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LABORATORY STUDIES ON CONVERSION OF BIOMASS INTO ENERGY SOURCE USING EFFECTIVE MICROORGANISIM

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ABSTRACT

Biomass generation, treatment and disposal are both economic and environmental problem of concern for the urban communities, especially in fast population exploding countries like India. Biomass is the constitution of all plants, broken branches, Residues of agriculture wastes like rice husk, straw, leaves, sugar cane, etc., forest leaves, broken branches, wood chipping, timber mill residues, water hyacinth, algae, dropping of birds, animals, industrial wastes from food processing, sugar industries, slaughter house, meat packing plants, tanneries, etc., municipal wastes solid waste, sewage treatment plant sludge, etc., The present study deals the sources, treatment and strategies for future management of biomass. In this study a detailed analysis of the quantification, characterization and leachate analysis of the biomass from JCT campus and developed a procedure for conversion of compost from biomass using simple and inexpensive equipment of the type commonly available in the urban and rural households. Further, a lab scale biomass reactor and produce vermicompost using earthworm has developed and performance analysis of biomass were analysed. During the study, necessary convention techniques and analysis of the wastes had been undertaken. Similarly, the model prototype of the reactor and performance were evolved with necessary recommendations incorporated in the study.

Keywords: Biomass, Reactor, EM solution, pH meter and Thermometer.

I. INTRODUCTION

Biomass generation, treatment and disposal are both economic and environmental problem of concern for the urban communities, especially in fast population exploding countries like India. The growth of biomass in our urban centers has outpaced the population growth in recent years. This trend can be ascribed for our changing lifestyles, food habits, and change in living standards. Biomass in cities are collected by respective municipalities and transported to designated disposal sites, which are normally low lying areas on the outskirts of the city. The limited revenues embarked for the municipalities make them ill equipped to provide for high costs involved in the collection, storage, treatment, and proper disposal of biomass. The insanitary methods

adopted for disposal of solid wastes is, therefore, a serious health concern. The poorly maintained landfill sites are prone to groundwater contamination because of leachate production. Open dumping of garbage facilitates the breeding of disease vectors such as flies, mosquitoes, cockroaches, rats, and other pests (CPCB 2008).

Biomass is increasing steadily during the recent days. Conventional handling of biomass poses serious environmental and public health concerns since large numbers of the landfills in India are not well engineered. Due to these problems, sound and sustainable methods of solid waste management have been sought by central and regional policy makers. Waste to energy schemes which provide energy in the forms of heat and/or electricity as by products are regarded sustainable.

1.1 Landfill Leachate

Among the reactions that occur in sanitary landfill, the leachate generation from the landfill is important as the leachate has extracted dissolved or suspended materials from the biomass. The production of leachate from a landfill site depends on (1) the initial moisture content, (2) the volume of rainfall allowed to enter the landfill, (3) the volume of other liquids deliberately added to the refuse, (4) waste composition and density (Daniele Bila.M et al., 2005). Among them there are some important compositions meant for consideration as shown in table 1.

1.2 Verimicompost

Vermicomposting is a simple biotechnical process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product. Vermicomposting differs from composting in several ways. It is a mesophilic process, utilizing microorganisms and earthworms that are active at 10-32°C (not ambient temperature but temperature within the pile of moist organic material). The process is faster than composting because the material passes through the earthworm gut, a significant but not yet fully understood transformation takes place, whereby the resulting earthworm castings (worm manure) are rich in microbial activity and plant growth regulators, and prepared with pest repellence attributes as well in short, earthworms, through a type of biological alchemy, are capable of transforming garbage into ‘black gold’ (Thankavel.k et al., 2002).

Table.1 Chemical composition of leachate from a landfill

S.No	Constituents	Composition range (mg/L)
1.	pH	3.7-8.5
2.	Alkalinity($CaCO_3$)	730-9500
3.	Chloride	47-2400
4.	Calcium	240-2330
5.	Hardness	200-7600
6.	Nitrogen	2.6-945
7.	Ammonia	0.22-465
8.	Potassium	28-1700
9.	Phosphate	0.3-130
10.	Sodium	85-3800
11.	Magnesium	64-410
12.	Total residue	1000-45000
13.	Sulphate	20-730
14.	Copper	0.1-9
15.	Nickel	0.01-0.8
16.	Zinc	0.03-135
17.	Iron	0.1-1700
18.	BOD	21700-30300
19.	COD	100-51000

II. MATERIALS AND METHODS

The biomass is collected in various sources and is segregated to non biodegradable and plastic free nature. It is sundried for few hours so as to get odour free and shredded to small fraction so that it can be readily taken up in to the reactor. There are two types of treatments by which the biomass can be converted into energy sources. One is aerobic and another is anaerobic. In anaerobic technique, the biomass is converted into liquid state and then converted into energy source as methane gas adopting biomethanisation principle, by aerobic method; the biomass can be converted into compost, using aeration technique. Plain compost and vermicompost shall be employed in this purpose. There are two types in aerobic, they are (1) Natural aeration, (2) Forced aeration.

2.1 Household Model

A household model is developed for vermicompost which would be very much useful for the disposal of biomass generating at household level itself and the application of the model would pay way for any needy place so that the pollution load can be eliminated at the source itself. It consists of a cylinder, half cutted, made of fibre, fitted over a MS angle stand to a height of 2 to 3". The bottom is circular nature with a gentle slope to one side and a hole of 5cm diameter is provided to drain the excess water collecting at the bottom. The hole is concealed with a perforated mesh of small holes, water collected at the bottom can drain and also no rats or snakes can enter from the bottom to eat up the earth worms.

The bottom is filled with packing materials like broken bricks to a height of 10 to 15 cm and the subsequent layer comprising of coir pith, shredded coconut shell, leaves is laid. The third layer is provided with soil bed with cow dung upon which the biomass is spreading every day or any time of generation. Water is sprinkled to keep the moisture content to the optimum. Earthworms of selective species are put into the reactor. The reactor

is covered with a lid of MS weld mesh cover with an opening arrangement to avoid entry of any foreign materials like birds, snake, rats, etc.,

2.2 Operation of the Model

It is simple to operate as the biomass collected from the house can be directly spread over the model. Water is sprinkled over the biomass randomly keep the mass in a semi weathered condition. Activated Effective Microorganism solution is added at the rate of 5ml/kg of feed waste. Since the top cover is open aeration is maintained without any hurdle. Earthworms will eat the biomass and go back into the soil cover and does not appear on the above surface. After some time the vermi cast can be manually collected and dried outside and used as manure.

2.3 Effective Microorganism

While converting the biomass of biodegradable matters, aeration is done by several methods such as wind row by turning the waste matters in a routine time interval for sufficient time. Depends upon the place where the reactor is kept, sometimes some odour may occur. In order to avoid the foul odour and also to speed up the reactor of the composting process, a specially derived solution called Effective Microorganism (EM) is being sprayed. The activated Effective Microorganism solution over the biomass will enhance the decomposition of the waste matter into composts on a faster rate, as the EM contains as many consortiums of microorganisms. The characteristic of the EM solution is shown in table 2.

Table.2 Characteristics of Effective Microorganism

S.No	Microorganism	Concentration
1.	Bacillus species	25%
2.	Pseudomonas striata	25%
3.	Pseudomonas fluorescence	25%
4.	Trichodermavilide	25%
5.	Fermented Broth	99%
6.	Preservatives	1%

2.4 Preparation of activated EM Solution

The EM is available in a dormant state and it requires activation before application. 1 liters of chlorine free water and 40gm of brown sugar are added with 4 ml of dormant EM kept in a plastic container for one week. After the activated period of one week it is stored in a minimal temperature and this activated EM is ready for application in treatment units. pH is determining factor and the EM is kept approximately to 4.5 pH.

2.5 Biomass Materials

Different organic wastes including industrial wastes can be processed for vermicompost. Effective Microorganisms are introduced to enhance the speed of the process. In this study biomass including solid wastes producing from households, vegetable wastes and fruit wastes are also added to enhance the volume. The initial characteristics of the biomass are shown in table 3.

Table.3 Initial characteristics of biomass		
S.No	**Parameters**	**Biomass values (%)**
1.	Nitrogen	0.59
2.	Phosphorus	0.30
3.	Potassium	0.40
4.	Magnesium	0.10
5.	Total solids	61
6.	Volatile solids	55
7.	pH	6.4
8.	Carbon	25.5
9.	Chloride	0.7
10.	Sulphate	0.1
11.	COD (mg/L)	650

2.6 Factors Affecting the Vermi Composting Process

There are several factors controlling the process of which the most important are

1. Aeration

Overfeeding, surplus moisture, poor bin design and poor ventilation can severely reduce the amount of air available to the worms. If there is a foul smell in the bin it may indicate the presence of large number of aerobic bacteria. Hence there should be enough ventilation and drainage holes in the bin. Oxygen is notably required for aerobic metabolism that may be present. During composting the oxygen consumption is directly proportional to the microbial activity with maximum oxygen consumption rate occurring at temperature between 20 to 30ºC.

2. Earthworm Density

Higher densities will increase the rate of vermicompost production. The density of earthworms in any vermicomposting process is related to the nutritional value of the biomass being processed and the processing temperature.

3. Nature of Biomass

One of the most important factors that control the establishment and continuity of earthworm population is food and its quality. Higher nitrogen ratio helps in faster growth and greater production of cocoons. Fresh wastage is not easily fed upon, decomposition by microbial activity is essential before worms can feed on fresh waste.

4. C/N Ratio

The Carbon-Nitrogen (C:N) ratio is the critical factor that limits earthworm populations. When the C:N ratio of the feed material increases it becomes difficult to extract enough nitrogen for tissue production. Materials with C:N ratios in the range 15:1 to 35:1 are considered to be suitable (Beulah Gnana Ananthi and Partheeban 2001).

5. Moisture

Moisture levels have to be maintained at around 40 to 50% so that microbial activity is high and food matter is easy to feed upon. Excess water leads to anaerobic conditions, which in turn lowers the pH and creates acidic

condition. Acidic conditions reduce productivity and causes migration (Yasir Ahmed and Renu Bhargava, 2005).

6. Temperature

The temperature should be between 20 to 30°C. Temperature affects metabolism, growth and reproduction. Temperatures in excess of 30 to 35°C are lethal to earth worms. Earth worms maintain lower body temperatures than the surrounding organic matter by their metabolic arrangements.

7. Light

Earthworms are very sensitive to light. The photo receptor cells detect light and the worm moves away in order to avoid strong light.

8. Hydrogen ion concentration (pH)

Worms are sensitive to change in pH and hence they prefer neutral condition. The acid or alkaline waste used in vermicomposting provided the waste pH in the range of 5 to 9 appears not to significantly affect the growth and reproduction of worms. The lowered pH in the medium hinders the normal activities of the worms, leading to weight loss and decline in population (Rao.K.S et al., 2002).

III. RESULTS AND DISCUSSION

Vermicomposting of the biomass samples collected from various sources is feed to the reactor. The result of the composition of the waste were analyzed at 1^{st}, 21^{st} and 40^{th} day for the samples for the parameters carbon, Nitrogen, Phosphorous, Potassium and pH values. The C/N ratio values are noted and discussed in the given table 5.

3.1 Parameters Maintained

In the vermicompost, pH, temperature and moisture content have major influence on worms during decomposition. (1) The pH range of 6.5-7.5 has been maintained, (2) A temperature value of 24ºC to 27ºC has been maintained, (3) A moisture content range of 45-55% has been maintained. Therefore all the above three parameters are measured before and worms are introduced after 15 days of partial decomposition of the wastes.

Table 4. Characteristics of biomass on various parameters

S.No	Parameters	Ranges (mg/L)
1.	Total Solids (gm/kg)	250 – 270
2.	Total Volatile Solids (gm/kg)	140– 150
3.	pH	6.5 – 7.5
4.	Total VFA (mg/L)	1000 – 1200
5.	Total COD (gm O_2/kg)	180 – 200
6.	Moisture content	55– 60
7.	C/N ratio	30– 34

3.2 Chemical Composition of Composting

The biomass waste collected are crushed and formed into slurry and mixed with 750ml of water and mixed with 250 ml of cow dung and 5 ml of activated EM solution is added and sprinkled over the reactor. The chemical

composition is measured after 2nd, 20th and 40th day for the parameters carbon, nitrogen, phosphorous, Potassium. The results are tabulated as shown in table 5.

3.3 Test of 21st day and 40th day

The four different samples are collected and sprayed on the reactor with 750ml of water to maintained moisture content every day. At the end of 21st day and 40th day samples are collected from the reactor, and analyzed for the chemical compositions for C, N, P, K and pH. The 21st day samples are tabulated as shown in table 5.

Table.5 Chemical composition of the wastes on the 2nd day

Si.No	Carbon	Nitrogen	Phosphorous	Potassium	pH
1.	55	2.8	1.4	1.4	2.7
2.	54	2.6	1.3	1.2	2.8
3.	53	2.7	1.2	1.3	3.0
4.	57	2.5	1.5	1.5	2.6
Chemical composition of the wastes on the 20th day					
Si.No	**Carbon**	**Nitrogen**	**Phosphorous**	**Potassium**	**pH**
1.	40	2.2	1.0	0.8	4.5
2.	43	1.9	1.2	1.1	5.0
3.	39	2.4	0.9	1.0	4.1
4.	47	2.0	1.3	0.9	5.2
Chemical composition of the wastes on the 40th day					
Si.No	**Carbon**	**Nitrogen**	**Phosphorous**	**Potassium**	**pH**
1.	18	1.2	0.7	0.7	6.2
2.	22	1.4	1.0	0.8	5.9
3.	26	0.9	0.8	0.5	6.1
4.	21	1.3	1.1	0.6	6.0

3.4 C/N Ratio

From the values obtained from the results of the chemical composition of the wastes from 2nd, 20th and 40th days are calculated and tabulated as furnished below

Table.6 C/N ratio of the biomass

Si.No	Samples	2nd day	20th day	40th day
1.	Sample 1	19.64	18.18	15.0
2.	Sample 2	20.77	22.63	15.7
3.	Sample 3	19.63	16.25	28.89
4.	Sample 4	22.80	23.5	16.15

From the above table it is evident that the C/N ratio has been accorded between 15 to 30 (preferably between 15 to 35), which is the required standard for good manure. The Carbon nitrogen on the 2nd day is higher and it is

decreasing subsequently with time. This is because of the loss of organic carbon bacteria. The end product in aerobic decomposition of organic matter is CO_2 and water.

IV. CONCLUSION

The biomass and other wastes can be converted into useful products namely vermicompost. In any way, the wastes are converted into useful products and thereby the pollution load is very much minimized, else as many health hazards will be enumerates and put the public into ill health. During the study, necessary convention techniques and analysis of the wastes has been under taken. Similarly, a model prototype of reactor and performance were evolved. The compost and vermin compost analysis will be undertaken by appropriate techniques. The usefulness of the products were tested by feeding them to the plants and socio economic analysis has conducted among the groups during the study period, which is on the positive side and also an easily maintainable one.

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