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# Sequels of Adding Bulking Agents on the Aerobic Bio-Drying Process of Municipal Solid Waste

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***Abstract***

*In recent years, the generation of Municipal Solid Waste (MSW) in India is increasing due to rapid social development. Various adapted treatment technologies for MSW are critically reviewed, along with their advantages and limitations. Combustion is an effective MSW treatment option that stabilizes waste and maximizes the reduction of waste volume, and contributes to energy recovery. However, many wastes to energy (WTE) plants in India are not operating to their full potential, the reason for which is the MSW in India has low calorific value and high moisture content. Most wastes sent to the WTE plants are unsegregated and also have high inert content. These wastes are just not suitable for burning in WTE plants. To burn them, additional fuel is required, thus making the plants expensive to run. This study applies Aerobic Bio-drying with bulking agents involving four trial samples to determine the reduction in the MSW sample's moisture content, making it suitable for energy recovery. The results of this study enabled us to know that the extent of water removal was highest in the reactor containing corn stalk in 28 days, along with the reduction in the production of leachate and odor.*

**Keywords** -*Municipal Solid Waste (MSW), Energy recovery, Combustion, Calorific value, Bio-drying, Bulking agent, leachate*

## I. INTRODUCTION

The term municipal solid waste (MSW) describes most of the non-toxic solid waste from a city, locality, or an urban area that requires periodic management. Sources of MSW include residential areas, commercial establishments and institutions, and industrial facilities, containing more toxic and require special treatment. These wastes also have a specified range of moisture content, which is defined as the ratio of the weight of water (wet weight- dry weight) to the total wet weight of the waste. Incineration is the combustion of waste in the presence of oxygen so that the waste is converted into carbon dioxide, water vapor, and ash. Waste-to-energy (WTE) or energy-from-waste (EFW) is the process of yielding energy in the form of electricity and/or heat by the initial treatment of waste. Aeration is a unit process in which air and solid waste are brought into intimate contact. Although aeration imparted a slight decrease in the moisture content, it engendered lower leachate production, much lower methane concentration, and a more significant decrease in organic matter contents in organic solid waste and leachate. Aerobic Bio-drying technology aims towards removing water by microbial activity, is regarded as the right solution for reducing the water content of wet organic waste. It is always necessary to add a bulking agent to modify the properties of MSW during composting or bio-drying because of high moisture content and low C/N ratio. Cornstalks, rice or wheat straw, sawdust or wood chips, wood peat, leaves, and yard waste are economical waste materials with rich carbon source and suitable to be used as a bulking agent. The significant advantage of the bio-drying process ate mass waste reduction, reduction of $CH_4, CO_2, SO_2, NO_x$ emission and dust emissions from waste landfills into the atmosphere. Many studies have revealed that bio drying affects the content of organic matter, the chemical composition and calorific values of solid waste. This method is environmentally friendly compared with high-cost treatment technologies and a sustainable way of waste management.

## II. SCOPE AND OBJECTIVES

Improper management of MSW will pose several environmental problems and human health effects. The addition of a bulking agent is to reduce the moisture content, making it suitable for WTE conversion. This will have an excellent effect in reducing the emission of Greenhouse gases, eliminating foul odor, and preventing leachate generation. The main objective of this study is conducting trials to check the reduction in moisture content by the addition of a bulking agent, record the temperature changes, and to check the odor, leachate production.

## III. MATERIALS AND METHODS

### *A. Methodology*

The process of bio drying is useful in developing countries facilitating the disposal of MSW and energy recovery. The previous studies examined and analyzed the current status of bio drying and the use of bulking agents and ideas to improve them further.

- *Reconnaissance Survey*
- *Sample Collection and Collection of selected Bulking Agents*
- *Experimental Setup& Periodic Monitoring*
- *Analysis & Comparison of Results after 28 days of test period*
- *Discussion*

### *B. Study Area*

The management of municipal solid waste is a statutory function of the Madurai Corporation. The Municipal Solid Waste mainly includes waste from residential, institutional, commercial establishments, and industries in the town. The public health department of the corporation, lead by the City Health Officer and Assistant Health Officer, should organize the Solid Waste Management in the city. For dynamic administration and day-to-day operational purposes, the town is divided into 4 Zones covering all the 100 Municipal Wards.

In Madurai City, garbage is generated at 406 grams per day per head, piling up to a massive quantum of 548 Metric Ton per day. Additionally, studies have been carried out to scrutinize the pattern of waste generation and collection at the municipality-level. Although Table 1 indicates 450 tons per day of waste generation, the measure of 450 tons per day has been presumed as the ideal generation of waste, though there will be an increase due to 100% coverage of street sweeping and which would not have any dire impact on waste processing activities since street sweeping contains mostly inert materials.

**Table 1 Vital features of solid waste generated in Madurai Corporation**

| Description | Details |
|---|---|
| Per Capita waste generated (kg/day) | 0.382 |
| Waste generated per day- approx. (MT) | 450.00 |
| Waste collected per day- approx. (MT) | 400.00 |
| Biodegradable waste (% of total waste) | 70% |
| Non-biodegradable waste | 50 to 45% |

**Source:**
http://www.maduraicorporation.co.in/pdf/swmdpr.pdf

### *C. Sample Collection*

The samples required for the study were collected from the MSW plant at vellakkal, as shown in Fig. 2 in Madurai. Vellakkal is located at 9.8745° N, 78.1165° E. In 2004, a study of the waste characterization of solid waste had been conducted by Madurai Corporation; approximately 65.40% of waste is degradable, while the rest is Non-degradable (which mainly includes paper, plastic Gloss).

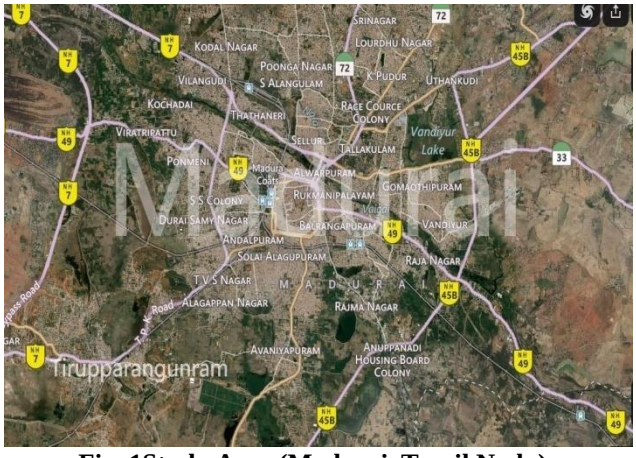


**Fig. 1Study Area (Madurai, Tamil Nadu)**


**Fig. 2 Vellakal (Municipal Solid Waste Management Plant, Madurai, Tamil Nadu)**

The waste samples sieved through 100mm screens were suitable for this study. It had a combination of biodegradable and non-biodegradable waste. We collected a sample of about 12kg for this study, as shown in Fig. 3.

**Fig. 3 Solid waste sample collected**

### *D. Bulking agents*

The aerobic bio-drying process enables the moisture from the waste to be drawn into the bulking agents, which are carbon-based material leaving a void volume in the waste, which allows smooth movement of air. It is generally accepted that bio drying using bulking agents can remove 30-80% of the water initially contained in the waste. Waste samples tend to have too high moisture content and inadequate structure for air space. Bulking agent gives the microbes space to expire. They are light in weight and have a low bulk density (typically less than 600 lbs per cubic yard).

Three bulking agents, namely (i) corn stalk, (ii) rice straw, and (iii) wood chips and sawdust, were chosen for this study.

#### *(i) Cornstalk*

Corn stack is a gramineous plant and is thick and robust. It is about 0.8-3m long and 2-4.5m wide

(diameter) with prominent nodes and internodes. An acre of soil can give rise to 400-500kg of dry corn stalks. It can be used as part of more environmentally friendly materials.

***(ii) Rice straw***

Rice straw is the vegetational part of the rice plant, cut at grain reap or later. It is a good source of energy but low in protein (2-7%), and its high silica content results in low digestibility. It is characterized by a typical composition of an agricultural-based lignocellulose residue. They have 64% cellulose with 63% crystalline cellulose, a strength of 450 MPa, elongation of 2.2%, and modulus similar to that of linen fibers and several minor organic compounds.

***(iii) Wood chips and sawdust***

Wood chips and sawdust has ash content generally less than 1% by weight, and ash also has a high melting point. Wood chips and sawdust are the usual bulking agent. The primary chemical constituents of sawdust are carbon (61%), hydrogen (5.20%), oxygen (33.82%), and nitrogen (approx. 1%). Dry wood contains cellulose, lignin, hemicelluloses, and a small amount (5-10%) of irrelevant materials as its primary constituents

## IV. EXPERIMENTAL SETUP

***A. Segregation of waste***

Waste segregation is the process of separation of waste into various elements. Waste sorting can occur manually at the household and collected by adopting curbside collection schemes or separated using automatic materials recovery facilities or mechanical biological treatment systems.

***B. Reactor setup***

The study involves four trials performed in a reactor of about 10L capacity (28.5 cm high, 25 cm inner diameter) was chosen for the experimental investigation. The reactors were made of stainless steel to minimize heat loss. The holes at the bottom of the reactor allowed the sample to be aerated and monitor the leachate generated.

Four aerobic bio-drying trials were conducted. The control treatment comprised 100% MSW without the addition of any bulking agent, and the other three contained 15% of one of the bulking agents (corn stalks, rice straw, wood chips &saw dust) and 85% MSW. Each reactor had about 2.5kg of MSW and three reactors with 375g of either of the bulking agent.

***C. Aerating the trial***

Aeration is a unit process in which air and solid waste are brought into intimate contact. Although aeration imparted a slight decrease in the moisture content, it engendered lower leachate production, much lower methane concentration, and a more significant decrease in organic matter contents in organic solid waste and leachate. In 28 days of investigation period for every 3 days, the four trials were subjected to regular turning for proper aeration.

***D. Determination of Moisture content***

Moisture content is the essential characteristic in landfill disposal and waste to energy conversion. This study mainly aims to determine the variations in moisture content in the waste sample after the addition of bulking agents, enabling us to determine the suitability of waste in energy production. The final moisture removal rates can be determined by drying methods using a hot air oven set at 105° C for about 10 hours. The check for moisture content was done in 4 trials on days 6, 15, 21, and 28.

***E. Determination of Temperature***

Similar to the process of composting organic materials, the aerobic bio-drying feedstock also changed temperature. The check for temperature was done 3 days once throughout a period of 28 days.

## V. RESULTS AND DISCUSSION

***A. Moisture content***

Table 2 represents the moisture content variation on days 6, 15, 21, and 28, respectively.

**Table 2 Moisture content on 6th, 15th, 21st, 28th day**

| Sample | MC on 6th day | MC on 15th day | MC on 21st day | MC on 28th day |
|---|---|---|---|---|
| **MSW** | 83.96% | 78.78% | 81.25% | 83.4% |
| **MSW+ corn stalk** | 73.61% | 68.05% | 58.51% | 49.31% |
| **MSW+ rice straw** | 81.35% | 69.78% | 68.20% | 60.72% |
| **MSW+ wood chips and saw dust** | 82.33% | 75.61% | 74.9% | 67.90% |

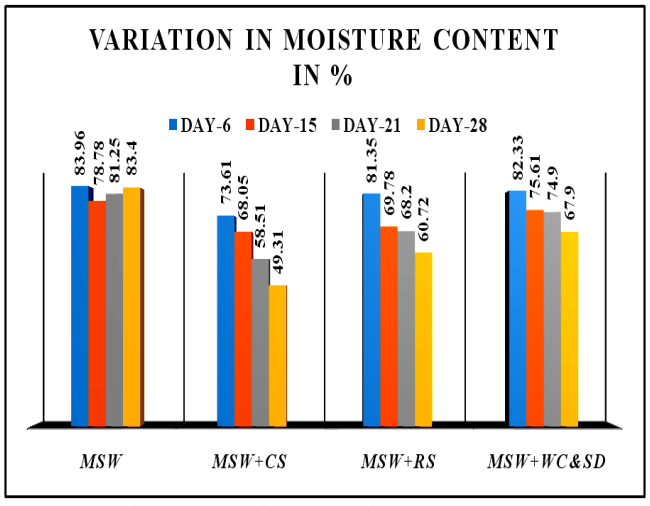


**Fig. 4 Variation in Moisture Content**

***B.Temperature***

On 1st day the temperature was maintained as room temperature, i.e., 30° C. The highest temperature was attained by corn stalk on day 6 measured from the bottom of the test reactor and on day 9 by wood chips and rice straw samples. Compared to MSW, the corn stalk, rice straw, and wood chips & sawdust showed higher temperature degradation. The results indicated that adding a bulking agent could create the advantage of microbial activity and promote volatile solids' degradation.

**Table 3 Temperature on 3rd, 6th, 9th, 12th, 15th, 18th, 21st, 24th, 27th day**

| DAYS | MSW (°C) | MSW + CS (°C) | MSW+ RS (°C) | MSW + WC&SD (°C) |
|---|---|---|---|---|
| 3 | 30 | 42 | 41 | 40 |
| 6 | 44 | 75 | 64 | 59 |
| 9 | 40 | 73 | 72 | 73 |
| 12 | 44 | 59 | 60 | 61 |
| 15 | 42 | 45 | 52 | 59 |
| 18 | 40 | 47 | 45 | 40 |
| 21 | 35 | 40 | 37 | 38 |
| 24 | 33 | 38 | 34 | 36 |
| 27 | 30 | 35 | 31 | 33 |

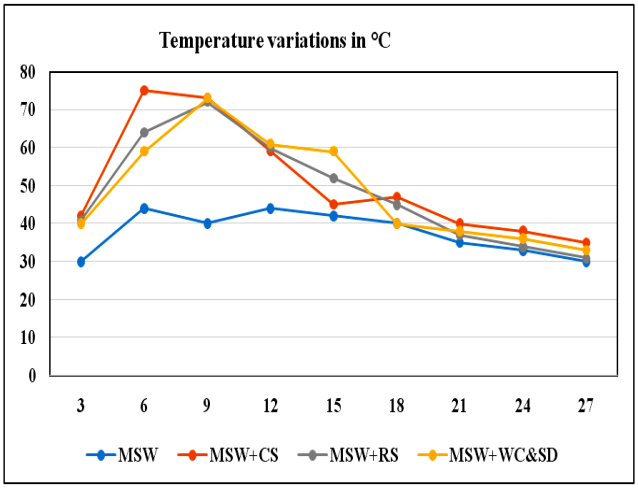


**Fig. 5Temperature Variation**

## V. CONCLUSION

Aerobic Bio-drying of MSW, besides bulking agents, effectively reduces the moisture content of solid waste. The addition of bulking agents achieved higher water removal in comparison with the reactor containing MSW. The best performance was achieved in the reactor having Corn Stalk as a bulking agent. The process of aerobic bio-drying using bulking agents reduced the production of leachate and odor in the reactors. At the end of 28 days, the moisture content reduction was 83.4%, 49.31%,60.72%, 69.70% for MSW, CS, RS, and WC treatments, respectively. This study enables to overcome the challenges in Solid Waste Management, enabling efficient disposal.

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