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PRODUCTION AND EVALUATION OF BRIQUETTES FROM MIXED ORGANIC FRACTIONS AND PLASTIC WASTE STREAMS

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Abstract

The most critical challenge of today's world is the accumulation of plastic waste. The traditional solid waste management methods including landfilling and incineration have resulted the greenhouse gas emissions and economic loss. The production of briquettes from mixed organic fractions of municipal solid waste and plastic waste streams is an economically, as well as environmentally sustainable way leading to end plastic pollution in developing countries. This study explores the production and evaluation of briquettes by mixing organic fractions including fruit, vegetable, cardboard, paper and plastic waste streams at different mixing rations. Six samples of briquettes were made by using single briquette manually operated machine and finally were examined for their calorific value based upon proximate analysis of waste streams. Results revealed a strong correlation between plastic content and calorific value. The sample containing the highest proportion of plastic waste stream showed the maximum calorific value ranging from 3228 to 3723 kcal/kg. The findings support a circular approach to waste management, offering a sustainable pathway to reduce landfill dependency as well as to end plastic pollution leading to mitigating climate change.

Keywords: Organic fractions, Plastic waste, Briquette

1. Introduction

The most critical and significant issue of today's world is the generation and accumulation of plastic waste in an open environment. The most environmental concern has been generated because of the global proliferation of plastic waste. The world produces more than 400 million tons of plastics every year which is more contributed by 36% packaging (the largest contributor to the plastic waste problem is single use plastic packaging designed for immediate disposal), Electrical/electronic (4%), building & construction (16%), transportation (7%), consumer & institution

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products (10%), industrial machinery (1%), textiles (14%), and other (12%) as reported by United Nation Environment Program (UNEP, 2018). The amount of single-use plastic waste is generated per person per kilogram by Australia, United States, South Korea, United Kingdom, Japan, France, Spain, Germany, China, and India as 59, 53, 44, 37, 36, 34, 22, 18 and 4 respectively (The Mindaroo Foundation, 2019). According to the study of Guardian, (2025), only 9.5% of the 400 million tons of produced plastic is recycled in 2022. The same study reported that the dependency on the usage of exhaustible energy resources exacerbates environmental degradation and underscores the inefficiency in the present recycling system. Pakistan ranks 6th and 3rd among plastic waste generators in the world and Asia, respectively. Three major sources of plastic waste in Pakistan include rejected fractions from industries, municipal solid waste produced in urban centers, and agricultural sector with contribution percentages of 16, 21, and 63% respectively. The organic wastes including fruit waste, vegetable waste, paper waste, cardboard waste etc., constitute a significant portion of municipal solid waste.

The improper management of organic waste and plastic waste streams generate greenhouse gases and other environmental issues including water pollution, soil pollution, air pollution etc. Instead of increasing awareness as well as many efforts, plastic waste along with other wastes generation continue to escalate with projections showing that the improper management of plastic waste could double to 121 million tons by 2050 in case of current practices of waste management (Guardian, 2024). Moreover, the plastic waste impacts include air pollution, respiratory disease from burning of plastic waste, revenue loss from failure to recycle plastic waste, marine pollution, soil pollution, etc. The commonly used traditional waste management methods including landfilling and incineration are insufficient and often environmental concern exists because of emission from these methods.

There is the need of time to unlock more innovative and sustainable ways that not only mitigate waste pollution but also explore the hidden energy potential of solid waste materials. Additionally, integrating organic fractions of municipal solid waste and plastic waste streams into value added products presents an opportunity to mitigate multiple environmental as well as socio-economic challenges simultaneously. Briquetting is a process of compressing waste streams into solid fuel blocks also called refused

derived fuel (RDF) which is a sustainable solution of plastic pollution. The conversion of plastic waste along with other waste steams into briquettes accelerates their calorific value and is used as efficient alternative fuels according to previous studies. The literature highlights that incorporating 10% plastic waste into briquettes can enhance the calorific value by up to 40% and double the comprehensive strength as reported by (Ab Jalil et al., 2022). Briquetting does not only divert organic and plastic waste streams from landfilling but also generates fuel having high calorific value, leading to contribute to a circular economy. Moreover, this process aligns with global efforts to reduce the dependency on fossil fuels and mitigate climate change impact (Guardian, 2025). In the light of these facts and figures, this study was conducted by focusing on the development of briquette using various proportions of organic and plastic waste streams. Moreover, this research seeks to provide a sustainable pathway for waste valorization.

2. Research Materials and Methods

In this study, two waste streams including mixed organic fractions of municipal solid waste (Mix-OFMSW) and plastic waste were selected. The Mix-OFMSW including fruit waste, vegetables waste, paper waste, and cardboard waste was collected from local markets as well as households. Whereas plastic waste streams such as polyethylene and polypropylene were taken from MSW stream. All selected waste streams were shredded up to 10mm to ensure homogeneity and sun-dried to reduce moisture content below 15% as recommended for achieving optimum briquette quality (Ab Jalil et al., 2022). Six different mixtures were prepared by varying plastic waste contents such as 0%, 10%, 20%, 30%, 40% and 50% by weight. The prepared mixture was blended and compressed by using a manual briquetting machine to convert into cylindrical shape of briquettes. The proximate analysis which includes moisture content (MC%), total solids (TS%), volatile solids (VS%) and ash contents (AC%) were determined by using oven dry and muffle furnace at 105ºC and 550ºC respectively. Whereas the ultimate analysis which includes carbon contents (CC%) hydrogen contents (HC%), nitrogen contents (NC%), oxygen contents (OC%), Sulphur contents (SC%), of waste streams were taken from previous studies. The calorific value (CV) of prepared briquettes was theoretically determined by using the following formula based upon the results of proximate analysis (Hani et al., 2000).

$$CV = 45B - 6W$$

Where CV is calorific value in kcal/kg, B is VS% and W is MC%. All experimental work was performed in triplicate to ensure the stability of results by following various stages of practical work as mentioned in following Figure-1.

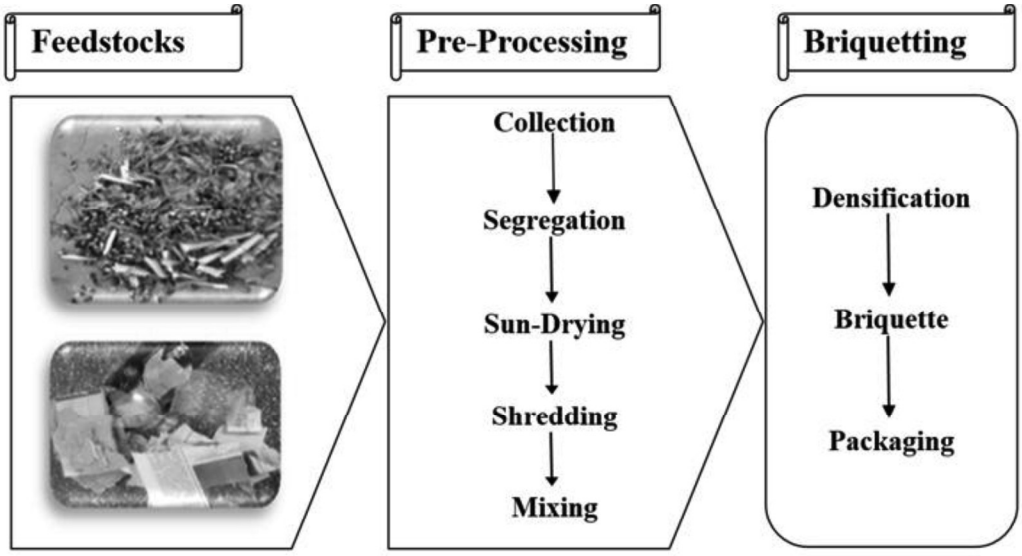


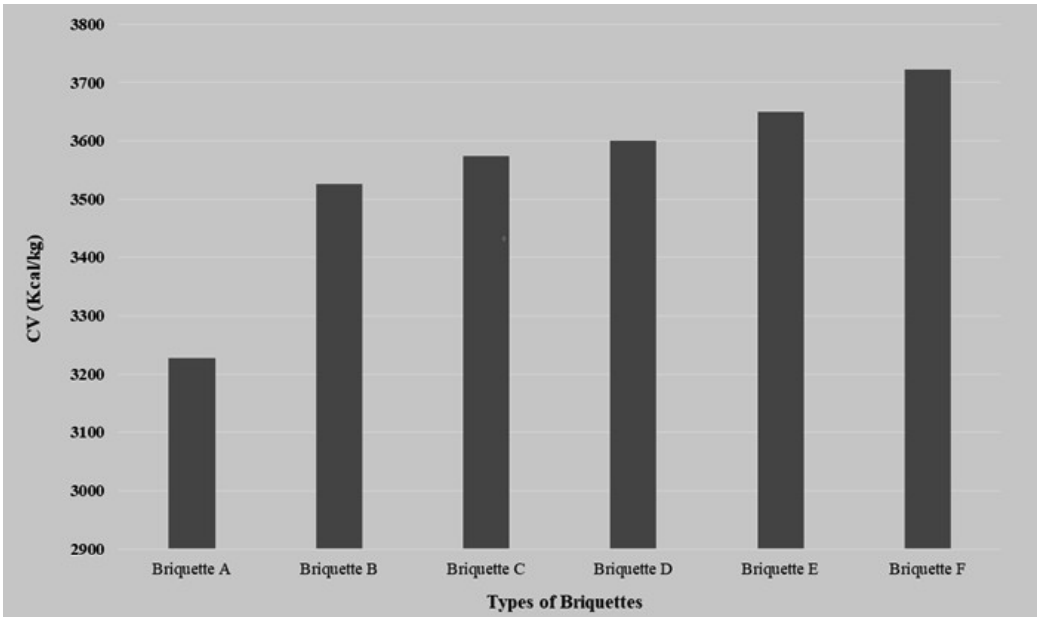
Figure-1: Process Flow Diagram for Production of Briquettes from Mixed Organic Fractions and Plastic Waste Streams

3. Results and Discussion

Six types of briquette sample were made with different compositions of fruit waste, vegetable waste, paper waste, cardboard waste and plastic waste streams. The contents of plastic waste streams ranged from 0 to 50% by weight. It was observed from the results that all samples showed good structural stability leading to enhance the cohesiveness of briquettes. The results of this study aligned with the findings of study (Ab Jalil et al., 2022) who concluded that the properties and energy content of briquettes could be improved by mixing plastic waste streams with biomass. The MC% of paper, plastic, cardboard, fruit and vegetable waste was determined as 14.28%, 31.81%, 21.00%, 45.23% and 30.46% respectively.

The results of VS% of paper, plastic, cardboard, fruit and vegetable waste were obtained as 89.41%, 75.74%, 83.75%, 95.54% and 97.76% respectively. It was observed that the CV of the six briquettes, named A, B, C, D, E and F increased as plastic contents increased. The briquette (F) with higher plastic waste content exhibited the highest CV of 3723 Kcal/kg, compared to 3228 Kcal/kg for the Briquette (A) without plastic waste as

shown in Fig.2. The MC% across all the samples remained below 10% which is considered as a standard for briquette (Ferronato et al., 2023).



The results regarding increasing the CV of briquette with increasing the contents of plastic waste streams of this study are aligned with previous studies (Ab Jalil et al., 2022). This is because of high hydrogen and carbon contents of plastic waste which significantly enhance the energy content of briquettes. Moreover, it is also crucial that the MC should be maintained because the higher MC could adversely affect the combustion efficiency of briquettes.

4. Conclusion and Recommendation

The increasing amount of solid waste, mostly plastic waste, has created many environmental as well as socio-economic issues all over the world. Environmental issues including water pollution, soil pollution, and air pollution because of the open dumping of waste streams have become serious issues especially in developing countries. Plastic waste generation and its improper management has posed adverse effect on ecosystem. This study performed to analyze the feasibility of organic fractions of municipal solid waste and plastic waste streams to produce briquettes by mixing all waste at various proportions. All selected waste streams were characterized by using standard methodologies. Six samples for producing briquettes were prepared and analyzed for calorific values. It was observed

from the results that increasing the contents of plastic waste streams enhanced the calorific value of briquettes. The calorific values obtained of all six samples of briquettes were determined in the range of 3228 Kcal/kg to 3723 Kcal/kg. The lowest value represented briquette without plastic waste whereas the highest result of CV showed that briquette contained highest portion of plastic waste stream. The findings of study support the dual advantages of using plastic waste streams with organic fractions of municipal solid waste; one is to mitigate environmental pollution and other is the supplementing the energy demand. The present work directly addresses the global call to "End Plastic Pollution" by transforming problematic waste into a resource, supporting circular economy principles and SDG targets. It has been recommended that further study is required for long term storage stability, emission during combustion and the effect of different plastic types may be explored to refine performance as well as safety.

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