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"MOISTURE CONTENT REDUCTION IN REFUSE DERIVED FUEL: UNVEILING THE POTENTIAL OF BIO-DRYING REACTOR"

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Abstract
Municipal solid waste (MSW) poses significant challenges to environmental sustainability and public health on a global scale. The management of municipal solid waste in India continues to pose a persistent and significant challenge, marked by environmental issues that are further compounded by the immense quantities of waste generated each day. The economic feasibility of energy recovery in Municipal Solid Waste (MSW) management is mostly dependent on the moisture content within the waste. Before considering the extraction of valuable energy, it is imperative to meticulously explore all viable approaches for waste reduction, recycling, and recovery. Established Waste-to-Energy technologies encompass the recovery of energy in the form of heat or electricity. The potential for energy recovery is influenced by the moisture content, calorific value, characteristics and composition of the MSW. The high calorific value RDF can be attained by minimizing the moisture content present in the Municipal Solid Waste. Bio-drying technology offers a promising solution by addressing the moisture content of MSW and facilitating its transformation into a valuable resource like Refuse-Derived Fuel (RDF). This study aimed to assess the efficacy of bio-drying at different temperatures in reducing the moisture content of organic and bio-degradable MSW samples. The results clearly demonstrated the effectiveness of bio-drying, with higher temperatures yielding more substantial reductions in moisture content. These findings emphasize the considerable potential of bio-drying as a viable MSW management technology in the Indian context. Further research and process optimization are essential to explore the possibility of enhancing overall process efficiency. Additionally, comprehensive evaluation of the quality and characteristics of bio-dried waste, including calorific value and stability, would provide valuable insights for its potential integration into waste-to-energy conversion and resource recovery systems.

Key words: Municipal Solid Waste, Moisture Content, Calorific Value, Bio-drying

Introduction
The total quantity of solid waste generated in India during 2020-2021 was 160,038.9 tonnes per day (TPD) (6). In India, the projected increase in MSW generation to 260,000 tonnes per day (TPD) by 2030 underscores the urgency for effective waste management strategies (1). The total quantity of solid waste generated in India during 2020-2021 was 160,038.9 tonnes per day (TPD) (6). Of this, 152,749.5 TPD was collected at a collection efficiency of 95.4%. 79,956.3 TPD (50%) of waste was treated and 29,427.2 TPD (18.4%) was landfilled. 50,655.4 TPD which is 31.7% of the total waste generated remains un-accounted. Municipal Solid Waste (MSW) encompasses two distinct categories: wet waste and dry waste, each characterized by unique physical properties and characteristics. Wet waste, also known as organic waste or biodegradable waste, primarily comprises food scraps, fruit and vegetable peels, leftovers, tea bags, coffee grounds, and similar materials. In contrast, dry waste consists of non-biodegradable and non-organic substances that undergo minimal decomposition. This category

encompasses items like paper, cardboard, plastic containers, glass bottles, metal cans, textiles, and packaging materials. Dry waste generally contains less moisture compared to wet waste and can be effectively processed through sorting, shredding, and baling for recycling, reuse, or energy recovery purposes. According to the Swachh Bharat Mission, the moisture content in municipal solid waste (MSW) in India is typically between 40% - 60% (2). The drying process for MSW will take a few days to several weeks, depending on a number of factors, including the method of drying used, the moisture content and composition of the waste. This range includes the time needed for initial drying, intermediate moisture reduction, and final moisture stabilization to achieve the desired moisture content suitable for Refuse – Derived Fuel (RDF) production (3). Drying of municipal solid waste (MSW) plays a significant role in the production of RDF, a type of fuel derived from non-recyclable MSW (4). The drying process is typically employed to reduce the moisture content of MSW, which enhances the calorific value and combustibility of the waste material along with the process efficiency and effectiveness of downstream processes (5).

The production of RDF involves, sorting of non-organic waste such as metals, glass and plastics etc., from the municipal solid waste and the remaining waste is shredded, dried and subjected to processing, resulting in the creation of a fuel that possesses a greater energy content.

Methodology

The bio-drying of the Municipal Solid Waste (MSW) was carried out in prototype reactor consisting of a feeding compartment with a diameter of 460 mm and a depth of 600 mm. It also includes 2 x 2 kW thermal coils, a thermocouple, two rotary arms connected to the main shaft at an angle of 45°, and a leachate collection system (9). The main shaft of the bioreactor is connected to a half HP motor with a gear box. The thermocouple employed in the bioreactor has the capability to measure temperatures across a broad range, specifically from 30°C to 90°C. It is composed of two dissimilar metal wires that are connected together at one end. The other ends of the wires are connected to a controller and gear box. This setup allows for temperature monitoring throughout the bio-drying process (10).

The bio-drying of the shredded waste in a controlled environment and elevated temperature not only accelerates the decomposition of organic compounds but also contributes to the elimination of pathogens and odour causing agents (8). The RDF feedstock which is having size greater than 70 mm is fed into the bio drying feeding chamber (11). The waste is feed into the drying chamber in a controlled and consistent manner, typically through manual feeding method (12). The drying chamber is made of durable, heat-resistant materials and is designed to maintain specific temperature and moisture conditions to optimize the drying process, which reduces volume and moisture content. The elevated temperatures within the reactor accelerate the drying process and promote the decomposition of organic matter. The control systems ensure that the desired temperature range is maintained throughout the process. High-quality RDF is produced in the lowest possible detention time and increases the energy content by removing the moisture content (13).

Once the bio-drying process is complete, the dried waste, is removed from the reactor manually. The samples were sent to the laboratory for conducting tests to acquire the corresponding results.

Results and discussions

The study encompassed collection of samples from the feeding chamber after the bio-drying process at different temperatures. After the bio-drying process, the final moisture content of the samples was determined. The results indicated that sample one has shown a substantial decrease in percentage of moisture content 38.84% at 40°C. Similarly, sample two exhibited a notable reduction of 42.66% at 50°C, while sample three experienced a significant decrease of 44.45% at 60°C. Notably, sample four had the lowest percentage of moisture content decrease, with a reduction of 59.57% at 70°C. **Figure 1.** illustrate the relationship between the temperature and corresponding final moisture content of the sample and **Figure 2.** represents the trend of moisture content for the final samples.

Figure 1. Temperature vs Moisture

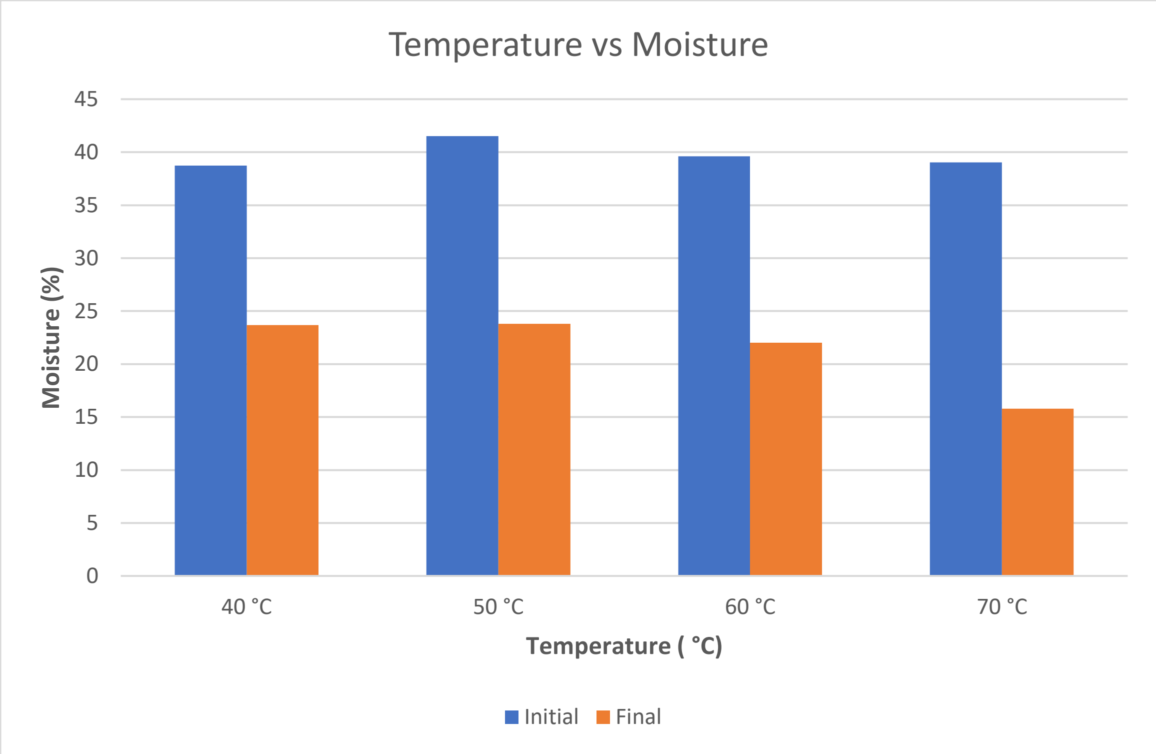
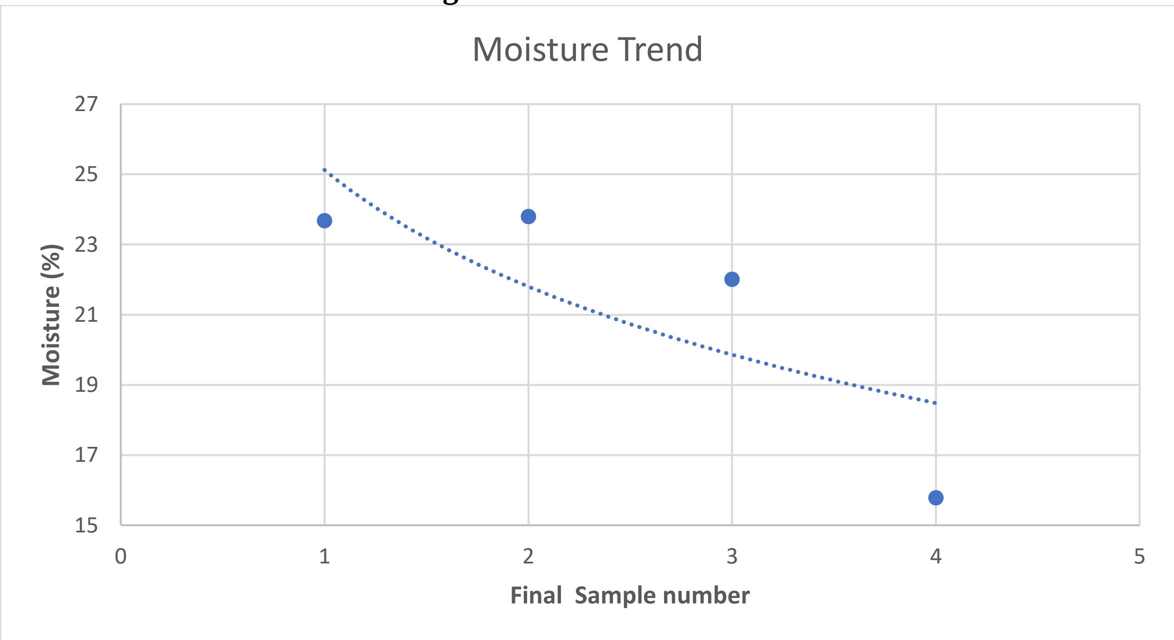


Figure 2. Moisture Trend



The bio-drying process at varying temperatures demonstrated a significant reduction in the moisture content of the municipal solid waste samples. Higher temperatures led to more substantial reductions in moisture content, indicating the effectiveness of the bio-drying process in removing moisture from the waste material (14).

The RDF has reduced moisture content making it suitable for use as a fuel (13). One of the key advantages of bio-drying is its ability to transform MSW into a high-calorific value fuel. The RDF produced through bio-drying has an increased energy content, making it a valuable resource for energy recovery in waste-to-energy facilities (7).

The findings highlight the potential of bio-drying as a viable technology for managing municipal solid waste (15). Moreover, the bio-drying process can contribute to waste volume reduction and minimize the environmental impact associated with waste disposal (15).

Further research and optimization of the bio-drying process need to be explored to realize the potential of achieving even lower moisture content, leading to enhanced overall process efficiency. Additionally, assessing the quality and characteristics of the bio-dried waste, including factors such as calorific value and stability, will provide valuable insights for potential applications in waste-to-energy conversion and resource recovery.

These investigations will play a significant role in advancing the field and unleashing the complete potential of bio-drying as a sustainable waste management solution.

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