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Termigradation: Use of Termites in Solid Waste Management

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Abstract - *Composting and Vermicomposting, used at present for biodegradation is not capable of degrading lignin or 'hard' biowaste such as coconut shells, stems and branches of trees and fibrous materials like sugarcane baggase and coconut husk. 'Termigradation' denote termite-based biodegradation processes. The in-situ termigradation involves bringing 'termireactors' to the nature. The present work attempts to put the above mentioned idea of in situ termigradation into practice. The project will study the effectiveness of in-situ termigradation of different solid wastes which are ligneous in nature. The material selected here are primarily those make up the major share in garden waste or municipal street wastes. The rate of consumption of substrate will be monitored as a function of time. It has been observed that most of the ligneous wastes undergone termigradation must faster than the conventional processes. The substrate consumption in most of the termireacter was observed to be more than 50% for a period of 60 days.*

***Key Words*: Termites, Termigaradation, Ligneous waste, Termireactors, Solid waste Management**

1. INTRODUCTION

Termigradation refers to controlled use of termites to biodegrade ligneous and other types of 'hard' bio-wastes which resist composting and vermicomposting. The objective here is to find processes having virtues like inexpensiveness, simplicity of execution, and viability at varying scales. S A Abbasi's work in 2007 has reflected upon the possibility of harnessing termites as bioagents for solid waste management. The three families of animals which have been called 'soil engineers' because of the massive roll to turn huge masses of soil, transport it, mix it with organic material, facilitate its aeration and wetting, and prevent its pH from falling dangerously low, are: earthworms, ants, and termites[11]. Of the other two, and indeed of all the other conceivable bioagents, thought of exploring termites is due to the following factors: Termites are very efficient mineralizers of cellulosic waste and are among the very few animal species who have the ability to digest lignin. This becomes possible because 'lower' termites have cellulolytic flagellates living symbiotically in the termite gut which can digest lignin. The higher termites constitute 75% of all known termite species. They harbor diverse microbiota and have their own special enzymes, as also enzymes derived from symbiotic bacteria, which enable them to mineralize lignin[17].

Termites are voracious feeders; some species can consume every day food quantities several times their body weight. By their sheer numbers and persistence, termites can rapidly 'grind down' hard substances like coconut shells and husks, sugarcane baggase and other constituents of municipal solid waste like dry leave and twigs, which defy composting or vermicomposting. Termites, typically, have very high rate of reproduction as the queens of most species keep laying eggs by thousands every day. They also grow very fast as they are among the most efficient utilizers of food, generating very little excreta. Even what little excreta they generate, is by-and-large re-ingested [3]. Termites also play an important role in carbon turnover in the environment. In addition, they are potential sources of biochemical catalysts for attempts towards converting ligneous wastes into biofuels[18]. Indeed all the 'destructive' abilities of termites which have given them a bad image compared to the benign image the ants enjoy are the ones which, if harnessed properly, can be turned into a powerful biowaste treatment technology.

1.1 Objective of the study

The main objective of the study is to provide a proof for the concept that termites can be effectively used for the degradation of ligneous solid wastes. This concept can be used for the development of termi-reactors which can effectively replace the existing techniques for the treatment of ligneous solid wastes. Attempts have made towards in-*situ* development of 'bioengines', in the form of termirectors which can effectively degrade hard biomass such as lignin

The specific objectives are

- Development of in situ termireactors
- Study the degradation efficiency of termites
- To study time taken for the degradation of different ligneous solid wastes
- To Develop an alternate for municipal landfills
- To reduce the space requirement for municipal landfills
- To develop a faster technology for the degradation of hard wastes
- To study the various factors influencing the termigradation

2. METHODOLOGY

2.1 Solid Waste Collection

Different solid waste selected for the study are coconut husk, sugarcane baggase, coconut spathe bowls, softwood, dry leaves, Wood scrap, sawdust, cardboard and paper wastes. Sugarcane baggase was collected from the local sugarcane juice vendor. Wood scrap and sawdust was collected from a local furniture manufacturer. The rest of the wastes such as coconut tree wastes, tree twigs, dried leaves and paper wastes were collected from domestic wastes. The paper wastes selected are tissue paper and a mixture of newspaper and waste papers. Thus the waste materials studies comprises of both industrial and domestic waste materials.

2.2 Setting of in-situ Termireactor

Gurjeet Kaur et al. in 2014 conducted a systematic survey of termite species in Northeastern Puducherry which is part of peninsular India. According to the study, In all the reactors, *Hypotermes obscuriceps* was the termite species recorded. To assess the consumption of different solid waste constituents by termites, each constituent was kept in an in situ termireactor of rectangular shape, made up from thin aluminium sheets if it requires a holder. Else they are kept as such. Each of the termireactors was placed in a shallow pit, dug in the ground, or kept on plane ground, at a measured distance away from the termite mound. In each of the termireactors, 100 g (fresh weight) of the substrate was placed. The equivalent dry weight of each substrate was concurrently determined by oven-drying a known mass to a constant weight at 105°C. The substrates were moistened with tap water, to the extent that the contents become damp but not soggy. To protect the substrates from rainfall, direct sunlight, and disturbance by other animals, they were covered with polythene sheets. The covers were removed once in 2 days, to assess the termite action, to maintain adequate moisture content and to see if any interference of other soil macro fauna like ants was occurring.

After 30 days, the substrate remaining unconsumed by the termites was carefully removed from the termireactor. Care was taken to brush off any soil particles adhering to the surface of the residue. The residue was air dried for 24 hours and their weight is determined. Then the residue is again kept in the termireactors and the procedure is repeated for 45 days and 60 days. During the 60 days measurement, the residue was oven dried at 105°C to constant weight. The substrate remained unconsumed deducted from the initial dry weight of the materials will give the substrate consumed by the termites. It thus gives the measure of termigradability of the waste samples. The rate of consumption of the substrates was monitored as a function of time.

3. RESULTS AND DISCUSSION

The results obtained from the 'termigradation' of 10 different substrates is reported in terms of fraction of the substrate consumed (dry weight), is presented in Table 1. Different solid waste selected for the study are coconut husk, sugarcane baggase, coconut spathe bowls, softwood, dry leaves, Wood scrap, sawdust, cardboard and paper wastes. Sugarcane baggase was collected from the local sugarcane juice vendor. Wood scrap and sawdust was collected from a local furniture manufacturer. The rest of the wastes such as coconut tree wastes, tree twigs, dried leaves and paper wastes were collected from domestic wastes. The paper wastes selected are tissue paper and a mixture of newspaper and waste papers. Thus the waste materials studies comprises of both industrial and domestic waste materials.

Table -1: Percentage consumption of different substrates

Substrates	**Percentage (%) of substrates consumed**		
	30 days	**45 days**	**60 days**
Coconut husk	27	36	40
Sugarcane baggase	100	100	100
Mango tree twigs	68	74	86
Dried leaves	20	24	30
Tissue paper	47	52	60
Paper waste	40	48	55
Cardboard	38	40	44
Coconut spathe bowls	35	42	50
Wood scrap	50	65	90
Saw dust	80	88	95

The results show that not only ligneous material but other tough-to-degrade substrates like cardboard were also consumed by termites (up to 44%). Because of their resistance to biodegradation, cardboard pieces and dried leaves often are used as bulking agents in composting or vermicomposting. Moreover, substrates such as coconut husk and coconut spathe bowls, which resist bioprocessing during composting or vermicomposting, were also successfully consumed by termites. The studies thus confirm the potential of termites in processing ligneous and other 'hard' substances which defy composting, vermicomposting, and other forms of bacterial action in conventional solid waste management systems. The chart 1, 2 and 3 gives the average consumption of substrates in 30 days, 45 days, and 60 days respectively.

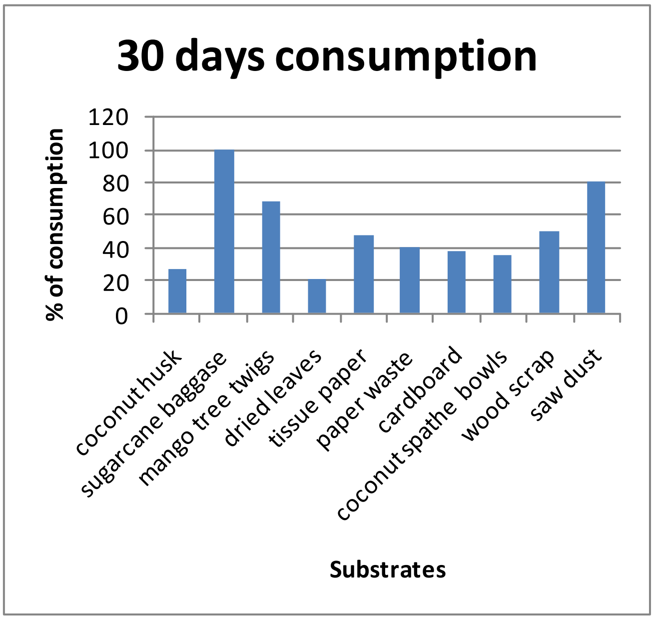

Chart -1: Average consumption of the substrates by termites in 30 days.

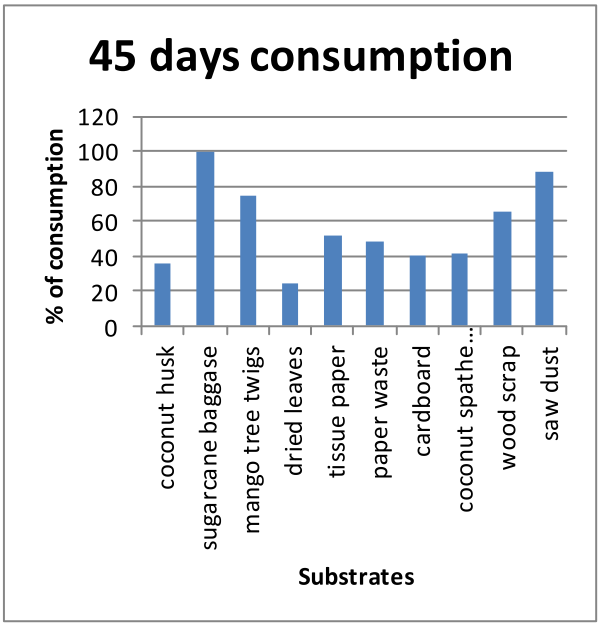

Chart -2: Average consumption of the substrates by termites in 45 days.

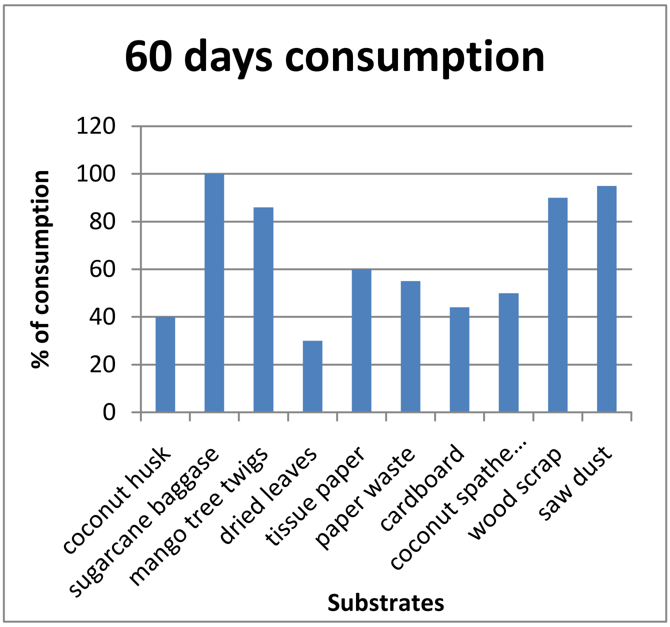

Chart -3: Average consumption of the substrates by termites in 60 days.

More than 50% consumption was observed by 60 days in substrates like sugar cane baggase, mango tree twigs, paper wastes, wood scrape and saw dust. Figure 1 shows scolonized termireactors during the course of the study. In case of sugarcane bagasse 100% consumption by termites are observed even before 30 days of observation.

Fig -1: Colonized sugarcane baggase after 30 days

The present study is based on the extent of substrate consumed and does not give any information on the quantity or the characteristics of termicast. The reason is that in contrast to vermicomposting where 50% to 60% of the substrate is converted to vermicast, termites produce no 'termicast'. This is because termites are extremely efficient utilizers of food due to the staggering diversity of the microflora present in their gut[18].

4. CONCLUSIONS

Based on this study it can be concluded that termigradation offers a viable solution to the present challenges in the management of igneous solid wastes. The studies provide a fairly convincing 'proof-of-concept' that termites can be used for the assimilative disposal of MSW. Termites are very efficient mineralizers of cellulosic waste and are among the very few animal species that have the ability to digest lignin. Termites are voracious feeders and their sheer numbers and persistence, can rapidly 'grind down' hard substances. They have very high rate of reproduction and are most efficient utilizers of food, generating very little excreta. In this project the 'termigradability' and the compost-ability of 10 different substrates were studied in terms of fraction of the substrate consumed as dry weight basis for a period of 60 days. The decomposition observed in termireactors was fairly high for different hard ligneous wastes. 100% degradation was observed in case of sugarcane baggase. Other materials such as mango tree twigs, wood scrap and saw dust had a consumption rate of 86%, 90% and 95% respectively. Another notable observation is in the case of cardboard a tough-to-degrade substrate was consumed by termites (up to 44%). Coconut husk and coconut spathe bowls had a consumption rate of 40% and 50% respectively. Even the paper wastes had a degradation rate of more than 50%.

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