

Sustainable Bio-Energy Sources for Pulp and Paper Mills



Vinay Dwivedi*
EVP (Works)



Gouri Shankar Patnaik*
General Manager (QA & TS)



Sunil Kumar Pradhan*
Asst Director (PAPRI)



Upendra Prasad Tripathy *
Sr. Scientist-B (PAPRI)

J K Paper Ltd.
Rayagada, Odisha

Abstract: Energy demand of India has been increasing rapidly due to continuous growth of population and industrialization. Most of the energy requirement of the Pulp and Paper Industries (PPI) is still fulfilled through burning of fossil fuel. Millions of years are required to generate fossil fuels in earth and their reserves are finite. Each year, closely 500 million tons of agricultural residues and 7.5 million tons of textile waste is generated in India and most of the Agri residues are left in the field to decompose or are burnt on open fields, resulting in significant environmental impacts. To meet climate objective and to increase sustainable growth, the use of these renewable resources in the industrial sector is crucial. And these Agri residues and forest biomass have potential to utilize as an energy source, which will help to cut the use of fossil fuel. This paper provides the insightful potential availability of Agri residue resources in India and its fuel properties.

Keywords: Biomass, Fossil fuel, Energy, Waste, Agri residue, Forest waste, Sustainable development, etc.

Introduction

Paper industry plays an important role in socio-economic development of a country. It is one of the essential commodities even after the growth of electronic media. The global demand of paper is continuously increasing. In addition to such traditional products as newspapers, books, magazines and writing paper, a new world of mail order catalogues marketing and promotional materials and household papers has developed in recent years. The pulp and paper mills require large amount of steam and electricity for the production of paper. Globally pulp and paper mills are the largest contributor to the economy, generating paper products and employment opportunities. In the context of global climate change, reduction of greenhouse gas emissions is a major challenge in the present times.

Power plays a great role wherever man lives. Energy is a key factor for the development and social prosperity of any country. Modern society demand for energy is continuously increasing. The pulp and paper diminution of non-renewable fossil fuels and increasing impact of climate change demand an immediate shift towards sustainable energy source [1]. The concept of sustainability has been applied over the years in all manufacturing activities including pulp and papermills, which represent an important world-wide economic activity. India is the fourth largest energy consumer in world after United state, China and Russia. Biomass from agriculture waste can make a substantial contribution to supplying future energy demand in a sustainable way [2]. It is presently the largest global contributor of renewable energy and has a significant potential to expand in the generation of energy [3]. In the present research a clear survey of available agriculture waste in India as well as in Odisha is given and their potential to provide energy source is identified. Again, evaluation of the potential green energy resources to minimize the use of fossil fuel in Indian paper industry is identified. The different available biomass in India is given bellow in figure-1.

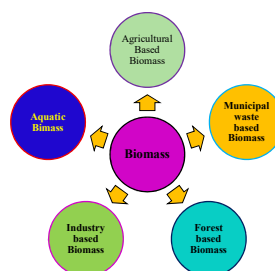


Figure-1: Biomass Availability in India

There are mainly four generation of possible biofuels characterized by their sources. The first-generation biofuel is otherwise known as conventional biofuel generally manufactured from sugar, starch or vegetable oils acquired from crops is transformed into biodiesel through the process fermentation, distillation and trans esterification. Alcohols are generally used as first generation biofuel generated from starch and sugar by fermentation [4]. The second-generation biofuel is manufactured from non-wood crops, lignocellulosic biomass, or woody crops, agricultural residues or waste plant material. Agricultural and forest residue undergoes thermochemical pre-treatment such as gasification to synthesize syngas which is a mixture of CO, H₂ and hydrocarbon [5]. Third Generation Biofuels are based on algae having naturally more than 50% oil content. The algae can be grown in waste water and oil content can be extracted and processed to produce biodiesel. Fourth Generation Biofuels is generally produced from biomass that has absorbed carbon dioxide during their growth. The fourth-generation biofuel are produced using non-arable land and do not need to breakdown biomass. It includes electro-fuel and photobiological solar fuels. Various pre-treatment techniques like simply chopping, chipping or milling the raw feed stocks into ready to use material for subsequent conversion are given below.

• Palletisation:

Different biomass pieces by compressing can be converted into pellets which can produce higher calorific value as pellets typically have a bulk density about 650 kg/m³ that is 3.3 times higher than the wood chips. Again, due to

their low water content, pellets also have a high net calorific value about 17% higher than the wood chips.

• Pyrolysis:

Pyrolysis is the thermal decomposition of biomass occurring in the absence of oxygen (anaerobic environment) that produces a solid (charcoal), a liquid (pyrolysis oil or bio-oil) and producer gas. Bio oil has a high calorific value.

• Torrefaction:

Torrefaction is a thermal process that involves slowly heating the biomass at 200-300°C in the absence of oxygen. In this process the biomass degrades into a dry coal like product that has lost the fibrous structure and have high calorific value about 19-23 MJ/kg

• Pellet Fuels from Agricultural waste:

These biomasses were collected and cut them in small pieces then in a proper process made to powder form. Pellet formation has several steps such as waste sorting, grinding, drying, pressing cooling & packaging. During pressing, granules of the required size are stamped in a pellet press at pressure of 300bar and a temperature of 100°C. Under such conditions, lignin softens a polymeric organic compound due to which the particles of the mass stick together and the pellet acquires a stable shape and retains their strength in future. There are no additional chemicals used for pellet formation which is shown in figure-2.

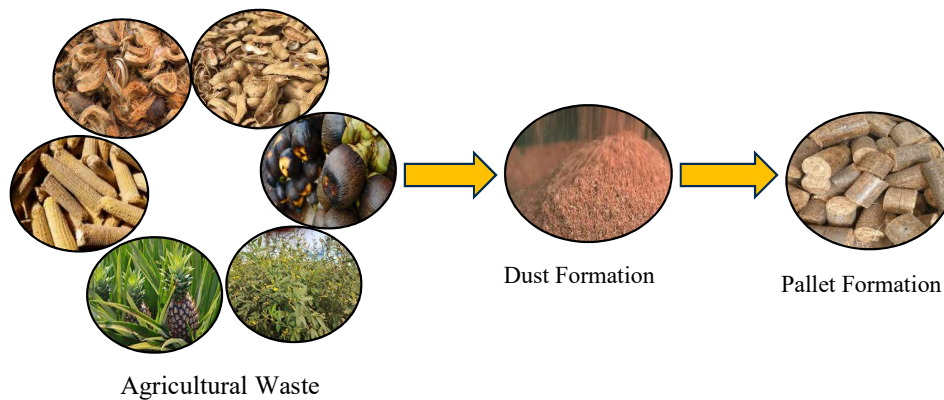


Figure-2: Process of Formation of Agriculture waste to Fuel

• Availability of Agriculture waste for Energy Generation:

The agricultural sector in India holds substantial potential for producing bioenergy and bioproducts from their waste material which can reduce the growing demand of energy. India ranks in terms of population, having approximate 17.76% of the world’s population [6]. The rate of urbanization is increasing very fast and presently 35% of the Indian population is in urban area. Crop residues like ground nut cells, coconut husk, dal plant, corn stover, sugarcane bagasse & trash, Pineapple leaf, cotton stalks Palm fruits may be used for generation of energy as these are organic material comprised of four principal elements such as carbon (C), hydrogen (H), nitrogen (N) and oxygen(O). The availability of these in India and Odisha is shown in figure-3

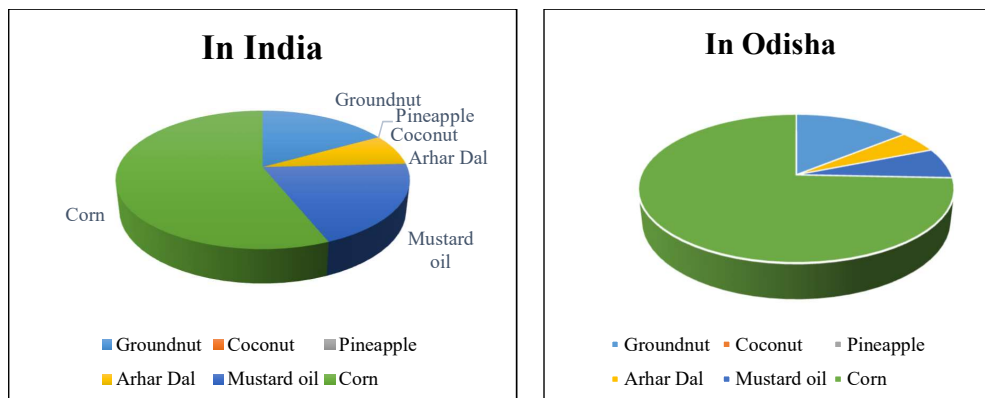


Figure-3: Availability in India and Odisha (in Million Tonnes)

2. Materials and Method:

The biomass available samples were collected from the local farming & forest areas in different locations. The most common studied feed stock for biofuel production and heat generation is Ground Nut cells, Coconut Husk, Pineapple leaf, Dal Plant, Mustard Straw, Corn Cob and Palm fruit as shown in figure-5. After collection air dried at room temperature and kept in a tight sealed polyethene bag. Then it was powdered to appropriate size and used for different analysis. The gross calorific value of these sample is determined with the help of an automated Bomb calorimeter (Model No: Parr 6100) shown below in figure-4 as per the standard IS 17654:2021.



Figure-4: Bomb Calorimeter

The ash content, Sulphur & volatile matter of these samples can be determined as per IS:17653:2021, IS 17833:2022 & IS 17844:2025.

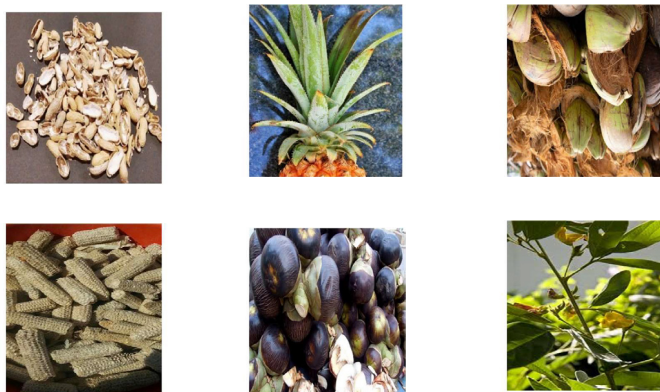


Figure-5: Different Source of Feed stocks for Biofuel Generation

3. Results and Discussion:

In the present work, we have taken some agricultural and forest biomass i.e. Ground nut shell, Coconut husk, Pineapple leaf, Dal plant, Mustard straw, Corn cob and Palm fruit for generation of biofuel. Groundnut is a crucial oil seed crop in India called “King of oil seeds” mainly cultivated in Odisha, Andhra Pradesh, Tamil Nadu, Gujarat, Rajasthan & Karnataka. The groundnut shells mainly contain cellulose, hemicellulose and lignin which can be used as a biofuel. Pineapple leaf is a strong lightweight cellulose rich natural fibre which can be used for generation of biofuel. India is the world’s largest producer and consumer of pulses (dal) with significant annual production more than 25 million tons. The waste product of dal is dal husk and dal plant which can be used for making biofuel. Similarly, Mustard straw, Corn cob, Coconut husk and Palm fruits are waste products after use these can be used for bio energy generation. The gross calorific value of these materials is given in the figure-6. Which clearly indicates groundnut cells have calorific value 4704 kcal/kg which is higher as compared with others but its ash content is 8.2% which is little bit higher. The dal plant has GCV 4346 kcal/kg and its ash content is 1.53% which is quite low. The total ash content of these samples is given in figure-7. The volatile matter of all these samples represented in

figure-8, shows that the volatile material present in dal plant is 81% which is quite higher than the others. The fixed carbon and sulphur content present in this raw material are given in figures-9 & 10 respectively. It shows the fixed carbon in pineapple leaves is 31.24% which is higher than others and the sulphur content in mustard straw is 1.02% whereas the sulphur content in ground nut cells is 1.0%. The Coconut husk, Pineapple leaf, Dal plant, Corn cobs & Palm fruit waste products mainly contain low ash and low sulphur content hence must contain less silica and can be used for making bioproduct for energy generation. Again, these waste materials have high GCV as indicated in figure-6.

Benefits & Industrial Applications:

- By using these waste products can reduce the unwanted garbage and reduce the waste generation and can protect the environment.
- Sustainable manufacturing process with reduced emission.
- Possible way to use this bioenergy in a greener way in Paper Industry
- Partial or complete elimination of fossil fuel from Industry.

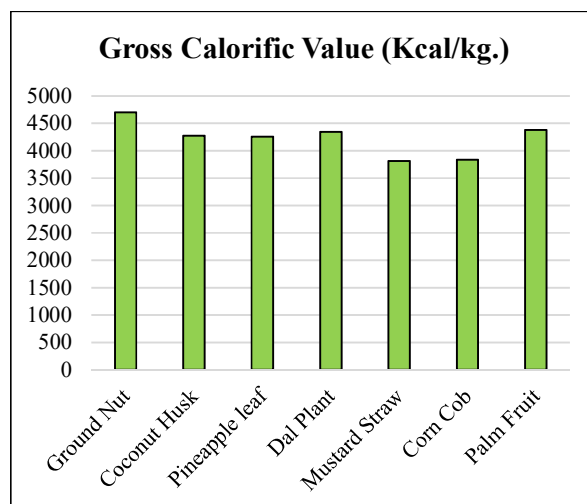


Figure-6: Gross Calorific Value (kcal/kg.)

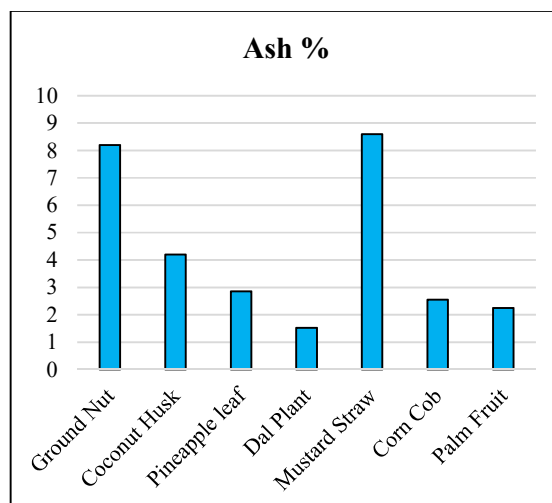


Figure-7: Ash %

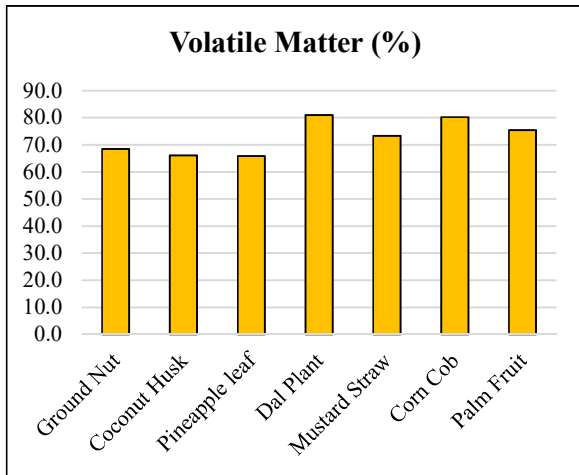


Figure-8: Volatile Matter (%)

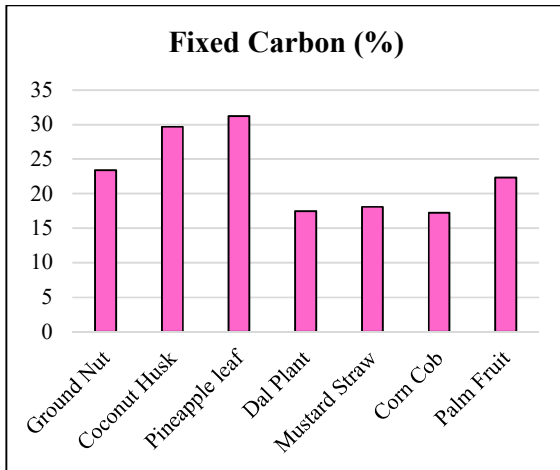


Figure-9: Fixed Carbon (%)

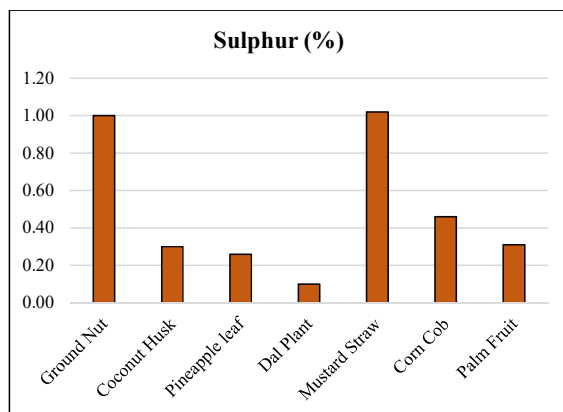


Figure-10: Sulphur (%)

4. Conclusion:

Agriculture waste as a clean and cost-effective material for generation of biofuel has a tremendous potential for applications in India. Bioenergy typically enhances the regional energy access and reduces use of fossil fuels. It can vitalize the agriculture sector and support increased use of renewable resources as feed stocks. Application of agriculture waste can protect the environment and protect the global climate change. As certain agricultural waste like Coconut husk, Pineapple leaf, Dal plant, Corn cobs & Palm fruit waste produces low ash and low sulphur content with high GCV can replace the use of fossil fuel.

5. References:

1. Kumar, Vineet, Pradeep Verma, Flavio Augusto De Freitas, Praveen Kumar Srivastava, Amit Vashishth, and Juliana Heloisa Pine Américo-Pinheiro. "A Critical Review on Biofuels Generation from Pulp-Paper Mill Sludge with Emphasis on Pretreatment Methods: Renewable Energy for Environmental Sustainability." *BMC Environmental Science* 2, no. 1 (2025): 2. <https://doi.org/10.1186/s44329-024-00016-0>.
2. Sahoo, Gyanaranjan, Amita Sharma, and Asim Chandra Dash. "Biomass from Trees for Bioenergy and Biofuels – A Briefing Paper." *Materials Today: Proceedings* 65 (2022): 461–67. <https://doi.org/10.1016/j.matpr.2022.02.639>.
3. Salameh, Tareq, Muhammad Tawalbeh, Mohammad Al-Shannag, Motasem Saidan, Khalid Bani Melhem, and Malek Alkasrawi. "Energy Saving in the Process of Bioethanol Production from Renewable Paper Mill Sludge." *Energy* 196 (April 2020): 117085. <https://doi.org/10.1016/j.energy.2020.117085>.
4. Mongkhonsiri, Ghochapon, Rafiqul Gani, Pomthong Malakul, and Suttichai Assabumrungrat. "Integration of the Biorefinery Concept for the Development of Sustainable Processes for Pulp and Paper Industry." *Computers & Chemical Engineering* 119 (November 2018): 70–84. <https://doi.org/10.1016/j.compchemeng.2018.07.019>.
5. Rao, P. Venkateswara, Saroj S. Baral, Ranjan Dey, and Srikanth Mutnuri. "Biogas Generation Potential by Anaerobic Digestion for Sustainable Energy Development in India." *Renewable and Sustainable Energy Reviews* 14, no. 7 (2010): 2086–94. <https://doi.org/10.1016/j.rser.2010.03.031>.
6. J. A, Japhet, Luka B. S, Maren I. B, and Datau S. G. "The Potential of Wood and Agricultural Waste for Pellet Fuel Development in Nigeria – A Technical Review." *International Journal of Engineering Applied Sciences and Technology* 04, no. 11 (2020): 598–607. <https://doi.org/10.33564/IJEAST.2020.v04i11.105>.