Conversion of Discarded Tender Coconut Shells Into Fuel: A Review

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Abstract- *Current Emerging issue is the management of solid waste. It is necessary to reduce the waste and dispose it properly. The Paper consists of Experimental brief study on conversion of used tender coconut shells into fuel. The Aim of this Project is to reduce the Amount of Solid Waste and also to utilize Waste into an effective fuels. Coconut Shells are being produced in Large Amount of Quantity in India. Tender coconut water is a natural drink which has high demand worldwide, particularly in tropical countries like India. However in major places due to lack of awareness tender coconut shells are simply discarded due to which environment degradation is created and thereby leading to waste management problem .Present study has been conducted to recycle them into effective fuel. It aims to convert into clean combustion fuel which will be applicable in domestic stoves leading to promotion of smokeless and eco-friendly practices in rural households. The conventional fuels made from coconut shells can also be used as supporting material for combustion, filtration and many such process. Present study aims in producing Activated Carbon and Briquettes from discarded tender coconut shells.*

Keywords*-* Tender coconut shells, Eco-Friendly, Environment, conventional fuels, combustion, waste management.

I. INTRODUCTION

When we heard word coconut or tender coconut shells, the first country to hit our minds is INDIA. Coconuts are used on regular basis for several purposes like marriages, ceremonies, temples, drinking purpose etc., everyone uses the water or white flesh inside it .After the usage it will be thrown out, as waste and this waste is enormous on roads of cities and in villages. Our focus is to utilize this waste in to a form as a household product as a part of solid waste management. A major portion of the coconut grown is used as tender coconut. Currently the tender coconut husk is not utilized in effective manner. As such the tender coconut husk is not usable for coir industry. Since the tender coconut husk is in soft form but with high moisture, with adequate fuel processing the tender coconut husk can be converted in to a valuable clean combustion fuel.

The coconut shell is hard and tough in nature (outside). This coconut shell in villages will be used as fuel for campfires, cooking purposes. Looking deep in that application point of view, it can be utilized as replacement for coal in villages and also in power plants.

In order to prevent the environmental degradation and to meet the ever-growing energy demand it is essential to develop new processes/ technology to convert this waste to energy. There are many cheap, easily available materials such as wheat husk, straw, palm fibre, rubber wood saw dust, Bamboo dust, date pits, palm fibre, coconut shell, groundnut shell, oil cake etc. which have been used as the source for the synthesis of activated carbon. They are used in the abatement of hazardous contaminants, treatment of municipal and industrial waste water, as catalyst or catalyst support in medicine and the recovery of valuable metals. Even activated carbon which will produce from discarded tender coconut shells has been used for the treatment of wastewater and significant colour reduction has been achieved.

Coconut shell is an agricultural waste which is available in very large quantities throughout the tropical countries of the world. Taking into consideration that approximately 15% of a coconut consists of the shell, world regional total quantity of coconut shells is around 9.3Mt/yr.With a calorific value of approximately5500kCal/kg, this quantity can replace about 6.9Mt/yr. of coal. (O. A. Sotannde 1*, 2017).

The effluents and sewage sludge discharged from many industries are the major causes of environmental pollution particularly in developing countries. The highly coloured effluents discharged during sugar production processes and molasses-based alcohol distilleries have remained one of the major environmental issues in many communities where sugar companies were sited. These effluents, when released into water bodies and farmlands, pose serious threat to aquatic life, soil microbes, crops as well as human life. This has made the reuse of industrial effluents an attractive option. Molasses-based effluent which is a solution of lower purity can be incorporated into fuel briquette technology. (O. A. Sotannde 1*, 2017)

To enhance sustainable and efficient fuel briquette production, careful considerations must be given to biomass residue selection based on availability and its ability to form good bond with binder and other biomass residues. The technology must also consider the appropriate biomass-binder ratio and selection of binder that can positively influence the briquette properties. (O. A. Sotannde 1*, 2017)

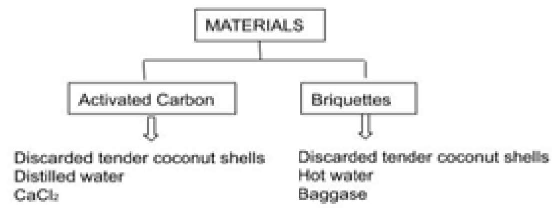
As environmental pollution is the major problem now a day's so need of activated carbon is growing day by day. Its texture characteristics and surface properties depend on the raw material and on the method used for its preparation. For AC, the removal of moisture is not required and it is easy for regeneration and has a high CO2 adsorption capacity at ambient pressure and also its good adsorption properties. (Dipa Das1, 2015)

Activated carbons can be prepared by either a physical method or chemical method. It is produced from a large number of carbonaceous raw materials like coal, lignite, wood and some agricultural product like rice husk, nut shell coconut shell, pea nut, sugarcane bagasse tamarind wood, saw dust and industrial waste products. The cost of Agricultural wastes are very low so it is considered to be a very important feedstock for preparation of AC. (Dipa Das1, 2015)

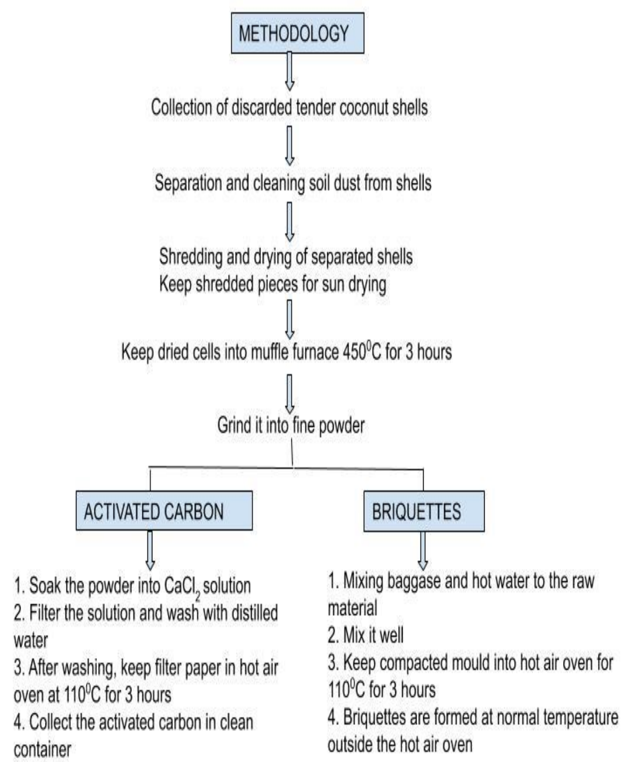
To prepare activated carbon from chemical activation, the steps are carbonization step and activation step. Raw material is impregnated with an activating reagent before carbonization step in chemical activation method. The effect of different chemical reagents on the production and quality of activated carbon was studied extensively by different researchers. (Dipa Das1, 2015)

Different chemicals are used like Zinc chloride (ZnCl2), phosphoric acid (H3PO4), Sulphuric acid(H2SO4), potassium hydroxide (KOH), sodium hydroxide (NaOH), and K2CO3. Chemical activation is better than physical activation process because it generally takes place at a lower temperature and shorter time and the development of a porous structure is better than that of physical activation. (Dipa Das1, 2015)

II. MATERIALS



III. METHODS



IV. RESULTS AND DISCUSSION

4.1 Briquettes

4.1.1 Compressed Density and Relaxed Density

The biomass material used and molasses content significantly influenced the compressed and relaxed densities of the briquette produced ($p < 0.001$). The type of biomass material used accounted for 40% and 61.5% of the total variations in compressed and relaxed densities of the briquettes while molasses content accounted for 51.4% and 25.1% respectively (Table 2). Coconut Shell (CNS) with coarser texture gave briquettes with higher compressed density averaged 0.80 g.cm-3 but lower relaxed density (0.73 g.cm-3) compared to Bambara Nut Shell (BNS) briquettes, which averaged 0.77 g.cm-3 and 0.75 g.cm-3 in both compressed and relaxed form respectively. (Sotannde, 2017). The Briquettes can also been made by using only Coconut shells.

4.1.2 Moisture Content of the Briquettes

Moisture content is one of the major indices for predicting durability and ignition behaviour of a briquette. The moisture content of the briquettes ranged from 4.93 – 8.02% with average of 6.94% in CNS briquette. With exception of CNS, briquettes produced from other biomass materials had the least moisture content when the molasses content was 30%. The moisture content range of the briquettes produced from the three biomass materials was quite encouraging and compared well with average of 7.10% recorded for sawdust briquette of , 2.50 – 6.76% for sawdust briquette from neem wood and 7.50 - 8.00% for some selected herbaceous plants. The low moisture content of the briquettes is expected to influence the durability and lower the energy required for water evaporation during combustion. (Sotannde, 2017)

4.1.3 Combustion Characteristics of the Briquettes

A) ***Percentage of Volatile Matter:***

The volatile matters are mainly the waxes, oils, resins, fats, tannins and aromatic compounds in a biomass material. They determine largely the ease of ignition and to some extent production of smoke during biomass combustion. The ease of ignition of the briquettes is largely dependent on the biomass material used as evidenced in 73.4% of the variance component while the binder content contributed 22%.The fuel related to smokeless grade is known to contain no more than 20% mass volatile substances. The values obtained in this study are much lower, so they can be considered as smokeless fuel. Meanwhile, the volatile matter of the briquettes from the three biomass materials decreased with increase inmolasses content up to 30%. Beyond this level (30% molasses content), further increase in molasses content resulted in lower volatile matter. Thus, binder content had significant effect on the burning rate of the briquettes. (Sotannde, 2017).

Table -1 Mean ±SD values of the average volatile matter, ash content, fixed carbon and heating values of the briquettes SD = Standard deviation

Biomass Material	Volatile Matter %	Ash Content %	Fixed Carbon %	Heating Value (MJ/Kg)
Coconut shells	9.96	6.21	83.83	32.12

B) Percentage of Ash in the Briquette:

Ash content is a function of the totality of inorganic mineral content in a biomass material notably calcium, potassium, magnesium, manganese and silica. They account for combustion remnant in form of ash. High ash content lowers the heating effect of the briquette. The biomass materials and molasses content produced significant effects on the ash content of the briquette ($p < 0.001$). About 70% of the total variation in the ash content of the briquette could be attributed to the biomass material used with molasses constituting about 23%.Briquettes produced from CNS-BNS mixture had the least ash content (4.48%) while CNS briquettes had the highest ash (6.21%).CNS briquettes had the highest ash (6.21%).The low ash briquettes have characteristic high heating energy value and are therefore suitable for both domestic and industrial fuel energy supply. (Sotannde, 2017).

C) ***Percentage Fixed Carbon of the Briquettes:***

The fixed carbon content varied significantly with biomass material and binder level used in briquette production ($p < 0.001$). The fixed carbon content of the briquette is largely dependent on the biomass material used in its production while the binder level accounted for 12.3%.Apart from the binder content, the difference could also be attributed to nature of briquetting materials and their compressed densities. Meanwhile, the percentage fixed carbon obtained in these briquettes is very high and within 84.7-96.9% obtained in carbonized. It is expected that the high percentage of fixed carbon and its smokeless flame will enhance the heat value and combustion duration of the briquette. (Sotannde, 2017).

4.1.4 Heating Value of the Briquettes

This is the most important combustion property for determining the suitability of a biomass material for fuel. It gives an indication of the quantity of fuel required to generate a specific amount of heat energy. The summation of the previous tests was reflected in the heating value. Approximately 76% of the total variation in heating value of the briquettes is traceable to the type of biomass material used in its production. Binder level on the other hand accounted for 17% of the heating value. Similar to volatile matter and fixed carbon content, the heating value increased with molasses content and peaked at 30% binder level. Beyond this, further increase in binder level resulted in significant decrease in the heating value. (Sotannde, 2017).

Calorific values and other relevant information mentioned in the following table. These briquettes can replace the coal usage and LPG usage in sun rising industries which are running on Thermal applications. Uses include domestic applications because of its less smoke and odour.(B.Koteswararao, 2016)

Table- 2 Specifications of Output (B.Koteswararao, 2016)

SR.NO.	NAME	SPECIFICATIONS
1	Calorific Value	2800-3600Kcal/Kg
2	Ash Content	10.5 %
3	Moisture Content	8.5 %
4	Volatile Matter	17-20%
5	Fixed Carbon	65-73 %
6	Foreign Matter	11-13%

The Test carried out by our team members the results were as follows:

Table-3 Actual Results of our Sample (Briquette)

Sr.NO.	PARAMETER	UNIT	RESULTS
1	Iodine Value	mg/g	210
2	Gross Calorific Value	Kcal/kg	5737

Briquettes were made using Coconut shells and Sugarcane Bagasse. Sugarcane Bagasse is used as Binder. The Calorific Value of Bagasse is around 2270 Kcal/kg. The Coconut shell has a high calorific value of 20.8 MJ/kg which can be used to produce steam, energy-rich gases, bio-oil, Biochar, etc.

4.2 Activated Carbon

4.2.1 Proximate and ultimate analysis

The results of proximate and ultimate analysis were shown in Tables 4 and 5. From this analysis it was observed that the fixed carbon content of AC was very high as compared to raw precursor, which results in better adsorbent for adsorption purpose. From the analyses it has been shown that the high volatile matter and low ash content of the precursor make it a good starting material for preparation of activated carbon. The carbon content of AC increases with the increasing of activation temperature from 500 to 600°C due to an increasing degree of aromaticity. In activated carbon hydrogen, nitrogen, sulphur and oxygen contents have been decreased because during pyrolysis and activation process, the coconut shell has been decomposed. During the decomposition, the volatile compounds containing mainly H, O, and N leave the carbonaceous product and the coconut shell becomes rich in carbon. Because $ZnCl_2$ removed the H and O away from the green coconut shell as H_2O and H_2 instead of removal of CO, CO_2 or hydrocarbons. From Table 5, it was observed that, the carbon content of activated carbons has been risen to from 41.185% to 72.04 wt. %; however, a decrease in the hydrogen and oxygen content from 9.416 to 2.963 wt. %, and 10.024 to 0.046 wt. % respectively. (Das, 2015)

Table-4 Proximate analysis of raw precursor and Activated carbon.

Sample	Moisture (Wt. %)	Volatile matter (Wt. %)	Fixed Carbon (Wt. %)	Ash (Wt. %)
Raw Precursor	1 1.834	44.969	40.633	2.564
Activated Carbon	2.983	17.208	78.907	0.902

Table-5 Ultimate analysis of raw precursor and Activated carbon. (Das, 2015)

Sample	C (%)	H (%)	N (%)	S (%)	O (%)
Raw Precursor	41.185	9.416	5.99	33.385	10.024
Activated Carbon	72.04	2.963	1.16	23.791	0.046

4.2.2 BET surface area and pore size distribution

Table 6 Shows the data related to total surface area, micro pore volume and micro pore surface area for activated carbon particle and raw precursor**.** Micro pore plays an important role for adsorption. Nitrogen adsorption was more in the case of activated carbon because of the presence of excess pores that developed during activation and carbonization that of raw precursor. In the case of activated carbon the small pore is called micro pore and the external surface areas consist of the meso pores and macro pores. (Das, 2015).

Table -6 Pore structure parameter for raw precursor and Activated carbon sample.

Sample	BET SSA (m^2/g)	V_{Tot} (cm^3/g)	V_{Micro} (cm^3/g)	A_{Micro} (m^2/g)	Avg. Pore radius (A^0)
Raw Precursor	59.728	0.05321	0	0	16.8461
Activated Carbon	995.799	0.4487	0.372	921.71	9.01198

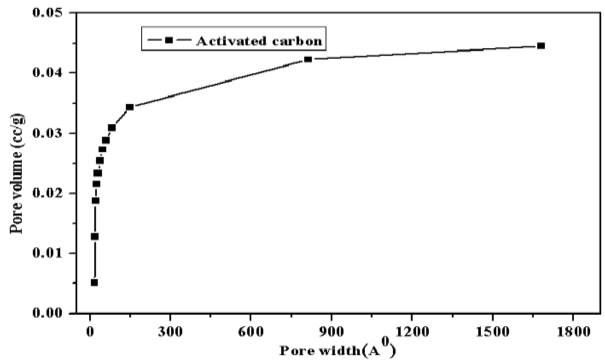


Figure-1 Pore size distribution plots of Activated carbon.

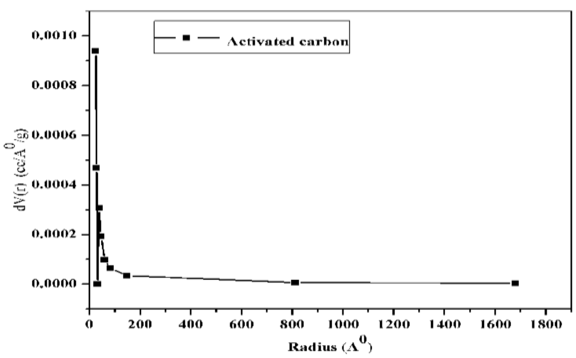


Figure-2 Pore width vs pore volume plot of Activated carbon. (Das, 2015)

V. CONCLUSION

This research reveals that coconut shell has the basic values required for a good fuel, such as high caloric value, low moisture content, low ash, low CO2, no offensive odour and low velocity on combustion compare to wood. The maximum and best use of a biomass, like fuel wood depends on the type of stove or cooking appliance used.

Therefore, where coconut shell is utilized as a fuel it will command a higher price than the traditional fuelwood thereby saving the people's income in addition to CO_2 free environment, reduced rate of deforestation and land degradation.

Briquette models made from the mixtures of rice husk and coconut shell charcoal have been successfully created in this research. Factors that might affect the content of heat energy value are moisture, volatile matter content, ash content, and the levels of fixed carbon. Briquettes with good physical and combustion properties can be produced from coconut shells. But the best quality briquette was produced when biomass residues were combined. Majority of the variations in briquette qualities were attributed to the type of biomass residues used with binder level also contributing significant effect.

The calorific value of these briquettes are much higher than normal wood and easy to carry. The operational cost is less compare to bulk quantity. The fuel produced is a good replacement for coal applications.

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