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Physical and Biochemical Assessment of Sugarcane Bagasse (Saccharum Officinarum)

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Abstract: ***Bagasse was milled into small size of 0.200152 mm volume surface mean diameter. The powder was found to be a rich source of many macro and micro nutrients, namely Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Iron, Manganese, Zinc, and Copper. FTIR spectrum indicates the possible presence of polysaccharides like cellulose, lignin and hemicelluloses, and polyphenols in the bagasse sample. Micro-images of the bagasse obtained through SEM shows the features of fiber structures. The fiber cells are cross-linked and surface seems to be rough and thick-walled. The fiber pith was found to have pits at some places. Proximate analysis through EDX shows the high proportions of Carbon (44.51%) and Oxygen (55.49%).***

Keywords: ***Biochemical, FTIR, Nutrients, Physical, SEM/EDS, Sugarcane Bagasse.***

I. INTRODUCTION

Sugarcane bagasse (*Saccharum Officinarum)* is a waste residue left after extraction of cane juice in a sugar mill [1]. Bagasse contributes to 25% of the total weight of sugarcane. Sugarcane bagasse is made up of two types of carbohydrate manly cellulose and hemicelluloses which are embedded in a lignin matrix [2]. Lignin is a phenolic macromolecule which are resistant to enzyme attack and breakdown [3]. Bagasse is mostly discarded as waste but it's a valuable resource which can be used as a boiler feed for energy generation in sugar and ethanol mills, renewable lignocellulosic material for biofuel production, as an animal feed, ingredient in composite materials, concrete and as biosorbent for adsorption of dyes [4]. The fibers from bagasse cannot be wasted since it is rich in valuable components and can be used for manufacture of economically, environmental friendly materials by extracting natural fibers [5].

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Hence, the characterization of bagasse is very important for its proper use and development of novel products. In this work, bagasse powder was prepared using ball mill followed by sieve fractionation of different size particles. The bagasse powder was checked for nutritional properties. Later physico-chemical characterization was carried out namely through scanning electron microscopy (SEM), Energy dispersive x-ray (EDX) diffraction and Fourier transform infrared spectrophotometer (FTIR). All these tools are key techniques that will help in identifying its possible recycle method and application.

II. EXPERIMENTATION

A. Collection of Bagasse

Sugarcane was subjected to conventional small-scale electric juice extractor from a local cane crusher in Bangalore, Karnataka wherein juice was separated from the cane. The residual biomass left after the extraction of juice is called as bagasse. The soft-core part pith of the partially dry bagasse was removed manually. The rind was discarded and soft pith core was cleaned thoroughly and shade dried. Dry Bagasse was subjected to size reduction into a fine powder using ball mill (Magnacon, India). Size characterization was done using Sieve equipment (Universal engineering, Bangalore) with known mesh cutoffs..

B. Nutritional analysis

Bagasse was characterized for nutritional content like carbon, Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Iron, Manganese, Zinc, Copper as per Jackson M.L, 1973, Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd, New Delhi and Piper, C.S., 1966. Soil and plant analysis. Hans Publisher; Bombay

C. FTIR Study

The Bruker-alpha FTIR spectrophotometer, Bruker, Germany was used to measures the infrared (IR) spectrum which are characteristic IR signal fingerprint of the molecular absorption and transmission of a particular types of chemical bonds (functional groups) present in dry powder of bagasse. The sample was used as such without any pretreatment and scanning was performed between the spectral ranges of 500-4000 cm^{-1} at a rate of 32, which gives a spectrum of distinctive "molecular fingerprint" which are later used to identify chemical bonds in the molecules.

D. SEM/EDS Analysis

Surface structure of bagasse, shape and particle size were taken on scanning electron microscopy (SEM) for three-dimensional appearance using JEOL, Singapore Model, JEOL JSM-7100F, Scanning Electron Microscope (FE-SEM) combined with a hot electron gun was used for imaging and chemical characterization of bagasse powder.

With a resolution of 1.2nm at 30kV and 3.0nm at 1kV, the instrument had a JEOL 129eV resolution silicon drift detector (SDD) for X-ray Energy Dispersive Spectroscope (EDS) for the elemental analysis.

III. RESULTS AND DISCUSSION

A. Nutritional content

The volume surface mean diameter of bagasse powder was 0.200152 mm and the same size materials were used throughout the studies. Bagasse was found to be a rich source of many macro and micro nutrients, namely Nitrogen (0.28 %), Phosphorus (0.10 %), Potassium (0.38 %), Calcium (0.19 %), Magnesium (0.16 %), Sulphur (0.04 %), Iron (145.2 ppm), Manganese (31.4 ppm), Zinc (18.54 ppm) and Copper (5.20 ppm). The same is represented in table 1.

Table- I: Nutritional properties of Bagasse.

Nutrient	Value in Bagasse
Total Nitrogen	0.28 %
Total Phosphorus	0.10 %
Total Potassium	0.38 %
Total Calcium	0.19 %
Total Magnesium	0.16 %
Total Sulphur	0.04 %
Total Iron	145.2 ppm
Total Manganese	31.4 ppm
Total Zinc	18.54 ppm
Total Copper	5.20 ppm

B. FTIR Spectrum analysis

The chemical structure of material is critical in understanding its nature which accounts for its behavior. FTIR spectrum in Figure I reflects the characteristic functional groups in powdered bagasse. When analyzing FTIR graph, the appearance of strong peak at 3443.80 cm^{-1} corresponds to the stretching vibrations of hydrogen bonded hydroxyl group in inter-and intra- molecular hydrogen bonding of polymers such as alcohols, phenols and carboxylic acids, as in pectin, cellulose and lignin, which, shows the presence of "free" hydroxyl groups on the adsorbent surface of cellulose and lignin. The absorptions of O-H stretching occur in the range of 3100–3600 cm^{-1}, therefore the observed peak can be attributed to OH groups present in lignin and carbohydrates. The stretch at 2925.23 cm^{-1} could be attributed to C-H aliphatic axial deformation in CH_2 and CH_3 groups from biopolymers like cellulose, lignin and hemicellulose. A broad stretch at 2061.27 cm^{-1} is designated to carbonyl, C=O functional groups of polysaccharides, while the sharp peak at 1632.77 cm^{-1} is attributed to –OH functional group along with C=C in the aromatic rings which gives an idea of polyphenols presence. Stretch at 1514.26 cm^{-1} is due to C=C rings vibrations of lignin component. Signal at 1423.20 cm^{-1} could be attributed to CH stretch of CH_3 and CH_2 units of biomolecules. Small tooth like stretch at 1383.09 cm^{-1} could be attributed to the methyl radical. The peak around 1260.81 cm^{-1} and 1051.61 cm^{-1} are due to the C–O stretching of polysaccharides like cellulose/hemicelluloses respectively. Small peat at 798.75 cm^{-1} could be assigned to Si-O-Si bond bending vibrations

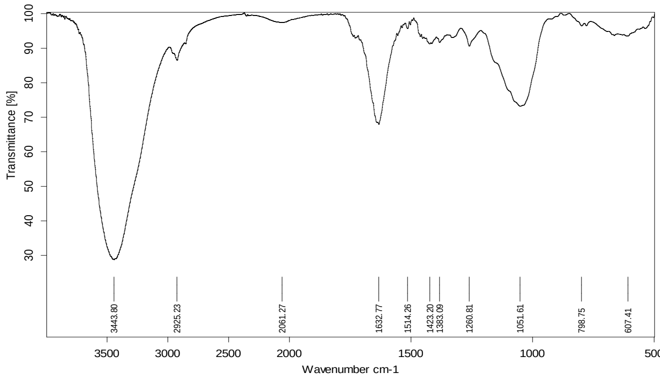
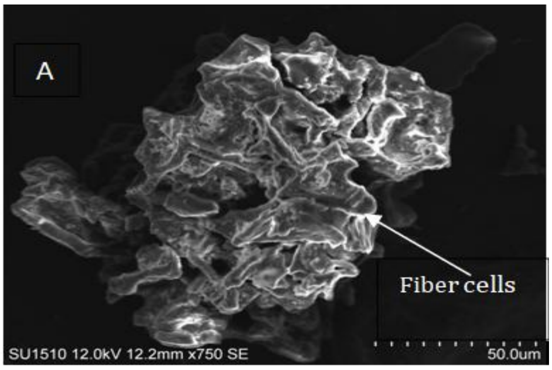


Figure I: FTIR spectrum of Bagasse

C. SEM/EDS Analysis

The use of SEM as an analytical technique proved to be highly important and versatile for studying the bagasse micro-structure. The micrographs obtained by scanning electron microscopy on the surfaces of grinded raw bagasse revealed the morphological features of fiber structures of the pith. The fiber surface seems to be rough, thick-walled and comprised of interlinked fiber cells with lots of space in between. The pith also contains pores called as pits at some places. Figure II (A to D) displays the SEM image of a sugarcane bagasse anatomy at different magnification. Energy dispersive x-ray (EDX) diffraction for elemental analysis of selected area (see point 1, 2 in figure III) in bagasse indicates that the bagasse contains predominately carbon and oxygen, and elemental composition in weight percentage is presented in Table II. The carbon is approximately 44.51% and Oxygen is around 55.49% by weight in the sample of bagasse powder.



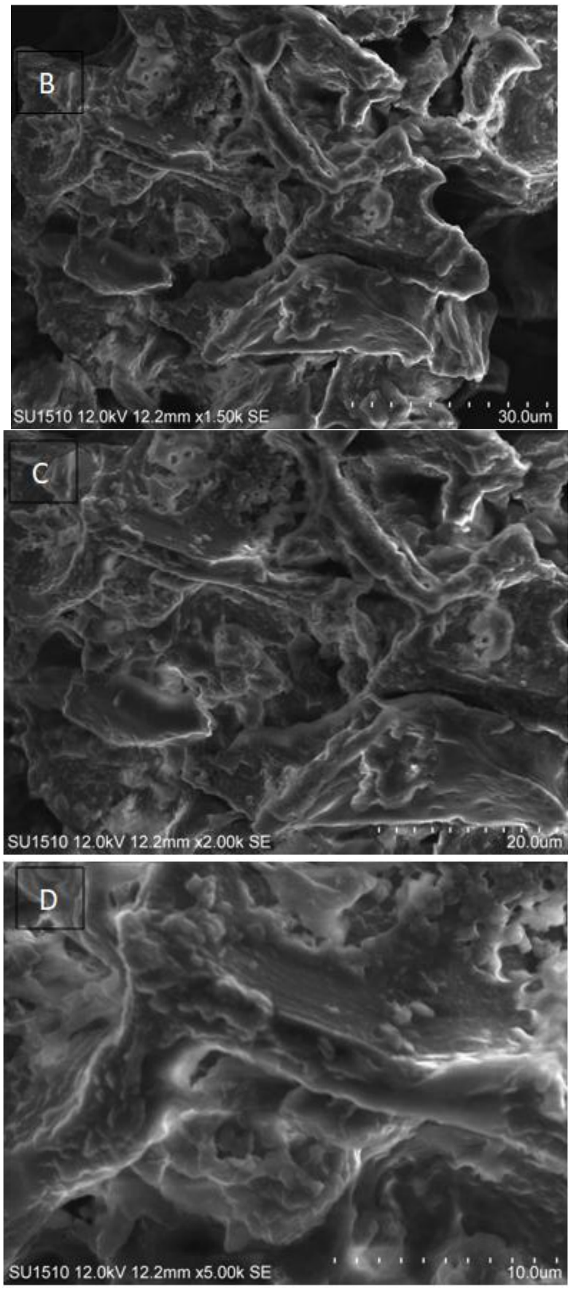


Figure II: (A to D) SEM image of a sugarcane bagasse structure at different magnification.

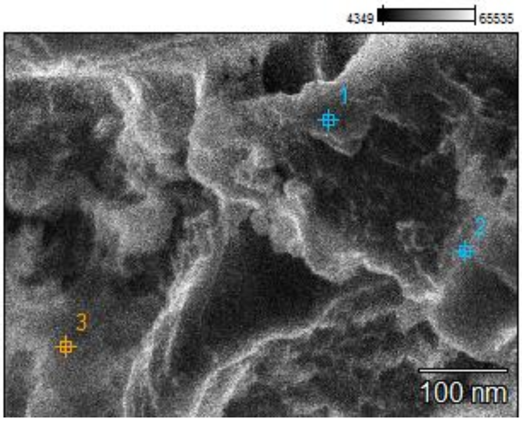


Figure III: Points checked for elemental analysis using EDX.

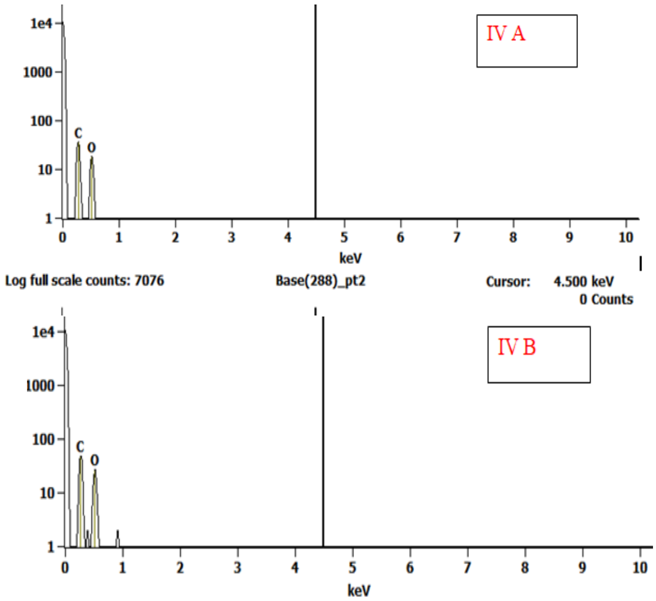


Figure IV (A, B). Energy dispersive x-ray (EDX) diffraction for elemental analysis at two spots (see Figure III) of Bagasse

Table- II: Elemental analysis of Bagasse using EDX

Weight %	*C*	*O*
Point 1	44.51	55.49
Point 2	42.42	57.58

IV. CONCLUSION

Bagasse was found to be a rich source of many macro and micro nutrients, namely Nitrogen (0.28 %), Phosphorus (0.10 %), Potassium (0.38 %), Calcium (0.19 %), Magnesium (0.16 %), Sulphur, (0.04 %), Iron (145.2 ppm), Manganese (31.4 ppm), Zinc (18.54 ppm) and Copper (5.20 ppm). FTIR peaks indicated the possible presence of polysaccharides like cellulose, lignin and hemicelluloses, and polyphenols. SEM Images shows the features of fiber structures of the pith. The fiber surface seems to be rough, thick-walled and comprised of interlinked fiber cells with lots of space in between. The pith was found to have pits at some places. Proximate analysis through EDX shows the presence of two basic elements in high proportions *viz.* Carbon (44.51%) and Oxygen (55.49%). The sugarcane bagasse predominantly consist of cellulose, lignin, hemicelluloses, therefore it is suitable for the production of paper, biodegradable food plates, packaging of food products etc. Till now the bagasse was either used for boiler feed, ethanol production or discarded as waste, but if it is recycled as paper, biodegradable food plates, or packaging of food products, it can reduce the usage of single use plastics and prevent the land and water pollution due to dumping of plastics. This will lead to sustainability of sugarcane waste and pollution prevention also. Additionally efforts can be made to explore possible applications of the sugarcane bagasse based on its nutritional profile, fiber strength, and nature.

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