MICROBIAL FORMULATION OF BIO-BRIQUETTES USING LIGNOCELLULOSIC AND FLORAL BIOMASS

M Prajakta Prakash Karale, Akash Ankush Shivankar, Meghmala Sheshrao Waghmode*, Neha Nitin Patil, Ravindra U. Mene

PDEA's Annasaheb Magar Mahavidyalaya, Hadapsar, Pune-411028, India

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ABSTRACT

Considering the cost of fuel, it is the need of the hour for the utilization of waste as a fuel source. Leaf litter waste and floral waste biomass present in the surrounding serve as potential materials in bio-briquettes formulation. Leaf litter wastes (Almond leaves, Ashoka leaves, Cluster fig leaves), and floral wastes such as (Marigold, Tuberose, and Rose) was used for the study. The waste was microbially treated using *Lactobacillus plantarum* ATCC 8014 and Lactobacillus brevis ATCC 14869 for rapid decomposition of wastes. The briquettes were formulated using wet briquetting, manual pressure, and cylindrical mould methods. Paper pulp along with wheat bran at a 35:5 ratio was used as an artificial binding agent. The preliminary analysis includes the contents of moisture, volatile matter, ash, fixed carbon, etc. Bio briquettes were ultimately analyzed by FESEM, FT-IR, TGA, Density, and Calorific values. Comparisons were done using untreated lignocellulosic biomass-based briquettes and commercially available briquettes. Briquettes made from waste that has undergone microbial processing have a calorific value of 5968.20w kJ/Kg, a density of 0.26 kg/cm3, 8.4% moisture content, 10% volatile matter content, 13.65% ash content, 67.95% fixed carbon content, a maximum burning time of 17 minutes, and a minimum ignition time of 3 minutes. While the briquettes made from untreated waste have calorific value of 4205.10 kJ/Kg, density of 0.20 kg/cm3, 10.8% moisture content, 15% volatile matter content, 15.11% ash content, 59.05% fixed carbon content. This comparative study shows microbially treated bio briquettes can offer good agriculture waste management and new fuel opportunities.

Keywords: Bio-briquettes, floral waste, Leaf litter waste, Wet briquetting.

* *Corresponding author: Meghmala Sheshrao Waghmode, E-mail: meghmicro@gmail.com, PDEA's Annasaheb Magar Mahavidyalaya, India*

1. Introduction: -

Energy is notably essential in improvement, national and local environmental protection *(Mohammed et al., 2020, Oladeji and Oyetunji, 2013)*. The issue of an energy crisis is raised by the depletion of natural resources *(Anggono et al., 2017)*. Fossil fuel is currently the primary energy source utilised to produce everyday fuels like kerosene and cooking gas *(Demirbas 2007)*. The prices of fuel are influenced by declining energy sources. Due to a large market's demands and scarce supplies, fuel prices will rise. Production and proper use of energy are very essential and to address these concerns and lead to sustainable improvement various new methods are used *(Ajimotokan et al., 2019, Pandey and Regmi, 2013)*. Biomass has been taken into consideration as an amazing capacity renewable energy source, both for the richer countries and for the developing world *(Demirbas 2007, Demirbas 2001)*. Biomass is considered the third-largest energy source in the world, after coal, oil, and other fuels *(Anggono et al., 2017, Bapat et al., 1997)*. Floral waste has been reported to have the potential to serve as the source as value added products (*Waghmode et al., 2018*).

The briquettes made from turning low bulk-density biomass into high bulk-density fuel are known as biomass briquettes. The unconventional energy source known as biomass briquettes is renewable, environmentally friendly, non-polluting, and cost-effective. Lignocellulosic biomass is largely employed because it is a plentiful, renewable resource produced from plants, and it is mostly made up of complex polymer sequences called polysaccharides (cellulose, hemicellulose, and lignin), which are naturally resistant to enzyme conversion. The briquette has strength because these changes are tightly bound together and challenging to separate. Second-generation biofuels can be produced using lignocellulosic biomass as a viable alternative to fossil fuels. These include plant waste, waste from the forest, and trash from agriculture. The process of making briquettes is a form of clean coal technology that will aid in the fight against global warming (*Tamilvanan, 2013*). Waste disposal from our surroundings and its use is a major challenge in growing nations, hence generation of value-added products from waste is the need of the hour. *(Onukak et al., 2017).*

In Nepal, people have been using biomass briquettes from the beginning of time. The burning of loose biomass produced adequate heat for keeping warm and cooking, although being inefficient. In order to make guitha, a traditional low-pressure bio-briquette, and cow and buffalo feces that was employed as a binder was combined with fillers including straw, jute sticks, and other biomass resources. In Asia and Africa, low-pressure fuel briquettes are very common. Although cheap and frequently used, these wood-based low-pressure briquettes have a limit on smoke and indoor air pollution (*Singh* 2013).

As a substitute for coal and cow dung cakes in cooking stoves, bio-briquettes have residential applications. For use as fuel in commercial boilers, furnaces, and brick kilns. Briquettes have a high boiler efficiency compared to coal, firewood, or loose biomass because of their low moisture content and high density. They cause less pollution and are easy to store, handle and transport. In comparison to coal, combustion is more consistent. The most popular method in India is to briquette raw agricultural leftovers without the use of a binder *(Ajimotokan et al., 2019, Tripathi et al. 1998).* In India, agricultural leftovers such as arhar stalk, cotton stalk, mustard stalk, maize stalk, groundnut shells, rice husk, tamarind shells, coir pith, sunflower stalk, etc. are frequently used for briquetting *(Ajimotokan et al., 2019, Tripathi et al. 1998)* to prevent deforestation and to conserve natural resources.

The main objectives were to make inexpensive briquettes utilizing leaf litter waste and flower waste that had undergone microbial treatment and to test the ultimate plus proximal characteristics as given in Fig.1.The main objective of this work was developing the methodology for bio-briquette preparation using easily accessible and cheap wastes. During the work the waste was treated with the microorganisms to improve the fuel characteristics of the briquettes and to reduce the time during the preparation.

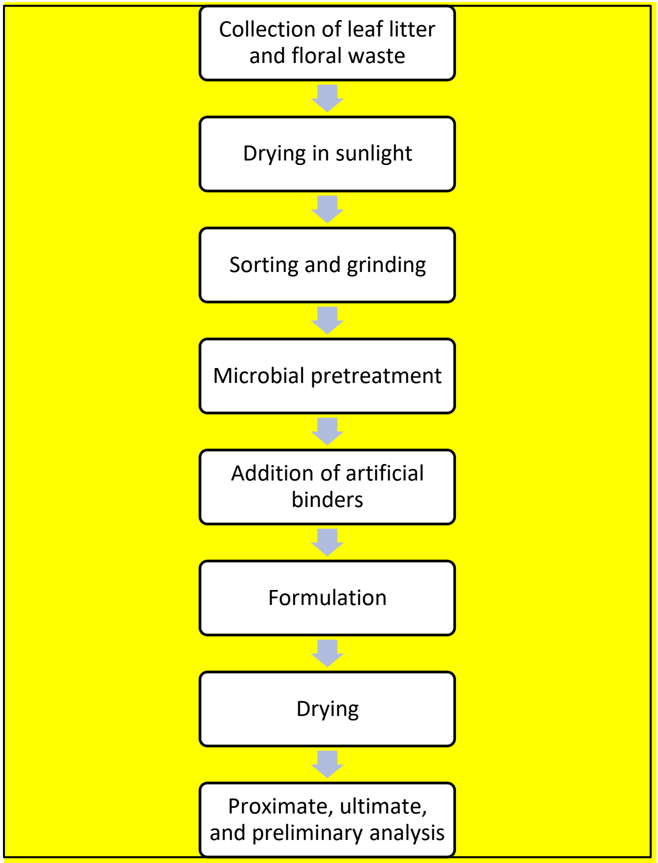


Figure 1: Flow chart of the production of leaf litter and floral waste bio-briquettes

2. Materials and Methods: -

2.1 Sample Collection: -

Leaf litter waste and floral waste from the nearby areas were collected. About 6 kg of floral waste and 6 kg of leaf litter waste was collected for the study which includes *Terminalia catappa* (Almond leaves), *Saracaasoca* (Ashoka leaves), *Ficus racemosa* (Cluster fig leaves), and floral waste such as *Tagetes erecta* (Marigold flowers), *Polianthes tuberosa* (Tuberose), *Rosa indica* (Rose), etc.

2.2 Sample Pre-treatment: -

The pre-treatment of the waste done as per the protocol suggested for sorting, drying, and Size reduction *(Onukak et al., 2017).* The Leaf Litter waste and Floral waste were carefully separated manually to get rid of impurities consisting of pieces of plastic, and other unwanted materials. The waste had been sun-dried for 5 days relying on ambient temperature (25^0C) and humidity to eliminate moisture content. Then the raw material was turned into a smaller size using Grinder, approximately 2-6mm size.

2.3 Microbial Treatment: -

The Pre-treated Leaf litter waste and floral waste were treated with Consortia of Lactic Acid Bacteria i.e., *Lactobacillus plantarium* ATCC 8014, *Lactobacillus brevis* ATCC 14869 and *Leuconostoc lactis* ATCC 19256 to reduce briquette formulation time as decomposition loosens fibers of biomass materials. Decomposition of 500-600g of pre-treated waste sample was done using 10% of inoculum and was incubated for 5 days at room temperature under aerobic conditions. Suitability of decomposed biomass for bio briquette production, ooze test, shake test and spring back test has been recommended. These tests are based on feeling and visual observation (Saikia et al., 2014). A shake test was run repeatedly to make sure the waste sample was decomposing to the appropriate extent till it turns into solid biomass with less moisture content. When shaken a few times vertically while being held above the upper half area, the good briquette material does not disintegrate.

2.4 Formulation of bio-briquettes: -

2.4.1 Preparation of binding agent from paper waste and wheat bran

Binding agent for briquette preparation was prepared as per the method of **(***Tamilvanan, 2013)*. The trash was first shred into smaller pieces and placed in a bucket of water. It was transformed into more water-rich paper pulp after two days. It was left in the sun for a while to let the surplus water evaporate. In a pan, the water and wheat bran were combined, and the mixture was then cooked on the stove until it coagulated.

2.4.2 Preparation of bio-briquettes: -

Bio briquettes were made using wet briquetting, densified briquetting, and carbonized briquetting method.

2.4.2a. Wet briquetting method

The decomposition of biomass material to the necessary degree in order to pressurize the wet briquettes at a lower pressure is the first phase in the wet briquetting process. The previously microbially treated raw material is combined with the synthetic binding agents, paper pulp and wheat bran, once it has attained the optimal amount of breakdown. The mixture was subsequently manually inflated in a 250mm-long, 100mm-diameter cylindrical mould. The pores in the sides of the cylindrical mold allow the excess water in the mixture to escape. The briquettes needed thorough drying for a week in the sun because they were still damp even after pressurization.

2.4.2b. Densified briquetting method

Densification is the process of combining flower and leaf litter waste into a product that has a higher density than the original raw material. The pre-treated waste samples were combined in a 60:35:5 ratio with the paper pulp and wheat bran. A manually controlled lever press with a 100mm internal diameter and a 250mm length was then used to pressurize the mixture. The perforations in the sides of the cylindrical mold allow the excess water in the mixture to drain away. Before examination, the briquettes were kept for a week to dry in the sun.

2.4.2c. Carbonization briquetting method

The carbonization process is required to transform biomass into fuel. It removes the water from the biomass, breaks down the cellulosic material, and leaves carbon in the form of charcoal, which can then be used as a raw material to create bio-briquettes. The pre-treated sample was heated for two hours at 400°C in a container. Then the carbonized material was mixed with the paper pulp and wheat bran. The mixture was then pressurized by a manually operated lever press with an internal diameter of 100mm and 250mm in length *(Ujjinappa & Sreepathi, 2018).*

2.5 Characterization of bio-briquettes: -

Proximate, Ultimate, and Preliminary analysis were used to quantify some of the physical properties of biomass briquettes that have an impact on combustion. These properties include moisture content, volatile matter content, fixed carbon content, ash content, density, calorific value, FESEM, TGA, FT-IR, burning time and ignition time, among others.

i. Preliminary analysis of bio-briquettes: -

Preliminary Analysis of the Formulated Bio-Briquette consists of the following test: -

a. Percentage moisture content.

Using the accepted technique, the percentage moisture content (PMC) was calculated (IS 1350 Part 1). Each sample weighed five grams, and the samples were oven-dried for two hours at 135 °C to achieve a consistent mass. The desiccator was then used to keep it cool. The sample's PMC was calculated using the change in weight (W2) after 15 minutes of cooling.

$$PMC = \frac{W1 - W2}{W1} \times 100$$

b. Percentage of Ash Content.

Using the accepted technique, the percentage of Ash Content (PAC) was determined (IS 1350 P1). Two grams of briquette sample were placed in a crucible with a known weight, heated for one hour at 700°C, and then cooled in a desiccator before being weighed to determine the weight of the ash. The PAC was calculated with following formula

$$PAC = \frac{W2 - W1}{Ws} \times 100$$

c. Percentage of volatile matter.

Using the Standard technique, the proportion of volatile matter (PVM) was calculated (IS 1978). In a crucible with a known weight, two grams of briquette sample were taken, oven-dried at 135°C for two hours, heated at 900°C for ten minutes, cooled in a desiccator for fifteen minutes, and then weighed. The PVM was calculated using:

$$PVM = \frac{W1 - W2}{W1} \times 100$$

d. Percentage of Fixed Carbon.

PVM, PMC, and PAC were added up, and the result was subtracted from 100 to determine the percentage of fixed carbon (PFC).

$$Fixed\ Carbon = 100\% - (PVM + PAC + PMC)$$

e. Density.

A briquette's mass density is determined by its mass in relation to its volume (USDA ARS). Each sample of briquettes is used to calculate the average value of mass density using the equation,

$$\rho = \frac{m}{v}$$

ii. Proximate analysis of bio-briquettes: -

Proximate Analysis according *(Afsal et al., 2020)* consists of the following test: -

a) Ignition time (min): The burner was used to ignite the bio-briquette samples. The ignition time was measured using a stopwatch as the length of time it took for each briquette to ignite.

b) Burning time (min): Using a timer, the amount of time it takes 100g of bio-briquette sample to burn all the way through to ash is recorded as the burning time.

iii. Ultimate Analysis of the Formulated Bio-Briquette consists of the following test: - The Ultimate analysis by *(Ayodeji Rapheal et.al 2022)* consist of the following methods:-

a) Thermo-gravimetric analysis (TGA): TGA was performed using a Thermostep Thermo-gravimetric Analyzer. To prevent unwelcome oxidation, the breakdown analysis of the created briquettes was carried out in a nitrogen atmosphere. Each measurement was performed using 3.2g of a sample heated at a rate of 10°C/min from room temperature to about 995°C (*Yiga & Lubwama, 2020).*

b) FTIR (Fourier Transform Infrared Spectroscopy)- IR spectra of waste flower and leaf litter were examined to determine the chemical functional groups present (Perkin Elmer). Each sample's FT-IR spectrum (1 mg) was used, and 40 scans with a resolution of 2 cm-1 were completed. A software standard graph was created for each sample using the spectra as input *(Veeresh and Narayana,* 2012).

c) Analysis using field emission scanning microscopy (FESEM) - FESEM analysis, which uses a Nova Nano SEM NPEP303 with a resolution of 1.0 nm at 15 kV, was utilised to determine the morphology and elemental makeup of the particles still present in the biomass feed after breakdown. XT microscope software for FESEM *(Blesa et al., 2003).*

2.6. Costing of Production of bio-briquettes: -

The costing of the raw materials used for the production of bio-briquettes were calculated and compared with the values of bio-briquettes that are available industrially.

3. Results: -

3.1 Sample Collection: - Leaf litter waste and floral waste from the nearby areas were collected. About 6 kg of floral waste and 6 kg of leaf litter waste was used for the bio briquette production.

3.2 Sample pre-treatment: - Collected waste samples were sorted, sundried and grinded to fine powder.

3.3 Microbial Treatment: - The Pre-treated Leaf litter waste and floral waste were treated with consortia of Lactic Acid Bacteria i.e., *Lactobacillus plantarium* ATCC 8014, *Lactobacillus brevis* ATCC 14869 and *Leuconostoc lactis* ATCC 19256 to reduce briquette formulation time as decomposition loosens fibres of biomass materials. It has been advised to do the oozing test, shaking test, and spring back test to determine whether decomposed biomass is suitable for making bio briquettes. According to Saikia et al. (2014), these exams are based on perception and visual observation. LAB treated leaf litter and floral biomass was converted into briquettes using Wet briquetting, Densified briquetting, and Carbonization briquetting method as shown in fig no 2. A Lever press machine was used for the preparation of biobriquettes (fig. 2g).

Figure 2: - Bio-briquettes formation using leaf litter waste and floral waste. (a)Decomposed floral. (b) Carbonized floral (c) Densified floral. (d) Densified Leaf litter. (e) Decomposed leaf litter. (f) Carbonized leaf litter. (g) A Lever press machine

3.4 Preliminary Analysis of Bio-briquettes: -

The preliminary analysis (moisture content, volatile matter content, ash content, fixed carbon content, density, calorific value) of Bio-briquettes were done by using standard techniques. The obtained results are given in table no1.

Table 1: - Preliminary analysis of Bio-briquettes.

Sr. No.	Name of Bio-briquettes	MC (%)	VMC (%)	AC (%)	FC (%)	D g/cm^3	CV kJ/Kg	BT (min)	IT (min)
1	Decomposed floral	8.40 ± 0.5	10 ± 0.33	13.65 ± 1.13	67.95 ± 0.46	0.26 ± 0.02	5,968.20 ± 14.12	17 ± 0.02	3 ± 0.02
2.	Decomposed Leaf litter	8.9 ± 0.51	11.5 ± 0.64	13.8 ± 1.15	66.54 ± 0.40	0.24 ± 0.08	2,543.03 ± 15.20	17 ± 0.02	3 ± 0.02

Sr. No.	Name of Bio-briquettes	MC (%)	VMC (%)	AC (%)	FC (%)	D g/cm^3	CV kJ/Kg	BT (min)	IT (min)
3.	Densified floral	10.9 ± 0.36	13 ± 0.41	6.16 ± 1.05	69.94 ± 0.20	0.23 ± 0.06	3,799.77 ± 10.30	10 ± 0.03	4 ± 0.03
4.	Densified Leaf litter	9.50 ± 0.62	10.42 ± 0.71	9.45 ± 1.21	61.05 ± 0.60	0.26 ± 0.04	4,584.55 ± 16.15	12 ± 0.01	5 ± 0.01
5.	Carbonized floral	6.50 ± 0.31	16 ± 0.45	10.14 ± 1.09	67.36 ± 0.55	0.22 ± 0.04	4,662.10 ± 13.36	12 ± 0.03	5 ± 0.03
6.	Carbonized Leaf litter	6.04 ± 0.41	11.4 ± 0.51	16.9 ± 1.20	75.64 ± 0.30	1.58 ± 0.09	3,304.16 ± 13.21	13 ± 0.01	6 ± 0.01
7.	Commercially Available	10.8 ± 0.55	15 ± 0.68	15.11 ± 1.20	59.05 ± 0.57	0.20 ± 0.02	4,205.10 ± 16.13	15 ± 0.02	7 ± 0.02

MC = Moisture content, VMC = Volatile matter content, AC = Ash content, FC = Fixed carbon, D = Density, CV = Calorific value, BT = Burning time, and IT = Ignition time. Along with ± mean error.

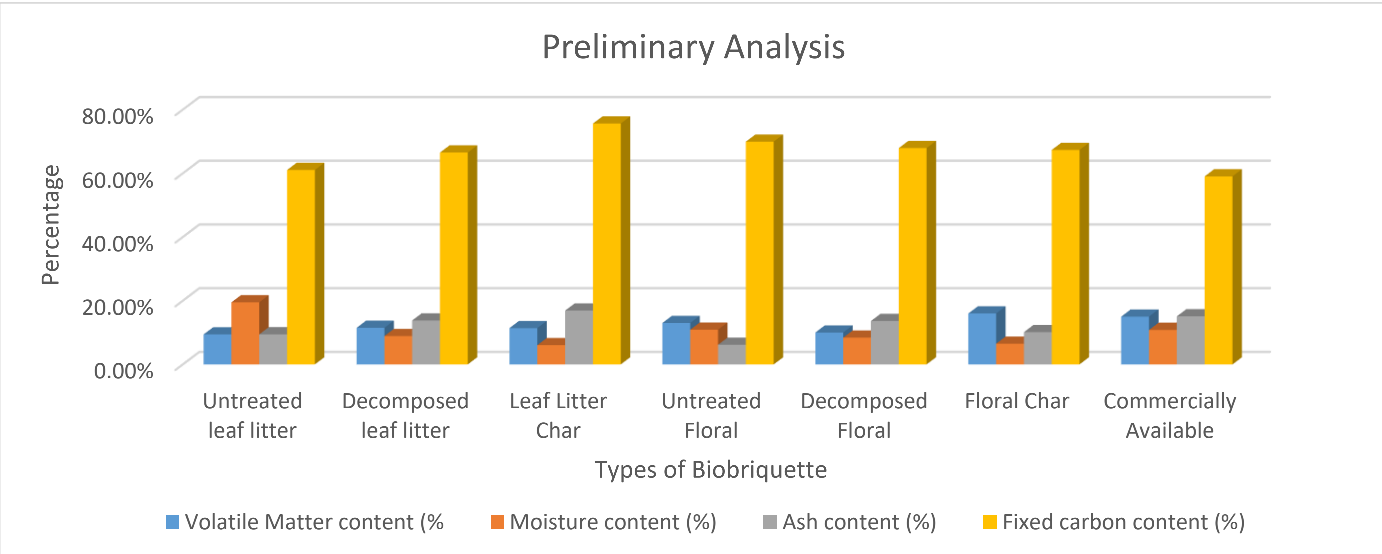


Figure 3: - Graph of Preliminary analysis of bio-briquettes

Table no 1, fig 3, shows the results of the preliminary analysis of biomass briquettes. Decomposed flower briquettes were the most significant briquette among all the briquette samples, according to the data, with the highest moisture content, volatile matter content, ash content, and fixed carbon content of 8.40%, 10%, 13%, and 67.95%, respectively. The moisture percentage, volatile matter content, ash content, and fixed carbon content of additional briquette samples, such as disintegrated leaf litter, is shown to be 8.9%, 11.5%, 13. 8%, and 66.54%, respectively. The moisture content, volatile matter content, ash content, and fixed carbon content of a densified floral bio-briquette are 10, 9, 13, 6, 16, and 69.94%, respectively. The moisture content of a densified leaf litter briquette is 9.50%, the volatile matter content is 10.42%, the ash content is 9.45%, and the fixed carbon content is 61.05 percent. Carbonized floral shows a moisture content 6.50%, volatile matter content 16%, ash content 10.14%, fixed carbon 67.36%. A carbonized leaf litter briquette's moisture content is 6.04 percent, volatile matter is 11.4 percent, ash is 16.9 percent, and fixed carbon is 75.64 percent. The moisture content of commercially available bio-briquette is 10.8%, the volatile matter content is 15%, the ash content is 15.11%, and the fixed carbon content is 59. 05%.

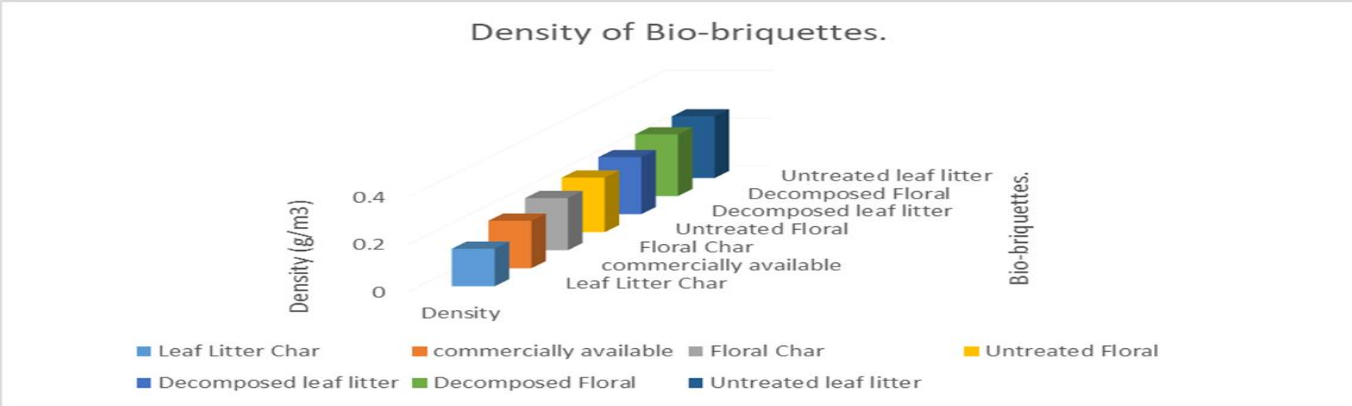


Figure 4: - Graph of Densities of bio-briquettes

Table no1 and fig 4, indicate the densities of the biomass briquettes formulated using microbial treatment. Decomposed floral bio-briquette and densified leaf litter bio-briquettes showed the highest densities among all the formulated biomass briquettes i. e. , 0. 26g/cm3. Decomposed leaf litter bio-briquette and densified floral briquette showed 0. 24g/cm3 of density. Followed by carbonized floral bio-briquette showing 0. 22g/cm3. While carbonized leaf litter bio-briquette showed the lowest density of 1. 58g/cm3. And commercially available one showed 0. 02g/cm3 density.

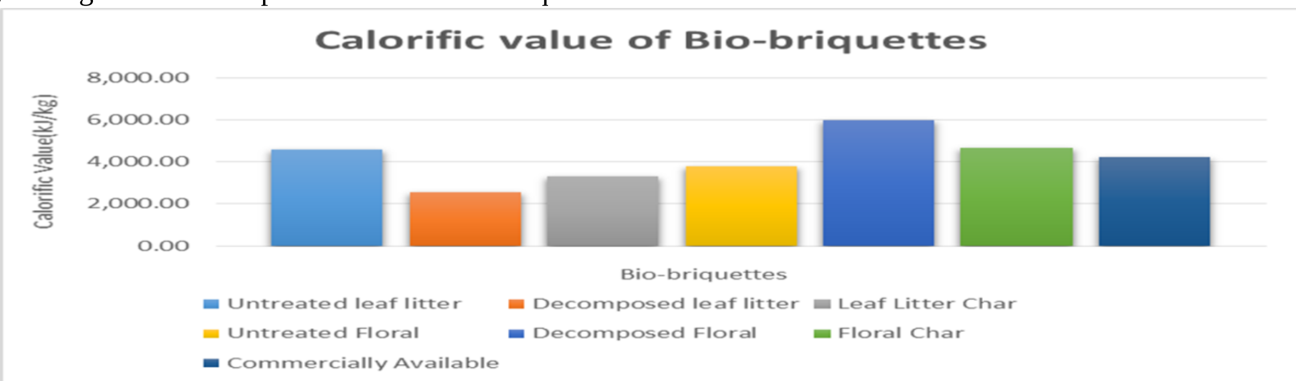


Figure 5: - Graph of Calorific values of bio-briquettes

Table no 1 and Fig 5, shows the results of the preliminary analysis of biomass briquettes. The results indicated that among all the briquette samples, decomposed floral briquettes were the most significant briquette with the highest calorific value of about 5,968.20 kJ/Kg. Followed by other briquette samples such as Densified leaf litter which showed 4,584.55kJ/Kg. Densified floral bio-briquette showed 3,799.77kJ/Kg of calorific value. Decomposed leaf litter briquette showed the calorific value of about 2,543.03kJ/Kg. Carbonized floral showed 4,662.10kJ/Kg of calorific value. Carbonized leaf litter briquette showed 3,304.16kJ/Kg of calorific value. And commercially available bio-briquette showed 4,205.10kJ/Kg of calorific value.

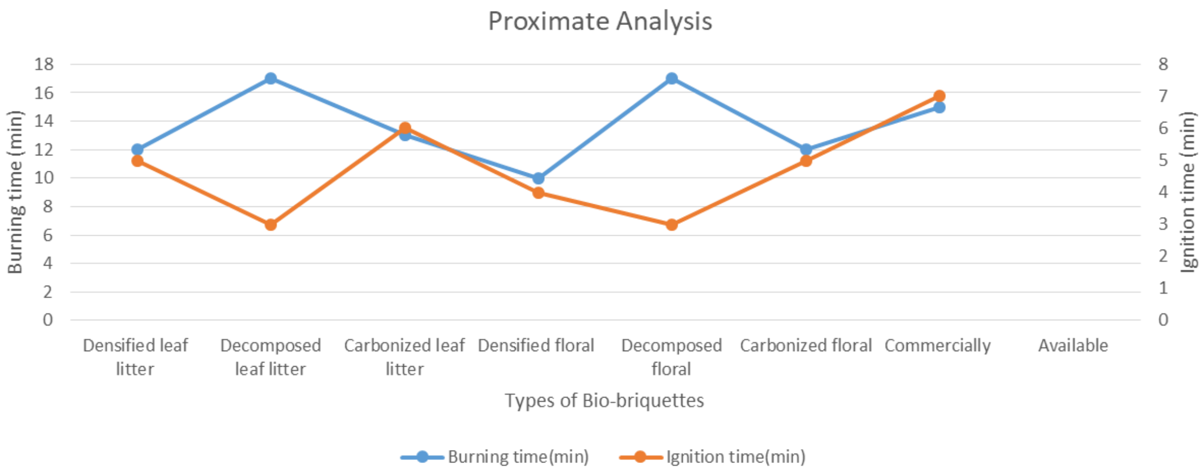


Figure 6: - Graph of Burning time and Ignition time of bio-briquettes

The findings of the Burning time and Ignition time of biomass briquettes are displayed in Table No. 1 and Fig. 6. The results indicated that among all the briquette samples, decomposed floral briquettes were the most significant briquette with the highest burning time of 17mins and lowest ignition time of 3mins. Followed by other briquette samples such as Densified leaf litter which showed burning time of 12mins and ignition time of 5mins. Densified floral bio-briquette showed 10mins of burning time and 4mins of ignition time. Decomposed leaf litter briquette showed 17mins of burning time and 3mins of ignition time. Carbonized floral showed 12mins of burning and 5mins of ignition time. Carbonized leaf litter briquette showed 13mins of burning and 6mins of ignition. Commercially available bio-briquette showed 15mins of burning and 7mins of ignition time.

3.5 Ultimate Analysis of Bio-briquettes: -

a. Thermo-gravimetric analysis of Decomposed floral bio-briquette: -

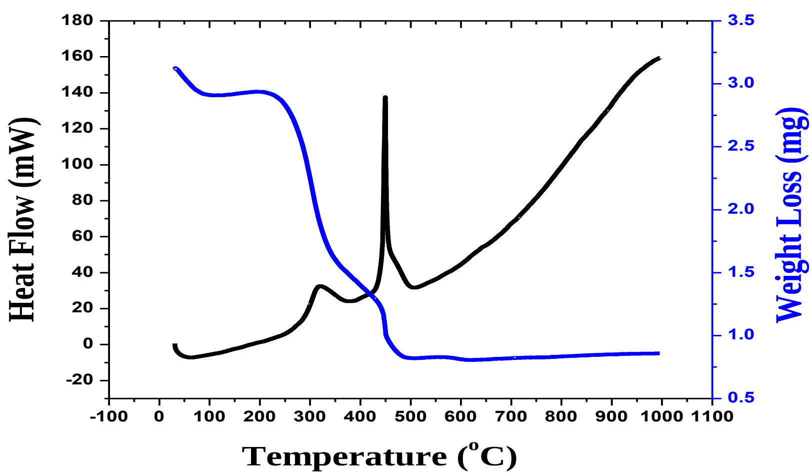


Figure7: - Graph of TGA of bio-briquettes

A Thermostep Thermo-Gravimetric Analyzer was used to conduct the thermogravimetric analysis (TGA). To prevent unwelcome oxidation, the breakdown analysis of the created briquettes was carried out in a nitrogen atmosphere. Each measurement was performed using 3.2g of a sample heated at a rate of 10°C/min from room temperature to about 995°C *(Yiga & Lubwama, 2020).* The TGA curve of weight loss (mg) vs heat flow (mW) for decomposing floral bio-briquettes is presented in Fig6. The most significant weight loss was 3.12mg. The fuel ignition temperature showed the removal of moisture content from 30°C to 200°C. Then removal of volatile matter content from 200°C to 500°C showed a weight loss of 1.5mg. In corresponding to weight loss, the heat flow increases and is maximum at 450°C during the removal of volatile matter content. Then the biofuel briquette is converted to ash when heated from 500°C to 998°C.

b. Fourier Transform Infrared Spectroscopy of Bio-briquette: -

To know the chemical functional groups, present in the floral and leaf litter wastes IR spectra were carried out using (Perkin Elmer). In FT-IR spectra (1mg) of each sample were used and 40 scans at a resolution of 2cm-1 were carried out. With the help of spectra, a software standard graph was plotted for each sample. *(Veeresh and Narayana*, 2012). Fig. 8 showed the FT-IR spectra analysis of Decomposed bio-briquettes having good chemical functional groups. The Peak at 472.75/cm, 93.98% T (432.83, 420.94, 452.38) is attributed to C-Br stretching mode and C-I stretching mode.

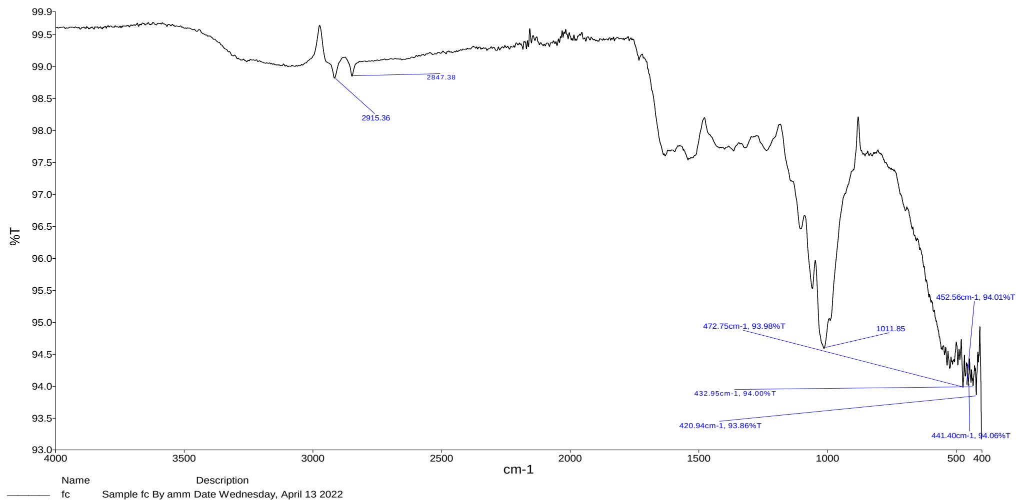
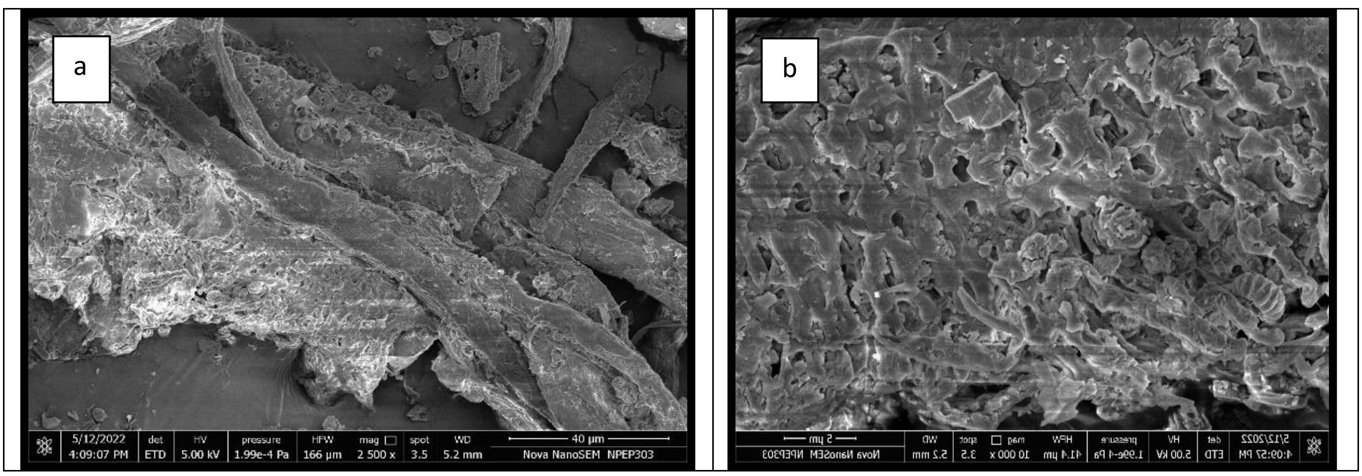


Figure 8: - FT-IR spectra of Decomposed bio-briquettes

c. Field Emission Scanning Microscopy (FESEM) Analysis: -

The morphology of the particles still present in the biomass feed after decomposition and their elemental content were discovered using FESEM analysis (Field emission Scanning Electron Microscope, Nova Nano SEM NPEP303 with Resolution: 1.0 nm at 15kV) and XT microscope software (*Blesa* et al., 2003). It is generally used to study morphology on the 3D surface of bio-briquettes. The decomposed floral briquettes had pores, and wide fibers are displayed on the surface as shown in Fig 9 (a), (b). It has a very rigid body with irregular structures having a predominance of floral shapes with channels as shown in fig 8(e) and (f). Their particle size varies from 13.8 micrometers to 166.8 micrometers. This morphological difference plays a very important part in energy valorization and helped in high heating values.



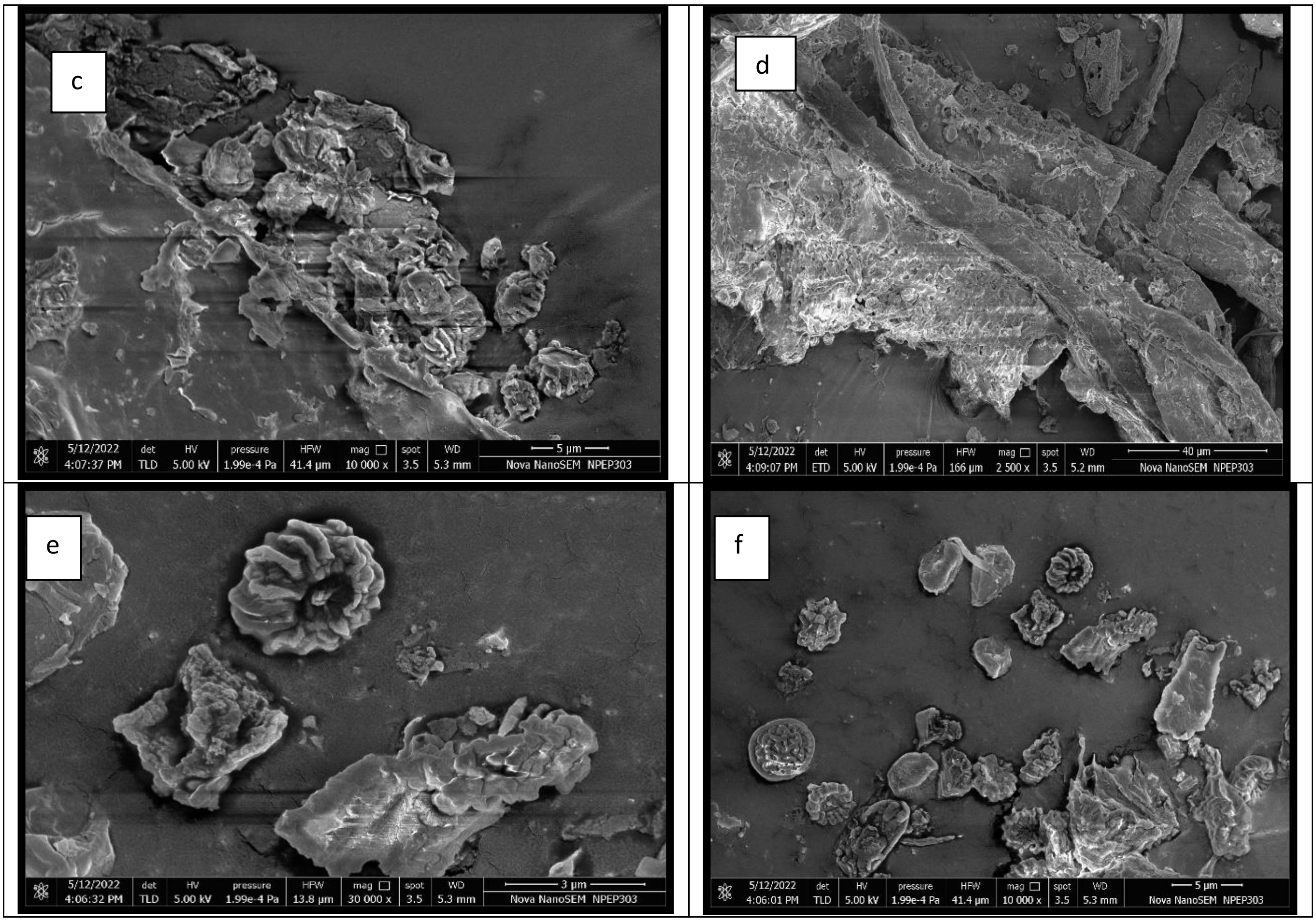


Figure 9: - FESEM images of decomposed bio-briquette. (a) Wide & rough fibers (b) Pores (e) Predominance of floral structures

3.6 Costing of Production of bio-briquettes: -

The production cost of Industrial bio-briquette and formulated bio-briquettes in India, 2022 is given in Table 2. The organic matter that is used in the production of formulated bio-briquettes is easily obtained, and available abundantly in the surrounding. While the raw material that is used by the industries cost approximately 15rs/kg. The artificial binders that are used in formulated bio-briquettes are also available and are of affordable prices. While the binders used by the industries are costly. The other techniques used in the bio-briquettes formulation are also cheaper and so this technique is proven to be cost-effective in comparison to industrial bio-briquettes.

Table 2: - Comparison of Production Cost of bio-briquettes

Components	**Cost of Industrial Bio-briquette (INR/kg)**	**Cost of Formulated Bio-briquette (INR/kg)**
Raw materials	15 Rs/ kg	Freely available in Surrounding
Paper waste	-	15 Rs /kg
Wheat bran	-	36 Rs /kg
Cassava starch	49 Rs / kg	-
Total	**64 Rs/kg**	**51 Rs/kg**

Discussion: -

Bio briquette production has been reported from tropical fruit waste (*Brunerová* et al., 2017), bamboo fiber and sugar cane skin (*Brunerová* et al., 2018), cashew nut shell waste (*Ifa* et al.,2020), hydrothermal pretreated cotton stalk and wood sawdust (*Song* et al., 2020), and water hycianth (*Rezania* et al., 2016). Value addition to the organic waste by its conversion into biofuel, will give insight for the poor rural woman to solve the problem of fuel with unaffordable price. During the conversion of waste biomass into fuel, various physico chemical treatments has been reported. Here we are reporting ecofriendly microbial pretreatment of leaf litter and floral waste.

Literature is replete with several research findings on briquetting from various types of biomasses *(Anggono et al., 2017)* while investigating an alternative source of renewable and sustainable energy, found biomass briquette made from waste *Pterocarpus indicus* leaves includes *tapioca* as a binder material, showed the increased calorific value and the low cost of the biomass briquette from as cost of tapioca as a binder material was low. Rice straw, banana leaves, and teak leaves were used by *(Madhurjya Saikia and Deben Baruah, 2013)* for densification using the wet briquetting procedure. They found that banana leaves take 28 days to decompose to the desired level, compared to 19 days for rice straw and teak leaves. Additionally, rice straw, banana leaves, and teak leaves have calorific values of 1357 kJ/kg and 0.20 g/cm3, 1498 kJ/kg and 0.17 g/cm3, and 1178 kJ/kg and 0.22 g/cm3, respectively. Briquettes made from mixtures of palm oil mill waste and rice husk were described by (*Obi et al,* 2016). Because of its larger density and relatively moderate moisture level, the corncob briquette has better physico-mechanical characteristics than the rice husk briquette. According to a prior study by *(Tamilvanan A, 2013)* published in the Journal of Biofuels, the moisture content, volatile matter content, ash content, and fixed carbon content of various bio-briquettes made from agricultural residues and wastepaper were 6.23%, 69.12%, 12.38%, and 8.49% for wastepaper, 6.52%, 75.78%, 12.48%, and 5.02% for dried leaves, and 8.67%, 78.93%, 14.72%, Rice straw is an example of lignocellulosic biomass that, in contrast to other biomass, requires some pre-treatment to speed up its breakdown. As per the study, grinding significantly improved solid reduction even without thermal pre-treatment *(Zhang & Zhang et al., 2006).* The current investigation of bio-briquettes employing microbial formulation revealed that lignocellulosic biomass and floral biomass could be completely degraded in 10 days and bio briquettes have a calorific value of 5,968.20 kJ/kg and a density of 0.26 g/cm3. More volatile matter content in biomass is associated with lower fixed carbon levels *(Thabuot et al., 2015).* Decomposed floral bio-briquettes had moisture content of 8.40%, volatile matter content of 10%, 13.65% ash, and 67.95% fixed carbon content. Decomposed leaf litter bio-briquettes had moisture contents of 8.9%, 11.5% volatile matter, 13.8% ash, and 66.54% fixed carbon. According to the current findings, microbial fermentation of the biomass and subsequent manufacture of its bio briquettes will improve the fuel's qualities.

A comparison of both past and present bio-briquette investigations revealed that the approach of microbial formulation is successful for degradation, producing positive outcomes for physical analysis.

Conclusion: -

Rapid increase in fuel prices, demands the need of alternative biofuel systems. Reuse of the lignocellulosic wastes is needed as part of value addition to biowaste. Bioconversion of lignocellulosic waste to bio briquettes will be the best and easily targetable approach. Microbial assisted lignocellulosic biomass denaturation step will help for the reduction in the duration and improvisation of the quality of the briquettes. Such strategies can be helpful for women living in rural areas with a scarcity of fuel. More research is needed for better technology in briquette formulation to meet all the desired criteria of fuel.

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