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Biomanagement of sago-sludge using an earthworm, *Lampito mauritii*

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Abstract: *In the present study vermicomposting was carried out at three different concentrations of sago-sludge namely, 50, 75 and 100% with an indigenous earthworm, Lampito mauritii for a period of 50 days. The fecundity of earthworm Lampito mauritii was found to be high in 50%. At the end of 50 days composting period. There were about 12 cocoons, 5 juveniles and 2 nonclitellates appeared at 50% sago-sludge concentration. The microbial analysis showed that after 40 days of composting their population stabilized and further increase in composting period did not increase their population size. Chemical analysis of Lampito mauritii worked substrates showed there is 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. From the initial value of 1.8, 1.4 and 0.5 mgkg^{-1} total nitrogen increased in a stepwise manner and reached a value of 5.8, 3.9 and 2.3 mgkg^{-1}, respectively for vermicomposing at 50, 75 and 100%. During composting the organic carbon decreased from its initial value of 56, 74 and 107mgkg^{-1} to 15, 25 and 58 mgkg^{-1} for vermicomposting and 34, 45 and 72 mgkg^{-1} for 50, 70 and 100% control, respectively. The results indicate that 50% and 75% concentration of sludge mixed with bedding material was ideal for the vermicomposting.*

Key words: *Sago-sludge, Lampito mauritii, Vermicomposting*
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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 (Surender Kumar *et al.,* 1992), fungal composting (Logakanthi *et al.,* 2006; Parthasarathi, 2006; Borowski and Szopa, 2007) thermal treatment (Burner, 1997; Binner *et al*., 2000; Burton and Ravi Shankar, 2000), pyrolysis (Gayle Woodside, 1999; Borup and Middlebrooks, 2000; Chiaramonti *et al*., 2007), 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 indigenous earthworm, *Lampito mauritii*. The role of earthworm as a decomposer system is known since Darwin (1881), Parthasarathi *et al.* (2007) and Oboh *et al.* (2007). Rajesh Banu *et al*. (2001) reported that earthworm, *Lampito mauritii* has shown 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). 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 50 days to assess the ability of earthworm, *Lampito mauritii* 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. It was analysed for pH, chloride, sulphate and nitrate, by method discribed by Trivedy and Goel (1984). The moisture content of the sludge was determined using moisture balance (Make: Sartorius, Model No: MA 30). Potassium was analysed using flame photometer (Make: chemito, Model: 1000). Earthworms belonging to the species *Lampito mauritii* were collected from culture bank of SPKCES (Sri Paramakalyani Centre for Environmental Sciences), Alwarkurichi, Tirunelveli, Tamil Nadu.

Bedding material preparation: The standard bedding material was prepared as per Rajesh Banu *et al*. (2005). Raw materials used were: *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 undergoing vermicomposing at 50%, 75% and 100% concentrations were mixed with standard bedding material at 50% and 25%, respectively and were designated as L50, L75 and L100%. Similarly the control setup also formulated by mixing bedding material and sago-sludge. In control setup no earthworms was introduced and were designated as C50, C75 and C100. 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. Ten breeders belonging to the species, *Lampito mauritii* were inoculated into the sago-sludge undergoing vermicomposting. All introduced worms were of nearly same size in length and in weight. The culture tubs were placed inside the laboratory. The experiment

was carried out at an ambient temperature (27-34°C). The moisture content was analysed using moisture balance (Make 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 for a period of 2 months. The upper surfaces of the culture tubs were covered with wire mesh to avoid entry of predators.

Chemical analysis: During the composting period sampling was done once in a week and it was analyzed for total nitrogen and phosphorus employing method given by Trivedy and Goel (1984). Total organic carbon was analyzed using TOC analyzer (Make: Analytika Gena; Model: Micro C). Bacterial enumeration was done at fortnightly. The technique followed for bacterial enumeration was spread plate technique in nutrient agar medium (APHA, 2005). After plating the petridishes were incubated overnight in an incubator at 30°C for observing colonies. The results are expressed as log CFU (colony forming units). Number of cocoons laid by 10 earthworms in different concentrations of the sago-sludge was hand picked and counted manually at weekly intervals. The development of cocoons upto juvenile stage was followed.

Results and Discussion

The physico-chemical characteristics of the sago-sludge after 2 hr sun drying are presented in Table 1. The problem faced during the vermicomposting of sago-sludge is attributed to its higher moisture content and ability to retain the moisture. Due to the above said problems the sago-sludge was sun dried for 2 days and then it was subjected to vermicomposting. The pH was slightly towards acidic range. The amount of organic carbon in the sago-sludge was found to be 110 mgkg^{-1}. The concentration of major nutrient nitrogen, phosphorus and potassium in the sago-sludge was found to be very low and it was 0.58 mg kg^{-1}, 1.69 mg kg^{-1} and 0.3 mg kg^{-1} respectively. Since sago-sludge do not have sufficient amount of major nutrients to support the growth of earthworms and microorganisms, it was decided to supplement with bedding material. The chloride and sluphate content of the sago-sludge was found to be 16 and 9.7 mgl^{-1} respectively and this high amount of chloride and sulphate in the sago-sludge was due to the addition of these compounds during the manufacturing process.

Earthworm fecundity is often expressed in various ways, the rate of cocoon production, the hatching success of these cocoons and number of offspring's emerging from each cocoon. It is the factor that determines the number of new individuals produced per unit time for a specific population of reproductive individuals. Table 2 depicts the life forms of *Lampito mauritii* at 50th day of vermicomposting. From the table it is clear that the reproductive strategy of *Lampito mauritii* 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 that leads to the reduced survival rate of earthworm. In literature many authors have reported that there is 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 towards the higher concentration of sago-sludge. In the 100% concentration of sago-sludge no juveniles and non-clitelates were observed during the 50 days of vermicomposting. Whereas in the 50% and 75% sago-sludge concentration 5, 2 and 2,1 juveniles and non-clitelates, appeared respectively. The results of the present study show very high level of survival and fecundity percentage when compared to the result of *Lampito mauritii* fecundity for paper and petrochemical sludge undergoing vermicomposting for a period of 60 days (Rajesh Banu *et al*., 2001).

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

Parameter	Values*
pH	6.4
Moisture content (%)	5
TOC	107
Total nitrogen	0.582
Phosphate	1.69
Potassium	0.3
Nitrite	0.338
Chloride	16.65
Sulphate	9.703

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

Table - 2: Fecundity of *Lampito mauritii* during the period of sago-sludge vermicomposting

Concentration of sago-sludge (%)	Life form of *Lampito mauritii*			
	Cocoons	Juveniles	Non-clitellates	Adults
50	12	5	2	-
75	8	2	1	-
100	4	-	-	-

Figure 1 depicts the pattern of bacterial colonization during the 50-day period of biomanagement of sago-sludge. Initially there was an increase in the bacterial count in the first fortnight. The population of microorganisms steadily increased up to the 40th day for 50%, 75% and 100% concentrations. After at 40th day microbial population was stabilized in different concentrations of sago-sludge undergoing vermicomposting. Among the different concentrations of sago-sludge undergoing vermicomposting, microbial population was found to be high for 50%. This may be due to the presence of higher amount of bedding material that favours the microbial growth (Kavian *et al*., 1998). When compared to the control unit's microbial population was high for the vermicomposting units. It is known that earthworm acts as a bioreactor and promotes the growth of microorganisms (Edwards, 1988; Curry and Schmidt, 2007). It is also reported in the literature that earthworms will increase the microbial biomass during vermicomposting (Stachell *et al*., 1984).

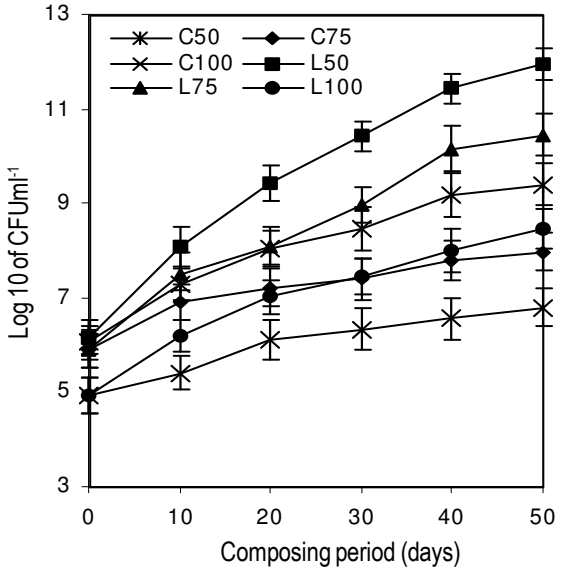

Fig. 1: Growth of microorganisms during the vermicomposting of sago-sludge

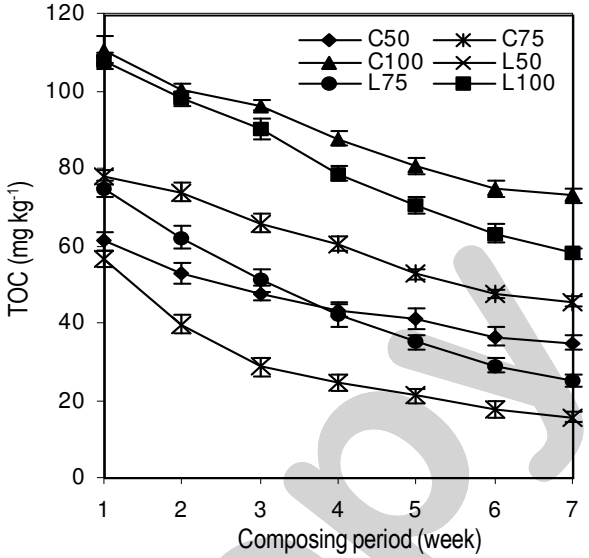

Fig. 2: Removal of total organic carbon during the vermicomposting of sago-sludge

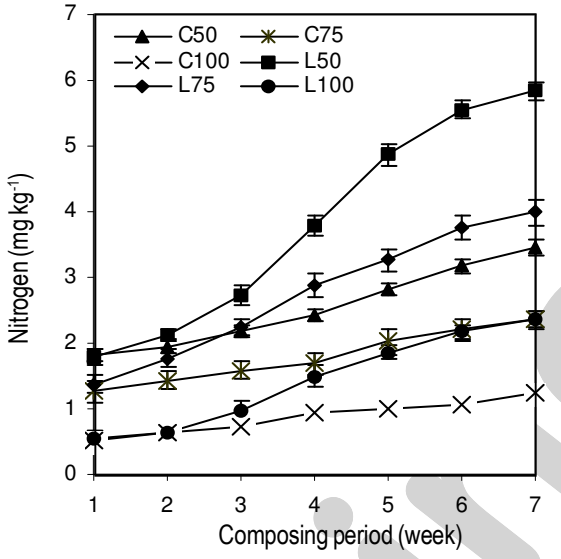

Fig. 3: Pattern of total nitrogen variation during the vermicomposting of sago-sludge

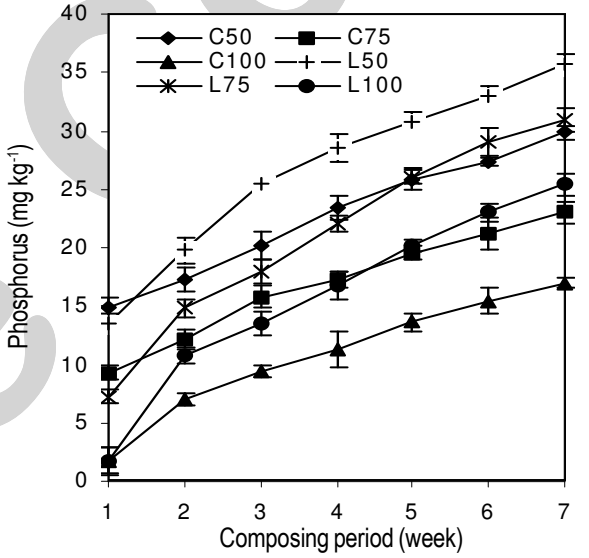

Fig. 4: Pattern of phosphorus variation during the vermicomposting of sago-sludge

Figure 2 illustrates utilization of total organic carbon during vermicomposting of sago-sludge. In 50% sago-sludge from the initial value of 61.2 and 56.4 mg kg^{-1} the TOC reduced to 34.8 and 15.6 mg kg^{-1} for control and vermicomposting, respectively. In 75% sago-sludge concentration, from the initial TOC value of 77.6 mg kg^{-1} it was reduced to 45.2 mg kg^{-1} for C75 and 74.6 to 25 mg kg^{-1} for L75, respectively. In the case of 100% concentration it was reduced to 72.8 and 58 mg kg^{-1} from its initial concentration 110.6 and 107 mg kg^{-1}, respectively for C 100 and L100. From the results it is clear that the sago-sludge that undergo vermicomposting show better utilization of TOC when compared to the control. This may be attributed to the activity of earthworm that increases the microbial population in the composting which in turn effectively utilizes the carbon in the compost (Burtelow *et al*., 1998; Goyal *et al*., 2005). Among the different concentrations of sago-sludge undergoing vermicomposting, the rate of TOC removal was more in 50% followed by 75% and 100%. The better reduction in carbon in the lower concentration was due to the presence of higher percentage of bedding material, which was rich in all essential nutrients needed for better vermicomposting as reported by (Kavian *et al*., 1996; Tripathi and Bhardwaj, 2004).

Figure 3 illustrates the variations in total nitrogen during the period of vermicomposting. Nitrogen is an essential plant nutrient

and it determines the value of the compost (Patrick *et al*., 2000). In all the sago-sludge concentration nitrogen content increased with the increase in composting period. In 50% sludge concentration nitrogen from its initial value of 1.8 to 1.7 mg kg^{-1} it was increased to 3.4 and 5.8 mg kg^{-1}, respectively for C50 and L50. In 75%, from the initial value of 1.2 and 1.3 mg kg^{-1} the nitrogen increased to 2.3 and 3.9 mg kg^{-1}respectively for C75 and L75. In the case of 100% sago-sludge concentration it was increased to 1.2 and 2.3 mg kg^{-1} from its initial concentration of 0.5 mg kg^{-1}, respectively for C100 and L100. From the results it can be concluded that increase in the fold of total nitrogen was higher for all concentrations of sago-sludge undergoing for vermicomposting than the control. Similar type of observation was reported by many investigators (Robinson *et al*., 1992; Lair *et al*., 1997). The higher fold increase in nitrogen content in sago-sludge undergoing vermicomposing is due to the nitrification that happens in earthworm casts, the ratio of nitrate-N to ammonium-N tends to increase when earthworms are present (Cortez *et al*., 2000). Nitrogen-fixing bacteria are found in the gut of earthworms and in earthworm casts, and higher nitrogenase activity, meaning greater rates of N-fixation, are found in casts when compared with soil (Simek and Pizl, 1989).

Phosphorus variation in the sago sludge during composting period is depicted 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 fold of phosphorus was higher for sago-sludge that subjected to vermicomposting than the control. Among the different concentration of sago-sludge, the fold in increase of phosphorus was higher for 50% followed by 75% and 100%. The phosphorus content of the compost increased gradual from the initial value of 14, 9 and 1 mg kg^{-1} to 36, 31 and 25 mg kg^{-1} for vermicomposting and 28, 20 and 16 mg kg^{-1} for 50, 70 and 100% control, respectively. From the above it is clearly known that the presence of bedding material is very essential for the composting and it helps in the growth of earthworm which is indirectly responsible for the increase in microbial population, nutrients and reduction of organic carbon in the compost, thus increasing the efficiency of composting (Nikita *et al*., 2007).

From the foregoing, earthworm biomanagement appears to be a viable option for managing sago-sludge. Biomanagement using earthworm, *Lampito mauritii* was enhanced with an addition of bedding material. Sago-sludge was found to be non toxic to the earthworm and amenable to composting. Further studies focus on the different earthworms; impacts of environmental factors on sago-sludge would help to evaluate the process and its application pave way for pilot scale experiment. Works on these aspects are in progress.

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