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# Fuel Potential Evaluation of Commonly Available Biomass of Rajasthan

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***Abstract***– ***Management and disposal of biomass wastes, produced from different agricultural and agro-industrial activities, is normally an are handling, storage, boiler efficiency, deposit formation (slagging and fouling), agglomeration, corrosion and/or erosion, combustion instability, particulate carryover and ash utilization issues are also associated. Hence this study of biomass chemical investigation and their combustion behaviour will help in the selection of suitable biomass and combustion technology for their effective utilization as solid fuel for Industrial purposes. Here some grass species, fodder crop residue and tree leaves were selected for chemical characterization and their combustion properties for their utmost utilization as fuel and energy generation. Highest cell wall constituent (Lignocellulosic material) was found environmental problem. Biomass heating in domestic purpose is considered as a mature, and proven technology and has been used successfully for many years in all developing countries. The main constraints for its utilization as direct combustion for industrial purposes in Crop residues. Tree leaves contain lower amount of cellulose, lignin and hemicellulose in comparison to crop residue and grass species. Crop residue distinct itself due to highest content of cellulose and lignin whereas highest hemicellulose content was found in grass species. Total Ash, were found higher in Tree leaves. IR spectroscopic study also reveals the presence of chemical groups influences the heating value, binding properties and ash content of the agricultural waste***

***Key Words***– ***Lignocellulosic material, Fossil fuels, Cellulose, Hemicellulose, Lignin, Slagging and Fouling, High Heating Value, Agglomeration.***

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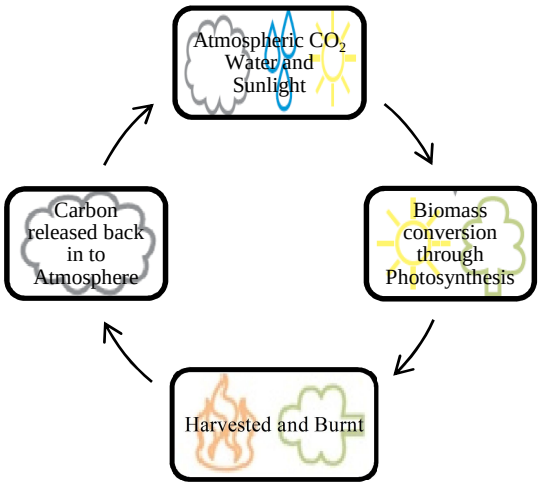
## I. INTRODUCTION

The potential use and management of renewable energy sources is necessary, if we have to achieve the changes required to address the impacts of global warming. Biomass stands as the third largest energy resources after coal and oil in the world. Its main constituent is Lignocellulosic material, which is the most abundant, least expensive, ever present renewable source for the production of bio-based product and Bioenergy. The energy stored by photosynthesis in the form of biomass is about ten times more than world's annual energy consumption [1].This source is the only alternative for energy generation after fossil fuels. Effective use of biomass represents a possible long term solution to the problem of dwindling petroleum and Fossil fuel reserves [2].

Biomass is a term for all organic material that obtained from plants (including algae, trees and crops) as well as living organism. Biomass is produced by green plants converting sunlight into plant material through photosynthesis and includes all land- and water-based vegetation, as well as all organic wastes. The biomass resource can be considered as organic matter, in which the energy of sunlight is stored in chemical bonds [3]. Typically photosynthesis

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converts less than 1% of the available sunlight to stored, chemical energy. When the bonds between adjacent carbon, hydrogen and oxygen molecules are broken by digestion, combustion, or decomposition, by extracting the energy stored in the chemical bonds and the subsequent 'energy' product combined with oxygen, the carbon is oxidized to produce CO2 and water. The process is cyclical, as the CO2 is then available to produce new biomass which is shown in Fig.1.
Biomass has always been a major source of energy for mankind and is presently estimated to contribute of the order 10– 14% of the world's energy supply [4].The value of a particular type of biomass depends on the chemical and physical properties of the large molecules from which it is made. Man for millennia has exploited the energy stored in these chemical bonds, by burning biomass as a fuel and by eating plants for the nutritional content of their sugar and starch. Biomass is available on a renewable basis, either through natural processes, or it can be made available as a by-product of human activities i.e. organic wastes. There is limited information regarding biomass chemical and structural constituent and their relation to the burning process. Kajan Kumar and Aditi Soni (2014) studied the nutritional content of common vegetation of Rajasthan [5]. Mineral status of this biomass was also studied by them [6]. Demirbas (2004) studied Combustion characteristics of different biomass fuels but this study is quite different because it describes about the chemical constituent of selected biomass and their individual elements role in burning and heat generation process [7].

## II. MATERIAL AND METHODS:

### A. Materials:

The study was carried out with three different biomass varieties, namely Grass (*Cencherus Ciliaris*), Crop residue (*Brassica Juncea*) and Tree leaves(*Prosopis Juliflora*) collected from Central Arid Zone Research Institute, Jodhpur situated in hot arid zone of western Rajasthan(26° 17' 12" N / 73° 1' 48" E).

### B. Sampling and preparation of samples:

Sampling and preparation of samples are carried out according to the international accepted method [8]. About 500 g fresh Matured plant leaves were collected and Individual contaminations were removed by thorough washing under running tape water followed by rinsing with distilled water, dried at $60^0$-$70^OC$ in a well ventilated oven or plant sample dryer till constant weight .The dried plant tissues are finely grinded in a grinder and passed through 100 mesh sieve. The grinded sample kept in air tight polythene container such as plastic bottles with screw cap to prevent adsorption of water from the humid environment and stored.

### C. Analysis Methods:

All the parameters were estimated by internationally accepted method. Dry material and Total ash content were determined by A.O.A.C (1975) [9]. The Lignocellulosic fraction such as Cellulose, Hemicellulose and Lignin were determined by the method of Goering and VanSoest, (1977) and VanSoest and Wine, (1968) [10 and 11]. Statically analysis is also carried out according to Snedecor and Cochran (1994) [12].
For IR investigation, 0.5mg of powdered sample (particle size ≤0.125 mm) was mulled with 200 mg dry KBR to produce an even distribution in KBr pellets. FTIR Spectra were recorded on ABB Bomem Spectrometer model MB3000 with Zn Se detector in transmittance acquisition mode over the wave number (500-4500 $cm^{-1}$) with a resolution of 4 $cm^{-1}$and 10 scan were averaged for each spectrum. Sample was run in a triplicate and all of them undertaken with a day period. The spectra were run and processed with a "HORIZON MB™ FTIR Software" Program.

## III. RESULTS AND DISCUSSIONS:

The result of Dry Material and Total Ash is shown in fig. 2. *Brassica Juncea* distinct itself with highest content of Dry material whereas Total Ash content was found maximum in *Prosopis Juliflora*. The Higher the dry materials, the higher

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amount Lignocellulosic materials are available for combustion.

Biomass usually in high moisture content resulting in a relatively low fuel calorific value [13].

In direct combustion, the hydrogen and carbon in a fuel combine with oxygen, a process which releases heat. This is the most common thermochemical method of converting biomass to energy. Biomass burns in three successive but overlapping stages, in first step, the contained water evaporates, and then there is distillation and probably combustion of volatile matters and finally the high temperature reaction of fixed carbon with oxygen. Only the last two steps release heat and provide us with energy [14]. Oxygen deficiency leads to incomplete combustion and the formation of many products of incomplete combustion. Excess air cools the system. The air requirements depend on the chemical and physical characteristics of the fuel. Direct combustion of biomass provides the majority of the rural population of the world with energy for cooking and heating. The chemical characteristics of lignocellulosic biomass are particularly important in combustion processes [15]. Therefore, these characteristics are important to the decision process for choosing combustion technologies. While energy content is affected by the carbohydrate content in the plant material, the non-combustible fraction (Inorganic constituent) is particularly important for combustion because of operational issues associated with boiler efficiency, boiler slagging and fouling, erosion and corrosion, combustion instability and particulate carryover [16]. The minerals that combine to form ash have no energy value, so the High Heating Value of a feedstock generally decreases as the ash content increases and consequently reducing boiler efficiency [17]. Silica (SiO2) is an abundant ash-forming mineral in crop residues that is abrasive, buffers acid reactions in pretreatment processes, adds to slagging problems in boilers. Maximum Ash content was found in Tree leaves.

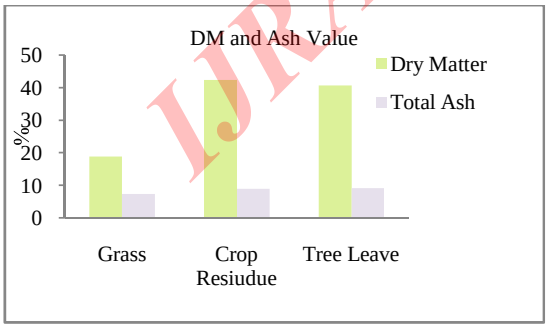



Fig. 2 Dry Matter and Ash Content

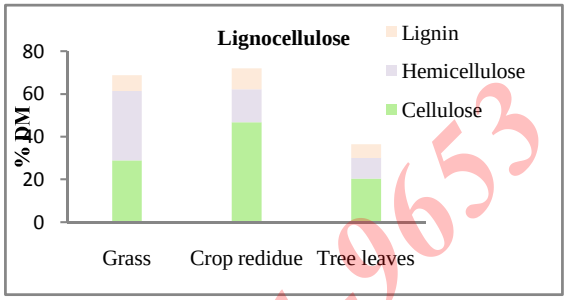



Fig. 3 Lignocellulosic Status

The main constraints for its utilization as direct combustion for industrial purposes are handling, storage, milling and feeding problems, deposit formation (slagging and fouling), agglomeration, corrosion and/or erosion, and ash utilization issues.

Cellulose is least energy producing component and main source of Char characterized by high surface area. Since Cellulose is a remarkable pure organic polymer, consisting solely of units of anhydroglucose held together in a giant straight-chain molecule [18]. It produces low heat content and energy after burning as comparison to Hemicellulose and Lignin[14].

Values of enthalpies are higher for the Hemicellulose than the cellulose; this component can be considered as highly energetic in regard to the fuels because unlike cellulose, hemicelluloses consist of different monosaccharide units. In addition, the polymer chains of hemicelluloses have short branches and are amorphous. Hemicelluloses are derived mainly from chains of pentose sugars, and act as the cement material holding together the cellulose micelles and fiber [19].

The High Heating Value of a lignocellulosic fuel is a function of its lignin content. In general, the HHVs of lignocellulosic fuels increase with increase of their lignin contents and the HHV is highly correlated with lignin content [18].

The empirical chemical formula of lignin is $C_{20}H_{19}O_{14}N_2$. Lignin is a complex, high molecular weight polymer built of hydroxyl phenyl propane units [20]. Lignin is a completely different polymeric material,

being highly cross-linked and having phenolic-like structures as the monomeric base. It is the lignin that holds the wood cells together and provides the extraordinary composite strength characteristics of a piece of wood. Lignins are

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polymers of aromatic compounds. Their functions are to provide structural strength, provide sealing of water-conducting systems that link roots with leaves, and protect plants against degradation [21]. Lignin is a macromolecule, which consists of alkyl phenols and has a complex three dimensional structure. Lignin is covalently linked with xylans in the case of hardwoods and with galactoglucomannans in softwoods [21]. The amount of Cellulose, Hemicellulose and Lignin are shown in Fig. 3. The amount of Total Ash is direct indication of Inorganic components present in biomass. It is also an inherent fuel property which is specified as a fuel characteristic and ash produced is partly dependent on the type and performance of the biomass plant it is being used in. In biomass, ash-forming matter can be present in four general forms: easily leachable salts, inorganic elements associated with the organic matter of the biomass, minerals included in the fuel structure and inorganic material - typically sand, salt or clay. Alkaline metals that are usually responsible for fouling of heat transfer surfaces are high in ash and are released in the gas phase during combustion. These inorganic compounds are in the form of salts or bound in the organic matter. Inorganic matter is bound mostly in Silicates, which are more stable at high temperature.

The chemical composition varies from species to species and within the same variety it varies

with the botanical origin, age and location in the tree (trunk, branches, crown and roots).

Mineral Components. Woody biomass is composed of many mineral elements. The principal elements include carbon, oxygen, and hydrogen. While these elements do not produce energy during combustion, they do affect the energy content of woody biomass.

*A. FTIR spectra analysis:*

The presence of chemical groups influences the calorific value, binding properties and ash content of the agricultural waste [15].

Fig. 4. shown the FT-IR spectra analysis of Biomass. The broad spectral band at 3441c m-1 was assigned to the stretching vibration of the hydrogen-bonded, alcoholic and phenolic hydroxyl groups [22]. Most of the remaining pronounced bands on the spectra were attributed to the fatty

acids and esters comprising lignocellulosic polymer. Strong absorption bands located at 2932, associated with the asymmetric or symmetric stretching vibrations of the methylene groups of general organic material content of the fibre [22], and smaller bands at 1404, which corresponded to methyl group bending vibrations due to lignin molecules. A relatively strong band at 1636cm-1 assigned to the O-H bending vibration of adsorbed water molecules or potentially hydrogen-bonded, C-O stretching vibration of the carbonyl bond in the ester group of lignin within the lignocelluloses polymer[23]. The aromatic domain of the Lignocelluloses was associated with a weak adsorption band located at 1650–1500 cm-1, which corresponded to the presence of phenolic compounds present in plant biomass [23]. Broad peak around 1065 cm-1 clearly indicates the higher content of cellulosic polysaccharides of carbohydrates [24]. The vibration located at 1,528 cm-1 is due to NH2 deformation and likely indicative of proteins or amino acids [25]. Bands at 1250cm-1 correspond to acetyl group present in pectin in lignin compound [26]. Pectin is also part of hemicelluloses. It is recognized that acetyl group occur generally in hemicelluloses [27]. A band at below 800 cm-1, corresponding to C-H and C-C out-of-plane bending vibration in the aromatic ring. A band at 2345cm-1 assigned to the presence of cyanide group as a secondary compound [28]. In all the spectra these bands are present but intensities of chemical groups were found to be varied from each other.

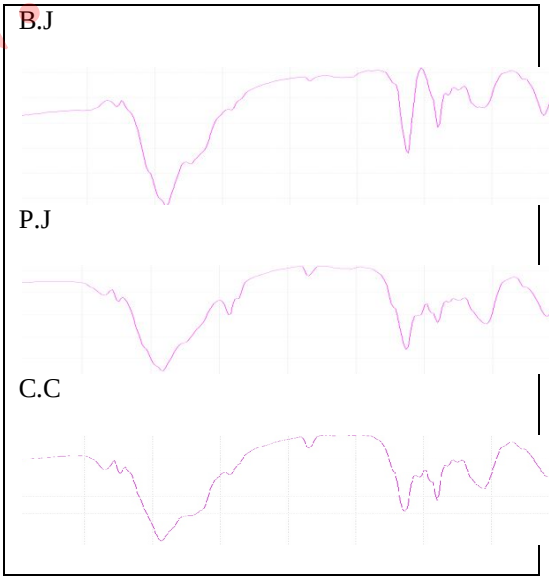



Fig. 4 FTIR-Spectra of Crop residue (B.J), Tree leaves (P.J) and Grass (C.C)

## IV. CONCLUSION AND RECOMMENDATION:

The result shown in above study indicates that all selected biomass are good source of feedstock for heat and energy

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generation. Since these biomasses are extensively distributed in this region, farmers of the area can very ideally use them as fodders as well as fuel for domestic purpose. The main constraints for its utilization as direct combustion for industrial purposes are handling, storage, milling and feeding problems, deposit formation (slagging and fouling), agglomeration, corrosion and/or erosion, and ash utilization issues involved.

On the basis of this study due consideration should be given to the utilization of biomass waste to enhance the quality and thereby optimizing the utility of these biomass wastes prior to use as fuel for combustion.

The knowledge of chemical constituent and their combustion strategy should help in identifying the suitability of this biomass residue for heat and energy generation on large scale. Abnormality of particular constituents in biomass can be removed accordingly and possible technical intervention can be made with the aim to enhance the utility of waste biomass for the production of heat and energy for large scale.

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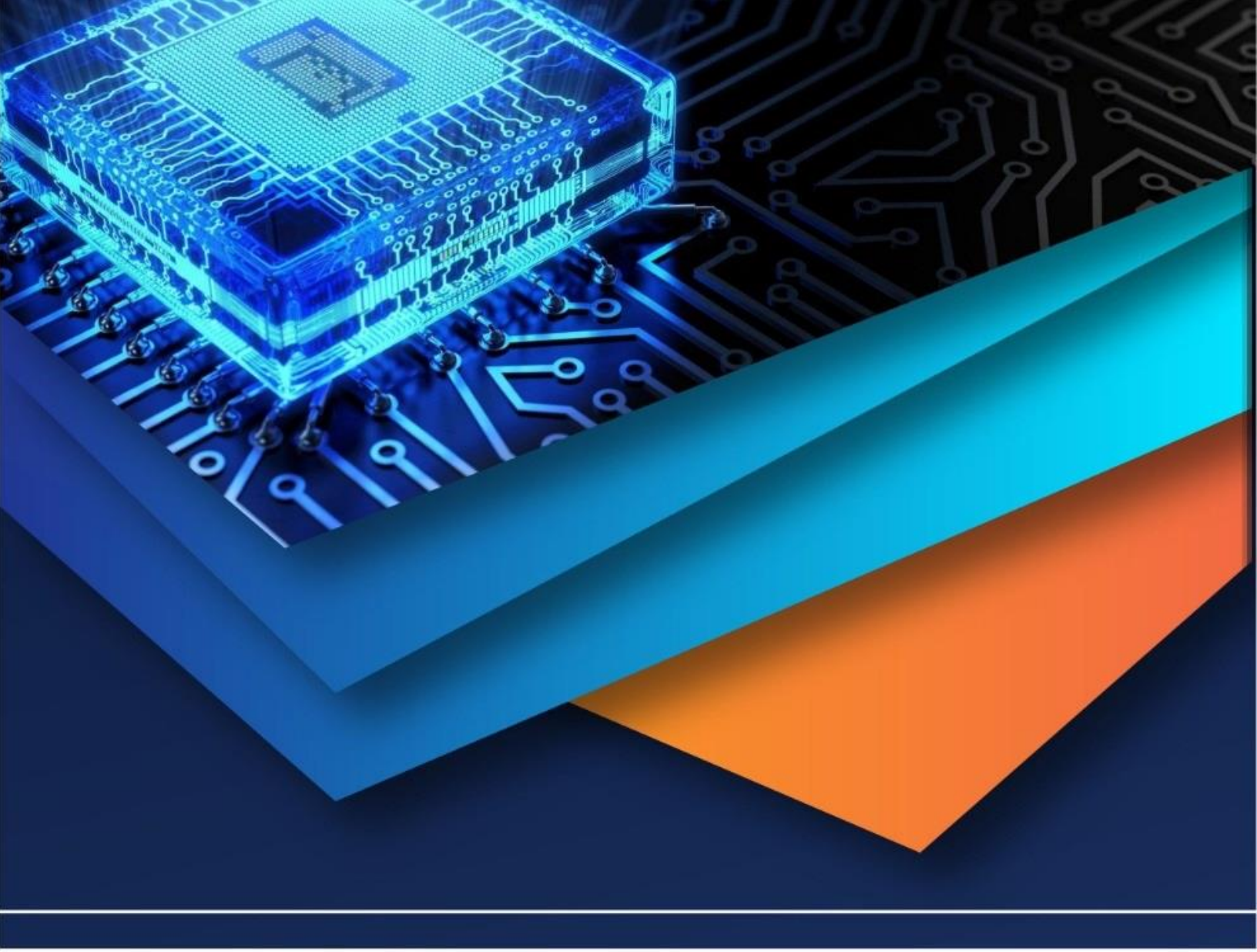
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