ASI

Carbon – Science and Technology

ISSN 0974 – 0546

http://www.applied-science-innovations.com

RESEARCH ARTICLE Received:10/03/2016; Accepted:17/04/2016

Shorea robusta: A sustainable biomass feedstock

Vishal Kumar Singh, Shubham Choudhary, Ramesh Chandra* and Dinesh Prasad

Department of Bio-Engineering, Birla Institute of Technology, Mesra, Ranchi-835215, Jharkhand, India

Abstract: The biomass feedstock needs to be available in a manner that is sustainable as well as renewable. However, obtaining reliable and cost effective supplies of biomass feedstock produced in a sustainable manner can prove to be difficult. Traditional biomass, mainly in the form of fallen leaves, fuel wood or dried dung, has long been the renewable and sustainable energy source for cooking and heating. Present study accounts for the biomass of fallen leaves of *Shorea robusta*, also known as sal, sakhua or shala tree, in the campus of BIT Mesra (Ranchi). These leaves are being gathered and burnt rather than being sold commercially. They contain water to varying degrees which affects their energy content. Hence, measurement of moisture content is critical for its biomass assessment. The leaves were collected, weighed, oven dried at 100^{o}C until constant weight, then dry sample was reweighed to calculate the moisture content that has been driven off. By subtraction of moisture content from the initial weight of leaves, biomass was calculated. Using Differential Scanning Calorimeter (DSC) the heat content of the leaves was calculated and the elemental analysis of leaf was done by CHNSO elemental analyser. Further, total biomass and carbon content of Sal tree was calculated using allometric equations so as to make a comparison to the biomass stored in dried fallen leaves.

Keywords: Sustainable, Shorea robusta, Biomass, moisture content, DSC, heat content, empirical formula, allometric

---

1 Introduction: Modern biomass and the bioenergy that can be extracted from it are estimated to contribute to the primary energy requirement of many countries in future. Biomass is a stored form of solar energy accumulated in plants by photosynthesis mainly in the form of cellulose, hemi-cellulose and lignin. Biomass is an important ecological indicator as it provides important information about fundamental ecological processes, energy capture as well as water and nutrient cycling because they are primary producers of the world that converts solar energy to chemical energy. So, in order to take the business of energy capture they also require water and nutrients. Therefore, the amount of biomass reflects energy capture as well as water and nutrient use. Biomass also acts as the indicator of species dominance as we generally assume that species that have the most biomass are the ones that are dominant in an area because of their access to these fundamental resources. Biomass can also provide information about carbon storage, hydrologic function as well as potential for conversion of plant biomass to animal biomass. Forests are one of the major biomass feedstock that is available in a manner which is sustainable as well as renewable. Hence, evaluation of forest's biomass from a region becomes important so as to determine the amount of desired products from them and to make sure that they are managed properly. According to Global Forest Resources Assessment (2010), world's forests accounts for 289 gigatonnes (Gt) of carbon in their biomass. India's forests contribute to about 8.58 to 9.57 GtC **[1, 2]**.

However, obtaining reliable and cost effective supplies of biomass feedstock produced in a sustainable manner can prove to be difficult. Traditional biomass, mainly in the form of fallen leaves, fuel wood or dried dung, has long been the renewable and sustainable energy source for cooking and heating. Moreover, fallen leaves are present over the life of plant and they are more sustainable than fuel wood because its use is associated with deforestation. Present study deals with the estimation of biomass of fallen leaves of *Shorea robusta*, also known as sal, sakhua or shala tree, in Mesra (Ranchi). The Sal tree is commonly known as Sakhua in the northern parts of India like Orissa, Jharkhand and MP. It is the state tree of Jharkhand and also has religious significance associated with it. Sal tree accounts for about 14% of the total forest area in India **[3]**. So, it is one of the important biomass feedstock. In this paper, we have attempted to estimate the biomass of fallen leaves of Sal tree and energy aspects for the same.

2. Methods and Materials

2.1 Study Site: BIT Mesra is situated in Ranchi, Jharkhand, India. The word, Jharkhand, literally means the land of forest cover, is located in northern part of India and shares its boundaries with Bihar in the north, West Bengal in the east, Odisha in the south and Chhatisgarh and Uttar Pradesh in the west. It has a geographical area of 79714km^2 and lies between 22^{0}00' and 24^{0}37' North latitude and 83^{0}15' and 87^{0}01' East longitude. The climate of the state in general is tropical with hot summers and cold winters. There are regional variations and some parts of the state like Ranchi, Netarhat, and Parasnath have a pleasant climate even during the summers. The recorded forest area of the State is 23,605 km^2, which is 29.61% of its geographical area. Dry Peninsular Sal is the most abundant forest type and occupies an area of 12700 km^2, which accounts for 53.80% of the total forest area of Jharkhand **[3]**.

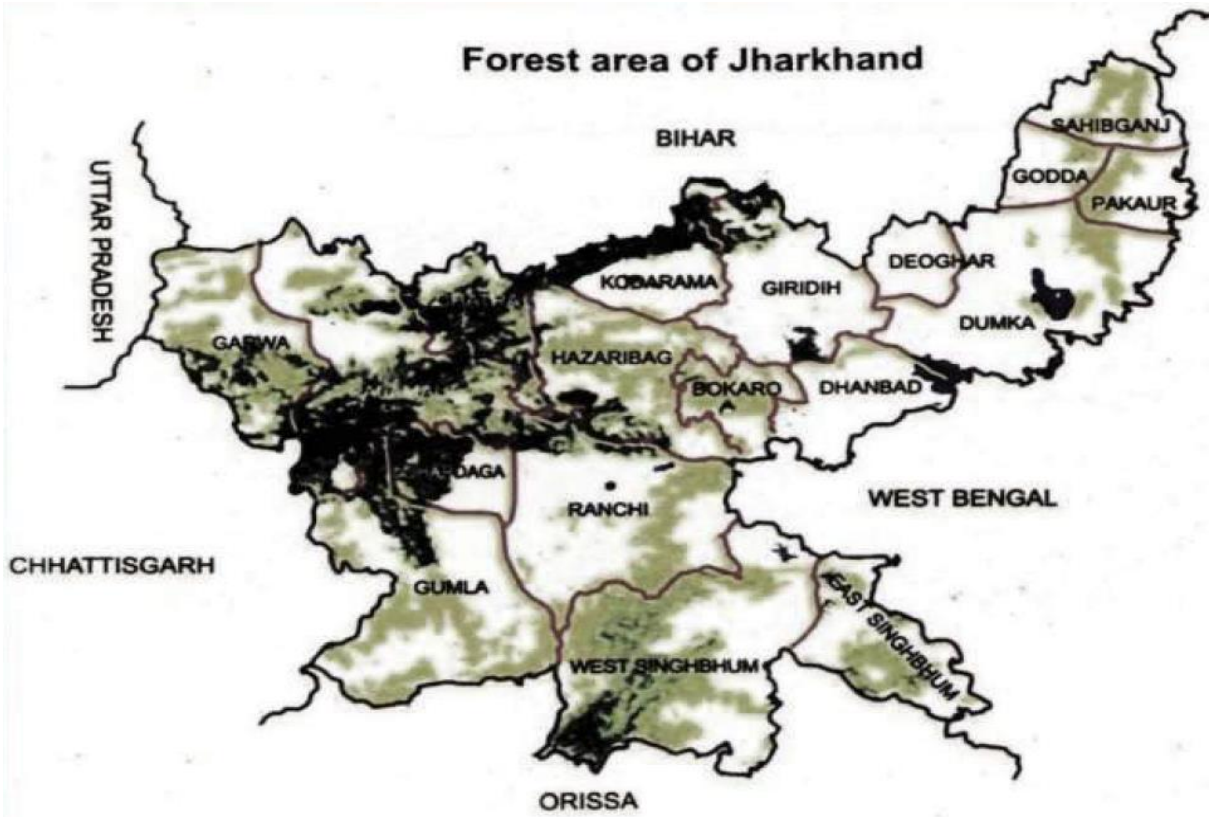

Figure (1): Jharkhand's Forest Cover (Adapted from: www.jharenvis.nic.in)

The study site was the BIT Mesra campus which is located in district Ranchi and has an area of 3.2 km^2 (780 acres), placed at the convergence of the rivers Jumar and Subarnrekha. The campus lies between the latitudes 23.41^{0}N and longitude 85.44^{0}E **[4]**.

Sample plots of 10 ×10 m were placed in forest area and then Sal tree density was calculated. To calculate the number of leaves in a tree we counted the number of leaves on a branchlet attached to the sub-branch of an underbranch. Then, the number of branchlet on a subbranch of that underbranch was counted. Next the number of subbranch on that underbranch was counted. Finally, the number of underbranch and branches on a tree was calculated. Finally all the data were multiplied to get the total number of leaves on a tree. Some branchlet was present on every underbranch. Leaves on this branchlet were also counted and the number of branchlet on an underbranch was counted. Then, this data was also added to earlier one to get more accurate figure. This gave us an approximate idea of number of leaves on a tree. Above procedure was repeated to get data for more trees.

Figure (2): Pictorial Representation of Bit Mesra (Adapted from: www.mapsofindia.com)

2.2 Moisture Content Determination: Steps used for the determination of moisture content are:

- Few fallen leaves of Sal tree were taken. Only dried leaves which had fallen down due to wind were taken and not the green ones.
- The leaves were weighed to get their initial weight.
- They were then dried in a hot air oven at 100^0C for 8 hours (after which they attained constant weight) and weight of each leaves was taken.
- The difference in the initial weight and the final constant weight gave the amount of water (moisture) in fallen leaves.

2.3 Determination of Heat Content: The steps used for heat content determination are:

- Few dried leaves were taken and grinded to make fine powder prior to DSC analysis by DSC Q10 V9.4 Build 287. An amount 1.5090 mg of powdered sample was taken in a crucible and placed on the sample pan. The reference crucible was placed at reference pan.
- The heating stage along with its oven was closed and the gas cylinder was opened to allow the inert gas flow into the sample chamber with flow rate 50ml/min.
- After setting the heat flow rate the experiment was started and a plot between heating rate and temperature was obtained. From the area of this curve we evaluated the heat content.

2.4 Elemental Analysis of Sal Leaf: Elemental analysis of leaf was done by CHNSO elemental analyser (Make: M/S Elementar, Germany; Vario EL). In the combustion furnace of CHNSO analyser carbon is converted to carbon CO_2, hydrogen to water, nitrogen to nitrogen gas and sulphur to SO_2. A variety of absorbents are used to absorb any additional impurity and combustion product. The combustion products are swept out using an inert carrier like helium. These are then heated over highly pure copper. The copper can absorb any excess oxygen present and converts nitrogen to its molecular state. These gases are then detected using GC separation and thermal conductivity detection.

2.5 Theoretical Estimation of Biomass of Sal Tree: The steps used for biomass estimation are:

- Diameter at breast height (DBH) of Sal tree was measured by diameter tape. The diameter was directly calculated by wrapping it around the tree at 4.5ft above the ground as these tapes are calibrated in units of pi, which is the ratio of circumference of any circle to its diameter.
- Above Ground Biomass (AGB) of the Sal tree was estimated using the following allometric equation-
  $Y = 0.0921 \times (DBH)^{2.5899}$
  This equation has been used earlier to calculate the biomass of primary species like *Shorea* spp., *Hopea* spp. and *Syzygium* spp **[5]**.
- Below Ground Biomass (BGB) of Sal Tree was calculated by using the equation **[6]**-
  $BGB = R \times AGB$
  where, R= root-shoot ratio =0.24(for Sal)
- Total biomass (TB) was obtained by the sum of AGB, BGB and dead organic matter of fallen leaves.
- Carbon content (C) was computed as - C=0.5TB

2.6 Data Analysis: Analysis of data was done using XLSTAT (2015.1) for Microsoft windows 8.1.

3 Results:

1. Moisture content with respect to wet weight is 0.45%.
2. Heat content is 242.8J/g when burnt up to temperature 140.49^0C (from Fig.4).
3. Elemental analysis shows that leaf sample contains C (47.5%), S (0.679%) and H (4.832%).

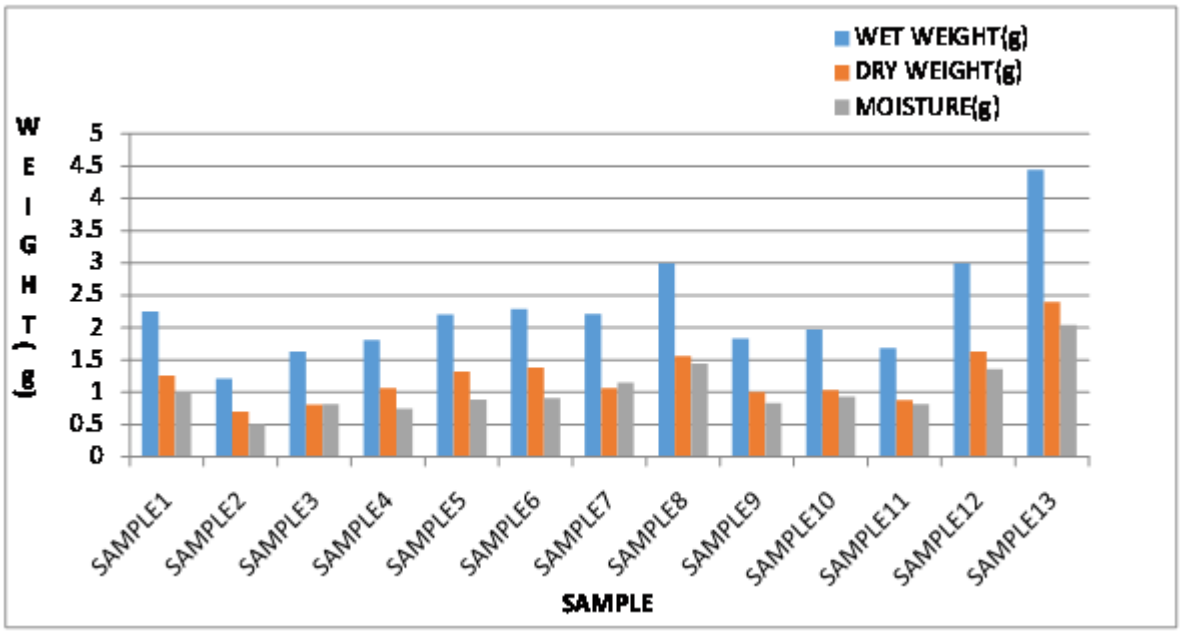

Figure (3): Moisture Content of fallen leaves

The total biomass of Sal trees is 565.75 ton ha^{-1}, was calculated from forest area of BIT Mesra campus which include Above Ground Biomass- 456.25 tonnes ha^{-1}, Below Ground Biomass- 109.51 tonnes ha^{-1}. The average Diameter at breast height of the Sal trees was between 25cm – 37cm and the density of Sal tree was approximately 600 trees ha^{-1}. Total carbon content 282.875 tonnes ha^{-1}.

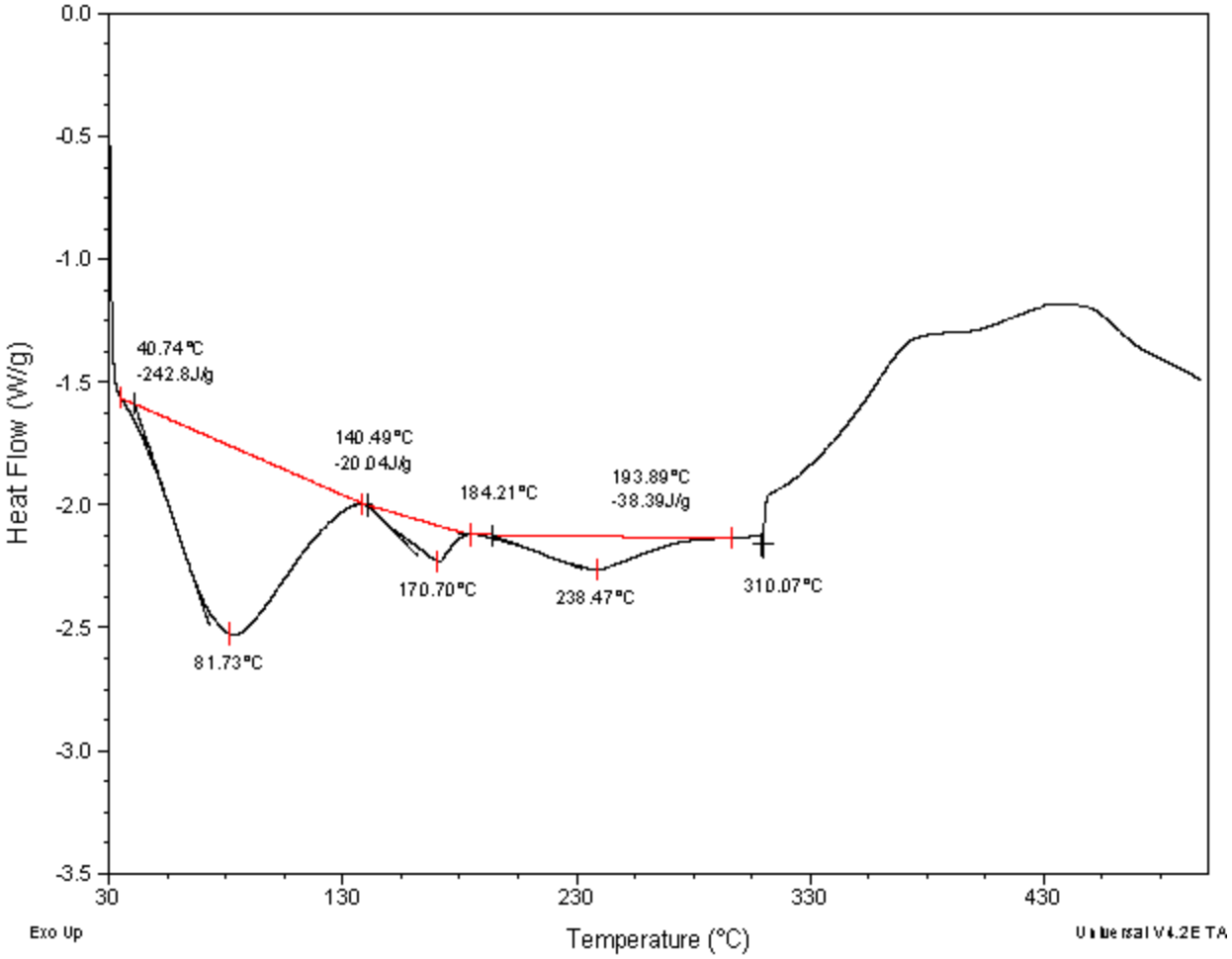

Figure (4): Differential Scanning Calorimeter of ***Shorea robusta*** leaf.

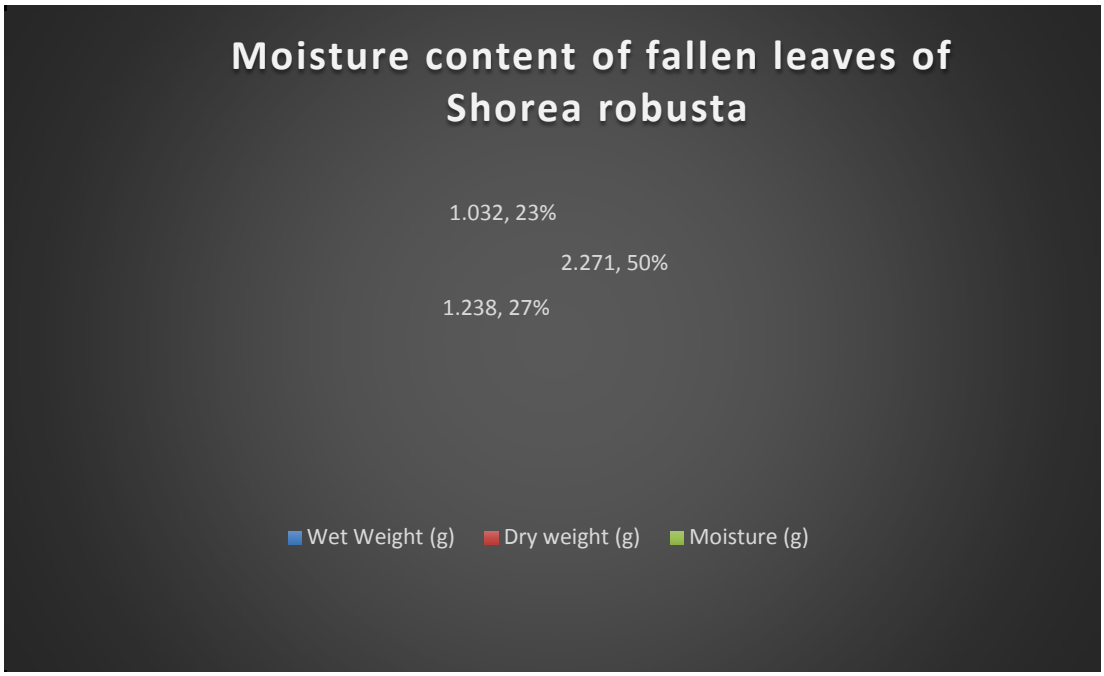

Figure (5): Moisture Content of fallen leaves of *Shorea robusta.*

4 Conclusions: This study provides relevant insight into the potential of Sal tree as a sustainable biomass feedstock. The total biomass stored in a single tree is 942.92 kg (since total biomass is 565.75 tonnes ha^{-1} and there are approximately 600 trees per hectare). However, sustainable biomass easily obtained from the Sal tree is only of the dried fallen leaf which is 92.88 kg. So, 9.85% of total energy of a Sal tree can be obtained without cutting the tree. This data may seem meagre at first sight but as we take account the total forest area covered by Sal tree we can easily assess the appreciable amount of energy residing in Sal.

References:

[1] G.S. Haripriya, Climate Change 56 (2003) 291.
[2] A. Chhabra and V.K. Dadhwal, Climatic Change 64(3) (2004) 341.
[3] Anonymous, "Jharkhand Forest," Available at: http://www.jharenvis.nic.in/WriteReadData/CMS/CBSE635089809322233501_Jharkhand%20Forest%20(Booklet).pdf (Accessed on: 14-01-2016).
[4] **Anonymous, "BIT Mesra," Available at:** www.bitmesra.ac.in (Accessed on: 14-01-2016).
[5] R.K. Heng and L.M. Tsai, Pertanika, Journal of Tropical Agricultural Science, 22(2) (1999) 117.
[6] G. Mandal and S.P. Mandal, International Journal of Environmental Biology 4(2) (2014) 157.

*****