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Biomanagement of sago-sludge using an earthworm, *Eudrilus eugeniae*

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Abstract: *Sago, the tapioca starch is manufactured by over 800 small-scale units located in the Salem district, Tamil Nadu, India. During the processing of sago it generates huge quantities of biodegradable solid waste, as crushed tubers. In present study an attempt was made to convert these biodegradable solid sago tubers into value added compost using an exotic earthworm, Eudrilus eugeniae. The experiments were carried out in a plastic tray at various concentrations of sago-sludge (50% 75% and 100%) for a period of 90 days. During the vermicomposting, data were collected on life form (cocoon, non clitellates, clitellates) of earthworm and it was found to be high in 50% followed by 75% and 100% concentrations. Chemical analysis of worked substrates showed a step wise increase of nitrogen and phosphorus. The fold increase of phosphorus and nitrogen were found to be high for sago-sludge undergoing vermicomposting than the control. During the composting period the organic carbon decreased from its initial value of 58, 76 and 107mg/kg to 21, 24 and 65 mg/kg for 50, 70 and 100%, respectively. The microbial analysis showed that after 75 days of composting, their population stabilized and further increase in composting period did not increase their population size. The results indicate that 50% and 75% concentration of sludge mixed with bedding material was ideal for the vermicomposting.*

Key words: *Sago-sludge, Eudrilus eugeniae, Vermicomposting, Total organic carbon*
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Introduction

Sago, the edible starch globules processed from the tubers of tapioca (*Mannihot utillisema*) is the staple diet among the middle-income groups in India. Processing of tapioca requires 20,000 to 30,000 liter of water per ton of sago; besides it produces equal quantity of highly organic, foul smelling and acidic wastewater along with sago-sludge (Rajesh Banu *et al*., 2006a, b). Hence, it is necessary to manage this huge quantity of biodegradable solid waste in an ecofriendly manner. In this context, several physical, chemical and biological methods have been tried to treat solids namely, gravity separation (Singh, 1992), anaerobic digestion (Rajesh Banu *et al.,* 2007), fungal composting (Logakanthi *et al.,* 2006) thermal treatment (Burner, 1997; Binner *et al.*, 2000; Burton and Ravi Shankar, 2000), pyrolysis (Gayle, 1999; Borup and Middlebrooks, 2000) and stabilization and solidification (Le Grega *et al.,* 1994). In the present study an attempt has been made to manage the biodegradable sago-sludge by vermicomposting technique using an exotic earthworm, *Eudrilus eugeniae*. The role of earthworm as a decomposer is known since Darwin (1881). Rajesh Banu *et al*. (2001) and Oboh *et al.* (2007) reported that earthworm *Eudrilus eugeniae* shows the potential to manage paper mill sludge successfully. The end product of vermicomposting is rich in essential micro and macronutrients along with microorganism in a very simple form (Logakanthi *et al*., 2000; Parthsarathi *et al.,* 2007). Adding cast not only improves the soil structure and fertility but also leads to improvement in overall plant growth and thus increases their yield too (Kavian and Ghatnekar, 1991; Kavian *et al*., 1998). The experiments were carried out for a period of 90 days to assess the ability of earthworm, *Eudrilus eugeniae* to compost the sago-sludge.

Materials and Methods

The raw material for this experiment, sago was collected from small-scale sago making industry, situated near Salem District, Tamilnadu, India. pH, moisture, total dissolved solids of sago were measured following standard methods (Trivedi and Goel, 1984). Sodium and potassium were analysed using flame photometer (chemito, Model: 1000).

Bedding material preparation: The standard bedding material was prepared (Rajesh Banu *et al*., 2005). Raw material used was: *Mangifera indica* foliage, cow dung and saw dust. The bedding material was prepared by taking dry weight of *Mangifera indica*, cowdung and sawdust in the ratio of 4:4:2.

Vermi tub treatment process: The sago-sludge at 50%, 75% and 100% concentrations were mixed with standard bedding material at 50% and 25%, respectively. It was placed in the plastic tubs of size 10" X 14" X 40" accommodating 2 kg of material. The 100% concentration was prepared by taking 2 kg of sago-sludge as such. 10 breeders belonging to the species *Eudrilus eugeniae* were inoculated in different concentrations. All introduced worms were of nearly same size in length and in weight. The experiment was carried out at an ambient temperature (27-34^{o}C). The moisture content was analysed using moisture balance (Sartorius model: MA 30-000V3) and was maintained at 60-65%. The pH of the bedding material during the study ranged from 6.4-7.4. The experiment was carried out in triplicate sets for a period of 3 months. The upper surfaces of the culture tubs were covered with wire mesh to avoid entry of predators.

Chemical analysis: During the composting period samples were once in a week analyzed to determine nitrogen, phosphorus employing methods detailed in Trivedi and Goel (1984). Bacterial enumeration was done every 14 days. The technique followed for bacterial enumeration was spread plate technique in nutrient agar medium (APHA, 2005). Number of cocoons laid by 10 earthworms per week in different concentration of the sago-sludge was counted. The development of cocoons upto juvenile stage was followed. Total organic carbon was analyzed using TOC analyzer (Analytika Gena; Model: Micro C).

Results and Discussion

The physico-chemical characteristics of the sago-sludge are presented in Table 1. The moisture content of the sago-sludge was above 40%. The problem faced during the vermicomposting of sago-sludge was attributed to its high moisture content and ability to retain the moisture. Thus, the sago-sludge was sun dried for 2 days before subjected to vermicomposting. The pH was towards to acidic range. The amount of organic carbon in the sago-sludge was found to be 110 mg/kg. The chloride content of the sago-sludge was 16 mgl^{-1} and this high amount of chloride in the sago-sludge was due to the addition of chlorine compounds during the manufacturing process. The concentrations of nitrogen (0.58 mg/kg), phosphorus (1.69 mg/kg) and potassium (0.3 mg/kg) in the sago-sludge were found to be low. Since sago-sludge did not have sufficient amount of major nutrients to support the growth of earthworms and microorganisms (Rajesh Banu *et al*., 2001), it was decided to supplement with bedding material.

Earthworm fecundity is often expressed in various ways, viz., the rate of cocoon production, hatching success of cocoons and number of offspring's emerging from each cocoon. The success of the composting depends upon the fecundity of the earthworm. Table 2 depicts the life forms of *Eudrilus eugeniae at* 90^{th} day of vermicomposting. From the table it is clear that the reproductive pattern of *Eudrilus eugeniae* was lower in 100% and 75% concentration when compared to that of 50%. This might be due to the fact that both 100% and 75% concentrations have lower amount of bedding material and the higher amount of moisture content. Main problem encountered during the vermicomposting of sago-sludge is the maintenance of moisture level. In the case of 100% sago-sludge it was very difficult to maintain the moisture level which led to the formation of anaerobic condition, reducing the survival rate of earthworm. Many authors reported a relationship between the moisture level and survival of earthworm (Muyima *et al*., 1994; Reinecke and Venter, 1985; Viljoen and Reinecke, 1989). Number of juveniles and non-clitellates count also showed similar trends (Table 2). The results of the present study showed high level of fecundity when compared with the results of other biomanagement studies like paper-sludge and petrochemical-sludge vermicomposting (Rajesh Banu *et al*., 2001, 2005).

Table - 1: Physico-chemical characteristics of sago-sludge

S.No.	Parameter	Values*
1	pH	6.4
2	Moisture content (%)	45
3	TOC	107
4	TKN	0.582
5	Phosphate	1.69
6	Potassium	0.3
7	Nitrite	0.338
8	Chloride	16.65
9	Sulphate	9.703

*All values except pH are in mgl^{-1}

Figure 1 depicts the pattern of bacterial colonization during the 90-day period of biomanagement of sago-sludge. From the figure it was evident that there was an increase in the bacterial count in the first fortnight. From then onwards the population of microorganisms increased steadily up to 60^{th} day, for 50%, 75% and 100% concentrations. After 60^{th} day, microbial population was stabilized in different concentrations of sago-sludge undergoing vermicomposting. Microbial population was also found to be high at 50%. This might be due to the high fecundity of earthworm at 50% concentration when compared to 75% and 100%. It is known that earthworm acts as a bioreactor and promotes the growth of microorganisms (Edwards, 1988; Stachell *et al*., 1984).

Figure 2 illustrates utilization of total organic carbon during vermicomposting of sago-sludge. In the case of 50% sago-sludge concentration TOC reduced from 61.2 and 56.4 mg/kg to 34.8 and 15.6 for control and composting, respectively**.** In 75% sago-sludge concentration, from the initial TOC value of 77.6 mg/kg it was reduced to 45.2mg/kg for control and 74.6 to 25 mg/kg for vermicomposting, respectively where as in the case of 100% it was reduced to 72.8 and 58 mg/kg from its initial concentrations of 110.6 and 107 mg/kg, for control and vermicomposting, respectively. It was evident that the sago-sludge that underwent vermicomposting showed better utilization of TOC when compared to the control. This might be attributed to the respiratory activity of

Table - 2: Fecundity of *Eudrilus eugeniae* during the period of vermicomposting

S.No.	Concentration of sago-sludge (%)	Life form of *Eudrilus eugeniae*			
		Cocoons*	Juveniles*	Non-clitellates*	Adults*
1	50	55	30	18	5
2	75	32	14	8	-
3	100	12	5	3	-

*Values are average of triplicates

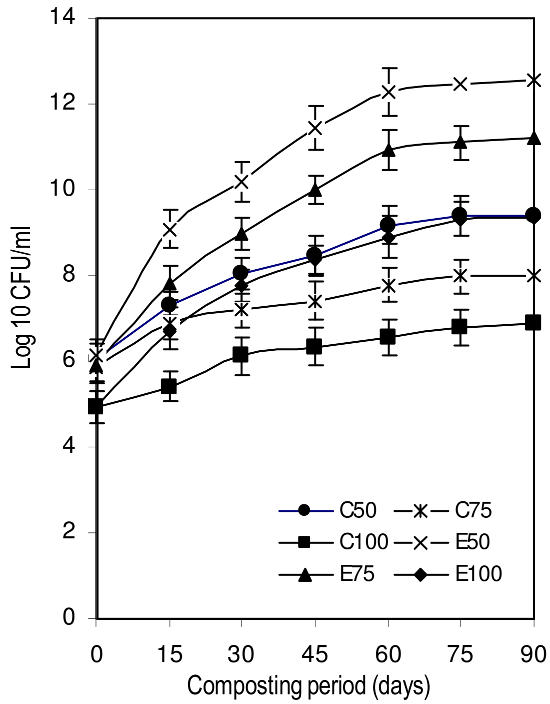

Fig. 1: Growth of microorganisms during the vermicomposting of sago-sludge

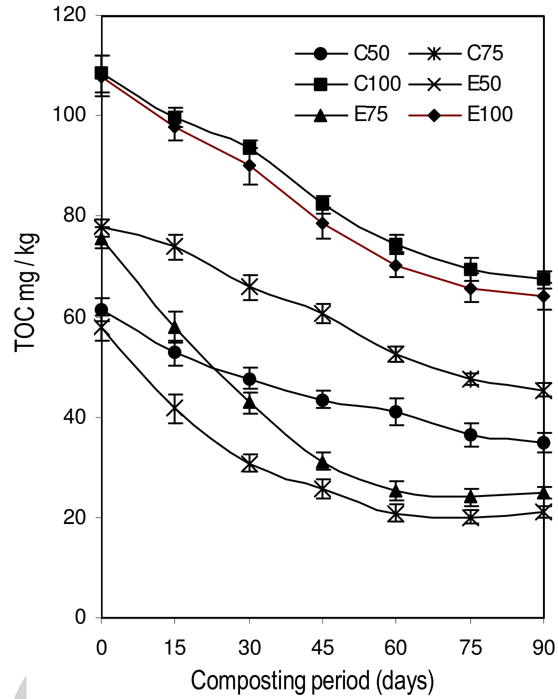

Fig. 2: Removal of total organic carbon during the vermicomposting of sago-sludge

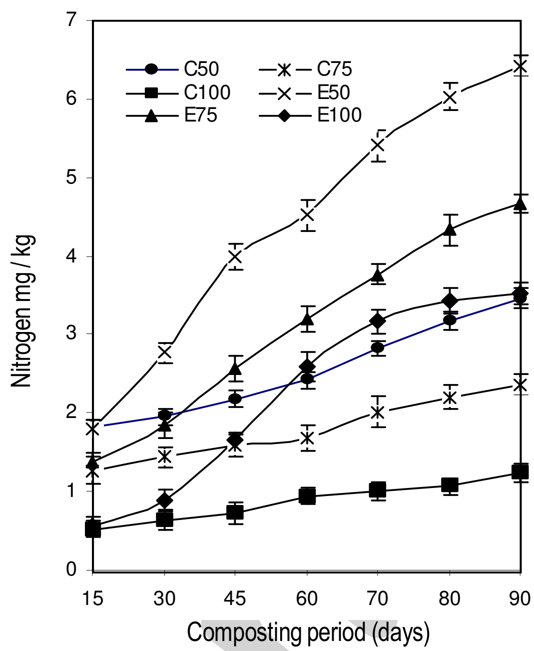

Fig. 3: Pattern of nitrogen variation during the vermicomposting of sago-sludge

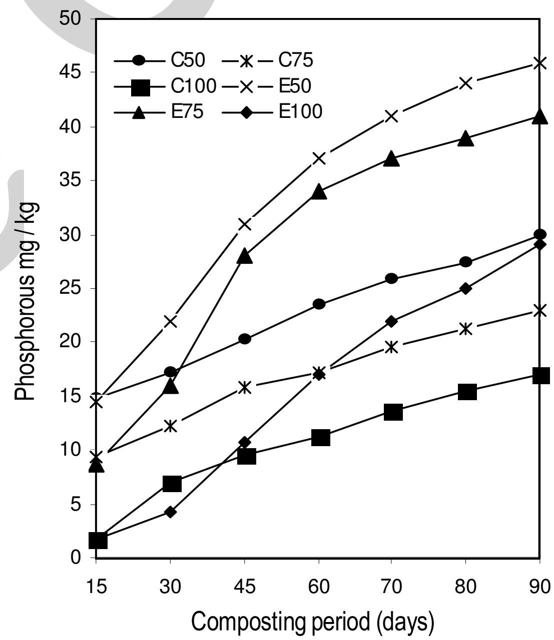

Fig. 4: Pattern of phosphorus variation during the vermicomposting of sago-sludge

earthworms and microorganisms (Curry *et al.,* 1995; Edwards and Bohlen, 1996). Among the different concentrations of sago-sludge undergoing vermicomposing, the 50 and 75% concentrations showed slight increase in organic carbon after 75 days. The increase in organic carbon at the final stage of vermicomposting may be due to the addition of earthworm casts, which are rich in organic carbon (Tripathi and Bhardwaj, 2004). The rate of TOC removal was found to be high in 50% followed by 75% and 100% concentrations, respectively. At lower sago-sludge concentration the activity of *Eudrilus eugeniae* (Table 2) was high, which increased the rate of organic carbon degradation by enhancing microbial activity (Kavian *et al*., 1996).

Figure 3 illustrates the variations in nitrogen during the period of vermicomposting. In all the sago-sludge concentrations nitrogen content increased with the increase in composting period. In 50% sludge concentration, nitrogen from its initial value of 1.8 mg/kg was increased to 3.4 and 6.4 mg/kg, respectively for control and vermicomposting. In 75%, from the initial value of 1.3 and 1.4 mg/kg the nitrogen increased to 2.3 and 4.6 mg/kg respectively for control and vermicomposting. In the case of 100% sago-sludge concentration it was increased to 1.2 (control) and 3.5 (vermicomposting) mg/kg from their initial concentrations of 0.5 mg/kg. The increase in nitrogen and phosphorus in the vermicompost indicated that there was enhanced mineralization of these elements due to microbial and enzyme activity in the gut of the earthworms. Similar observations were reported earlier by many investigators (Robinson *et al*., 1992; Lair *et al*., 1997).

Phosphorus variations in the sago-sludge during composting period is shown in the Fig. 4. Robinson *et al*. (1992), have reported that the increase in the phosphate level during composting is mainly due to the activity of microorganisms that mineralize the phosphate. From the figure, it is clear that the increase in phosphorus was higher for sago-sludge that was subjected to vermicomposting than that of the control. Among the different concentrations of sago-sludge, the increase of phosphorus was higher for 50% followed by 75% and 100%.

The present study indicates that bedding material is very essential for the composting and it also helps in the growth of earthworm which is indirectly responsible for the increase in microbial population, nitrogen, phosphorus level and reduction of organic carbon in the compost. It can be concluded that sago-sludge was found to be non-toxic to the earthworm and amenable to vermicomposting. Further studies employing different earthworm species and on the impacts of low nutrient level and high moisture content, would help to evaluate the process and its application pave way for pilot scale experiment.

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