSTOCK

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Abstract

In what is arguably the first-ever report of its kind, we describe the use of the pernicious aquatic weed salvinia (Salvinia molesta) in generating vermicompost. The epigeic earthworms Eudrilus eugeniae and Eisenia fetida were separately used for the purpose in vermireactors which were operated in batch and continuous mode. The experimental protocol involves removing and quantifies the vermicast formed at the end of each 15-day run. In place of the vermicast an equivalent amount of feed (salvinia) was added to the continuous reactor each time. If any juveniles or cocoons had been formed, they were removed so that the number of animals initially kept didn't change. In this manner the reactors were operated for 9 months.

It was seen that the rate of vermicomposting, as indicated by the fraction of feed converted to vermicompost per fortnight was initially low (about 8 and 12% in the first run of E. eugeniae followed by 7% with E. fetida in reactor with both continuous and batch mode) but it increased steadily with time till it touched about 38% by E. eugeniae and 31.5% by E. fetida in the 18th run (i.e after 270 days of operation). The E. eugeniae was by far the efficient producer of vermicasts, followed by the other epigeic E. fetida. Likewise continuous reactor performed better compared to batch mode. The worm zoomass and fecundity (as reflected in the production of juveniles and cocoons) also increased. Evidently, with time, the earthworms got adapted to the feed.

The studies establish the suitability of salvinia as a feedstock for generating vermicompost.

Keywords: Vermicomposting; E. eugeniae; E. fetida: vermicast; Salvinia molesta.

INTRODUCTION

Salvinia molesta (Mitchell) is a free-floating aquatic weed, which has colonised several parts of the world, notably Africa (Mitchell, 1969 and Mitchell, 1970), India (Cook and Gut, 1971; Thomas, 1976 and Thomas, 1981), Australia (Finlayson, *et al.,* 1982), Ceylon (Williams, 1956), and Papua New Guinea (Mitchell, D.S., 1979 and Mitchell *et al.,* 1980). The plant has a very high growth rate (Mitchell, 1970; Gaudet, 1973 and Abbasi and Nipaney, 1982) and, in this respect and in terms of adaptability and competitiveness, this weed appears to have an edge over water hyacinth *(Eichhornia crassipes* Mart) which is regarded the

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world's most problematic weed (Mitchell, 1970 and Gupta, 1979).

Several concerted attempts for the destruction of this weed through chemical methods (George, 1956, Mani *et al.,* 1976, Room *et al.,* 1981 and Patnaik, 1972), mechanical methods (Gupta, 1979 and Gaudet, 1976), and biological methods (Thomas, 1976, Room *et al.,* 1981, National Science Research Council, 1974, Thomas, 1975 and National Academy of Sciences, 1976), have been fruitless. Attempts to find ways and means of utilizing the weed have also met with little success became the weed isn't palatable to animals, it contain no medicinals or other chemicals worth extraction, and has had no other redeeming feature manifested so far.

The free-floating water fern indigenous to South America, is currently recognized as the world's most intransigent weeds (Russell, 1987) mainly because of its propensity to grow very rapidly at the expense of other weeds, even water hyacinth (*Eichhornia crassipes,* Mart). The aquatic weeds, especially Salvinia, azolla, hydrilla and *Cyperus* are highly productive, and can easily attain biomass yields of 10 dry t ha^{-1} $year^{-1}$, or more (Reddy and DeBusk, 1985). It is difficult to control or destroy the weeds through chemical or biological agents owing to the high costs and environmental backlash (Abbasi and Nipaney, 1986; Abbasi *et al.,* 1988). Periodical harvesting and utilization is apparently the best strategy for keeping the weeds under control, and amongst the various utilization option, vermicomposting is one.

Vermicomposting is the only pollution control bioprocess which has a multicellular animal as the main bioagent (Abbasi *et al.,* 2009). Reports by several authors (Gajalakshmi and Abbasi, 2002; Gajalakshmi and Abbasi, 2004a & b; Gajalakshmi *et al.,* 2005; Sankar Ganesh *et al.,* 2009 and Tognetti, 2011) and have confirmed what was a widespread belief thus far—that vermicompost is a better and even has an edge over synthetic chemical fertilizers. The latter attribute may be due to the growth-stimulating hormones and enzymes secreted by the earthworms in their vermicast (Abbasi *et al.,* 2005). These findings are expected to further stimulate interest in vermicomposting and an attempt has been made to provide an appropriate technology to diminish the current status of serious aquatic weed problems. In the present study, an attempt has been made to process salvinia by vermicomposting (Abbasi *et al.,* 2009). The objectives of the present study are 1) to assess the performance and efficiency of vermireactors operated in two modes: batch and continuous in vermicomposting an aquatic weed, Salvinia 2) to compare the performance of two earthworm species *E. eugeniae* and *E. fetida* in vermicomposting of salvinia, in terms of vermicast production, change in zoomass and reproduction.

Experimental

The epigeic *Eudrilus eugeniae* (Kinberg) is a manure worm which has been extensively used in North America and Europe for vermicomposting because of its voracious appetite, high rate of growth, and reproductive ability. A few years back it was brought to India and has been favoured with progressively increasing application in the vermicomposting of animal manure and other forms of biomass (Ashok Kumar, 1994; Ismail, 1998).

Eisenia fetida (Savigny) is also classified as epigeic or humus feeder earthworm (Ismail, 1997; Gajalakshmi *et al,* 2001). It has a greater potential as waste decomposers and prolific feeders. It can feed upon a wide variety of degradable organic wastes. It has a wider tolerance for temperature than *E.eugeniae*, which allows the species to be cultivated in areas with high temperature. *E.fetida* is probably the species best suited for vermicomposting throughout the country (Gajalakshmi and Abbasi, 2004).

Vermicomposting

Circular, 5l plastic containers (dia. 16 cm, depth 5 cm) were used as vermireactors. Healthy, adult *E. eugeniae* and *E. fetida* earthworms were randomly picked for use in vermireactors from the cultures maintained in the lab as cow dung as feed. Each vermireactor was operated with earthworm density of 50/litre of reactor. Over it 1 kg (dry weight basis) of *Salvinia molesta* was spread. A double layer of water–saturated jute cloth was used as bedding in the vermireactor. All the vermireactors were maintained in an identical environment with respect to temperature and moisture. Separate sets were operated in batch and continuous modes. In each set a pair of reactors with everything the same as batch and continuous reactors, but without earthworms was operated as control.

Reactors operated in batch mode

The vermireactors operated in batch mode were disbanded once in every 15 days, to assess vermicast production, cocoon, hatchling and mortality. The parent worms were picked, counted to check if there was any mortality, washed and blotted dry for weighing, and then immediately put back in the reactors which were restarted with remaining feed. The juveniles, if any, generated in the previous run, were separated and the 250 worms, with which the reactors had been started, were weighed and reintroduced. If there was any mortality, the required numbers of new adult earthworms were introduced to maintain the same number of worms.

Reactors operated in continuous mode

In continuous mode of reactor, the protocol followed was the same as batch reactor, but each and every run was restarted with left over substrate (salvinia) as feed from the previous run. Also the feed from control reactor (it keeps the feed from the time of started reactor and would provide continuously to the continuous reactor) equivalent to amount of vermicast (dry weight) harvested from the previous run was added as feed.

In batch mode reactor, when all the feed was consumed or very low feed was left, the reactor was started with fresh feed.

Results and Discussion

In reactors with *E. eugeniae,* the vermicast recovery as the fraction of the feed mass was less (8.3 and 8 %) during the first two runs of reactor operation, indicating that the earthworms, which had been cultured with cowdung as the principal feed, took some time to acclimatize with the change over to salvinia feed. There was slow increase in vermicast output in the next runs. At the end of the fifth run, vermicast output of 12.6% was recorded. In subsequent runs there was slow increase in vermicast up to ninth run.

From run tenth to run eighteenth, the reactor output was following a steady increase; the maximum vermicast output of 38% was recorded in the 18th run.

The reactor with *E. fetida* also followed the same trend like *E. eugeniae*, a maximum output of 34% was recorded in the 18th run.

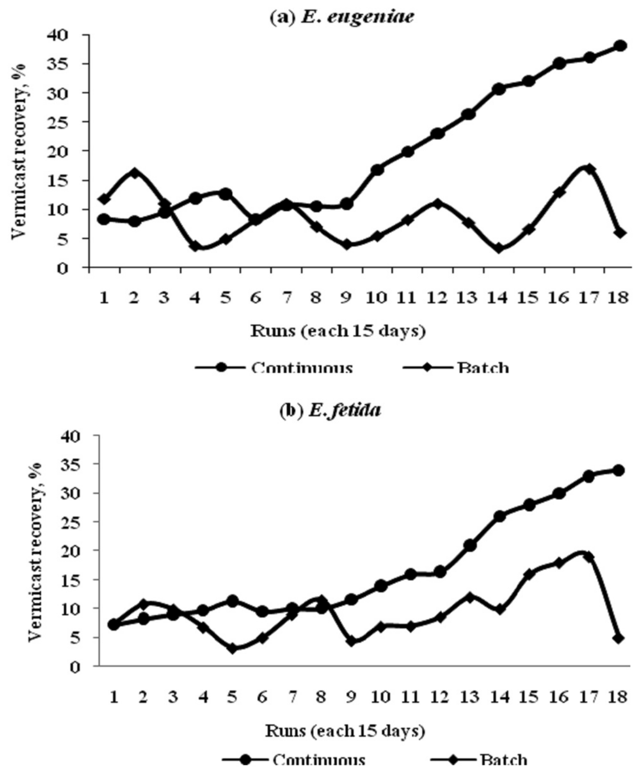

Figure 10.1: Vermicast recovery, %, as a function of time in reactors operated in continuous and batch mode with S. molesta as feed with the earthworm species (a) E. eugeniae (b) E. fetida

The vermicast output of batch reactors with *E. eugeniae* and *E. fetida* had shown the same trend. In all batch reactors in most of the runs, the vermicast output was high when the substrate turned older. The maximum vermicast output in reactor with *E. eugeniae* was 17% in 17th run and with *E. fetida* was 19% in the 17th run.

The average change in worm zoomass in each run was recorded. In reactors with *E. eugeniae* (continuous and batch mode) (Figure 10.2a), there was increase in zoomass in every run except 4th, 5th, 7th, 8th and 9th in batch and 6th and 9th run in continuous reactors.

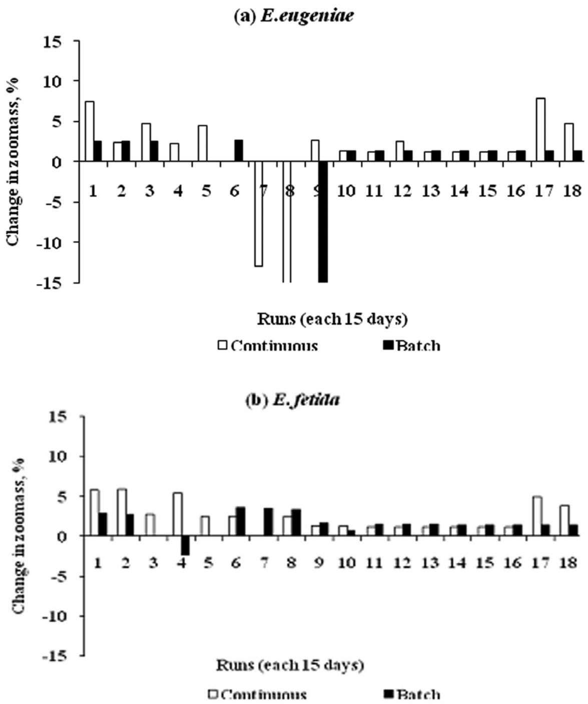

Figure 10.2 : Change in zoomass in reactors with S. molesta as feed with the earthworm species (a) E. eugeniae

(b) E. fetida

The minimum average change in zoomass was observed in 11th run (1.2%) and the maximum average zoomass was recorded in the continuous reactor in the 17th run (7.8%). The increase in zoomass clearly shows that the substrate is palatable to the worms.

The reactors with *E. fetida* also exhibited positive change in worm zoomass. The maximum average worm zoomass was recorded in the 2nd run (5.8%) of continuous and minimum zoomass in 10th run (0.6%) of batch reactor. The increase in zoomass was more in continuous reactors revealing that the continuous reactor performed a step better than batch reactors.

There was an increase in the number of juveniles and cocoons in all the runs of reactor.

In reactor with *E. eugeniae* operated in continuous mode, though there was increase in zoomass, 13 and 15% mortality was recorded in the 7th and 8th run respectively. In the batch reactor the mortality was 15% in the 9th run.

There was very little mortality in reactors with *E. fetida* operated in batch mode (2.4% in fourth run) only. There was no mortality in reactors operated in continuous mode. *E. fetida* proved themselves as tolerant species than *E. eugeniae* while vermicomposting salvinia.

Table 1

Reproduction Rate of Earthworms in Reactors Operated with S. Molesta

Runs (each 15 days)	*E. eugeniae*				*E. fetida*			
	Continuous		Batch		Continuous		Batch	
	Juveniles	Cocoons	Juveniles	Cocoons	Juveniles	Cocoons	Juveniles	Cocoons
1	17	28	18	25	8	13	11	17
2	15	31	14	26	14	22	12	18
3	18	22	11	15	15	18	4	7
4	16	25	5	12	11	14	4	7
5	12	23	7	15	6	11	6	14
6	5	11	9	13	7	7	4	14
7	7	7	11	8	5	11	9	18
8	8	12	13	5	12	8	7	12
9	6	10	2	9	15	9	5	11
10	18	11	9	12	9	18	13	15
11	12	17	8	11	7	12	9	13
12	18	22	9	15	5	9	6	11
13	16	17	4	9	12	17	13	15
14	18	21	7	12	14	19	9	11
15	25	31	12	18	16	21	11	15
16	19	22	14	17	18	23	13	18
17	21	26	15	19	21	25	11	12
18	23	27	18	21	23	27	15	15

CONCLUSION

i) In terms of efficiency of the reactors operated in continuous and batch mode, the continuous reactors performed better than batch mode with both species.

ii) Between the two species, *E. eugeniae* is better performer than *E. fetida* in terms of vermicast production, reproduction and gain in zoomass.

iii) The earthworms did not prefer fresh feed and accepted it as a diet only when salvinia became older.

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