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Characterization of paper and pulp properties from weed species

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ABSTRACT

The earth is covered with about 30% of forest land. Between the years 1990 and 2005, there was a net decrease (1.7%) in the global forest area at an annual rate of change of 0.11%. One of the major reasons for deforestation is logging of wood and using a substantial amount of this logged wood for the production of paper and pulp. Hence, non-woody plant species are being sought to complement the conventional process for paper and pulp production. In the present study, the chemical characteristics of three potential weeds *Merremia peltata* (L.) Merr., *Amaranthus viridis* L., and *Andropogon saccharoides* var. *erianthoides* Hack. which were locally available in abundance were analyzed through proximate analysis studies according to Technical Association of the Pulp and Paper Industry standard method. The results show that holocellulose content in *M. peltata* (L.) Merr., *A. viridis* L., and *A. saccharoides* var. *erianthoides* Hack. was found to be 64.19%, 73.26%, and 72.41%, respectively, which is found to be comparable with holocellulose content present in soft and hard wood trees. Furthermore, when the lignin content of *M. peltata* (L.) Merr. (19.46%), *A. viridis* L. (12.30%), and *A. saccharoides* var. *erianthoides* Hack. (22.19%) was analyzed in comparison with the other non-wood species such as sugar maple (21.79%), *Lantana camara* L. (26.93 ± 2.65%), and torpedo grass or *Panicum repens* L. Rank. (21.48%), a comparable result was obtained. These results affirm the potential of these species for use in pulp and paper industries. Furthermore, these species which are locally available can become a potential source of income if an organized effort to pool the biomass is considered.

1. INTRODUCTION

The supply of the preferred softwood is unable to meet the increasing demand for paper and pulp products. This has led to the diversification of different raw materials as supplies for pulp production [1]. Many societies have measured the level of civilization and development using the demand and the consumption rate of pulp and paper products as the basis [2]. As defined by the Oxford Dictionaries, paper is a "material manufactured in thin sheets from the pulp of wood or other fibrous substances." When moist cellulose fibers derived from different sources are pressed together and dried into thin, flexible sheets, a paper is formed. This versatile material finds several uses in packaging, cleaning, writing, and printing and in a number of industrial and construction processes. The bonds in the wood cells that hold together the woody cells are ruptured during the pulping process resulting in a fibrous mass, i.e., the pulp. Paper has a very distinctive ability to look fragile and strong, both at the same time. It is a biodegradable material and a potential alternative for plastic. For a long time, paper making process has involved the use of wood that are cut from tree stems, debarked, chipped and pulped [2]. According to the report on Ecology Global Network, the consumption of paper has grown over 400% in the past 40 years globally. Now, in every continent, paper industries use nearly 4 billion trees or 35% of the total trees cut around the world [3]. Paper has become an omnipresent part of the daily life by appearing in different forms and with different uses. We use paper in the form of tissue paper, cardboard packaging, stereo speakers, electrical plugs, etc. It has been estimated that on an average, 300 million tons of paper is consumed annually around the world. Virgin pulp is most commonly used to make the paper. However, 38% of the world's total fiber supply is from recycled paper and another 7% is from non-wood fibers obtained from plants such as hemp or kenaf. Although the United States (US) comprises only 5% of the world's population, it uses 30% of all paper! Around 200 billion dollars is generated by the forest and paper product industries using 28% of all woodcut in the U.S. This account for 7% of the total manufacturing output of the U.S. Furthermore, in regions with inadequate forest resources, there is a need to find non-wood plant fibers that are suitable for papermaking [4]. Moreover, wood cutting has become more difficult due to global warming and restrictions on carbon dioxide emissions. Although the price of wood pulp is unstable at present, it is expected to have an exponential rise in the long term [5].

Hence, it can be a boon if we can complement the pulping process with non-woody plant species, which are of less commercial importance or,

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in other words, weeds. The conventional approach of weed destruction is mass burning, which can contribute to the elevation of greenhouse gases. As we know, many of these weed species are pretty fibrous in nature, and they can be better exploited for eco-friendly strategies. Therefore, the present study concentrates on a few unexplored varieties of weeds which can be potential sources for paper and pulp generation.

To determine the suitability of certain invasive weed species that are available in abundance in the vicinity of North Bangalore for pulp generation is the main objective of this study. *Amaranthus viridis L.*, also known as slender amaranth or green amaranth, is a cosmopolitan species which belongs to the Amaranthaceae family. With an upright, light green stem, *A. viridis* L. grows to a height of 60–80 cm having branches originating from the base, this annual herb possesses ovate leaves which are 3–6 cm long and 2–4 cm wide and petioles of about 5 cm. It also has terminal panicles and small green flowers with 3 stamens [6]. Originally from the American tropics, the plant can be cultivated in a wide range of zones from the temperate through to many parts of the tropics. It requires a hot sheltered, well-drained fertile soil to do well. A prolific producer of seeds, the plant has often escaped from cultivation outside its native range and become a weed; often prostrate, flattened; found in waysides, vacant fields, crevices in the pavements, margins of asphalt strips, etc. [7]. Occasionally, it is spotted in croplands and wastelands as well [8].

Andropogon saccharoides var. *erianthoides* Hack. is a species of plant herb which belongs to the family of Poaceae. A synonym of this is *Bothriochloa saccharoides*. It is often used for thatching roofs. Commonly known as silver bluestem, it is found in plains, prairies, and rocky slopes, especially in limestone areas, often during the months of June–August (Silver Bluestem).

Merremia peltata (L.) Merr. is a coarse climbing vine with underground tubers and is commonly known as Big Leaf (GISD 2016). It is an invasive plant majorly found in the Pacific region, and it invades both dry lowland and mesic inland natural communities [9]. In general, found in gardens, pastures, and forest plantations, this species propagates either vegetatively or by seeds. Its ability to rapidly sprawl is conveniently used as ground cover to reduce erosion and nutrient losses.

2. MATERIALS AND METHODS

2.1. Plant Samples

To evaluate the suitability and feasibility in production, it is essential to determine the composition of the raw material [2], and hence, the study focuses on determining the chemical composition of three selected species, namely *A. viridis* L., *M. peltata* (L.) Merr., and *A. saccharoides* var. *erianthoides* Hack (Figure 1). The wild varieties of *A. viridis* L. and *M. peltata* (L.) Merr. plants were collected from North Bangalore area. Wild *A. saccharoides* var. *erianthoides* Hack. plants were collected from the Sir M. Visvesvaraya Institute of Technology campus. The raw material used in this study was the plant stem/stalk. To ensure that variations are kept to minimum, all the raw materials were taken from one harvest.

2.2. Processing of Plant Samples and Proximate Analysis

The samples were cleaned and cut into chips 2.0–2.5 cm in length. The chips were ground into a coarse powder and the portion passed through 35 meshes and retained on 60 meshes was used for determining the chemical composition. The ground samples were used for the experimental work on air dried (A.D) basis. The study involved carrying out the Proximate Chemical Analysis which was conducted as per Technical Association of the Pulp and Paper Industry Standard method [10]. Each sample had three replications, and the results were obtained as an average of the replications.

3. RESULTS AND DISCUSSION

A study of the chemical composition of the plant species is necessary to have a better understanding of their characteristics and there by determining their pulping process [11]. The results of the proximate chemical analysis are recorded in Table 1. It indicates the suitability of *M. peltata* (L.) Merr., *A. viridis* L., and *A. saccharoides* var. *erianthoides* Hack. for papermaking. Plant material of *M. peltata* (L.) Merr. contains 64.19% of holocellulose and 19.46% of lignin. The hot water and cold water solubility was 12.35% and 8.81%, respectively. The alcohol benzene ratio was 5.19%. Furthermore, 1% NaOH solubility is of importance in assessing the soundness of wood for decay and value ranging from 10% to 30% is normally considered adequate for further investigations [12]. The 1% NaOH solubility was 36.84% indicating that this plant material is more susceptible to decay. The ash content was 7.0%. The plant material of *A. viridis* L. contains 73.26% of holocellulose and 12.30% of lignin, which is favorable. The hot water and cold water solubility was 21.03% and 19.71%, respectively, indicating high amounts of extraneous components. The alcohol benzene ratio was 2.5%. The 1% NaOH solubility was 43.04% indicating that this plant material is highly susceptible to decay. The ash content was 11.25%.

A. saccharoides var. *erianthoides* Hack. was found to contain 72.41% holocellulose and 22.19% lignin. The hot water and cold water solubility was 7.55% and 6.75%, respectively. The alcohol benzene ratio was 3.75%. The 1% NaOH solubility was 39.20%. The ash content was 6.75%.

Table 1: Comparative proximate chemical analysis of different weed species used in the present study

Parameters (%)	*M. peltata* (L.) Merr.	*A. viridis* L.	*A. saccharoides* var. erianthoides Hack.	Sugar maple [14]	*Lantana camara* L. [12]	Torpedo grass [11]
Ash	7.0	11.25	6.75	0.84	2.3±0.19	7.39
Cold water solubility	8.81	19.71	5.40	0.52	n.d.	13.40
Hot water solubility	12.35	21.03	7.55	1.20	7.25±0.35	15.83
1% NaOH solubility	36.84	43.04	39.20	n.d.	18.75±0.97	51.97
Lignin	19.46	12.30	22.19	21.79	26.93±2.65	21.48
Solvent extractives	5.19	2.5	3.75	1.22	5.10±0.67	8.30
Holocellulose	64.19	73.26	72.41	75.96	66.0±2.50	62.25

M. peltata: Merremia peltata, A. viridis: Amaranthus viridis, A. saccharoides: Andropogon saccharoides

Figure 1: Weed species used in the present study. (a) *Merremia peltata* (L.) Merr. (b) *Amaranthus viridis* (L). and (c) *Andropogon saccharoides var. erianthoides* Hack

The results of 1% NaOH solubility for all three samples under study indicated that they are highly susceptible to decaying. Furthermore, the results of solvent extraction with ethanol benzene (1:2) mixture indicated that the samples contained low amounts of solvent-soluble, non-volatile material. The ash content of the samples under study was higher by nearly 7% in comparison to soft wood and hardwood which have 0.4% and 0.84%, respectively [13,14].

The results of the present study indicated very good concentrations of holocellulose (60% to 70%) in comparison with the conventional soft and hardwood sources (75% to 85%) [13,14]. The literature studies also suggest that potential weed species such as Torpedo grass, Water hyacinth, Giant bulrush, and Lantana can also be the better sources of fibers for pulping [11,12]. Complementing these weed based pulp along with the conventional sources would be a viable alternative for weed management. Reports also suggest the utility of agricultural wastes such as rice husk, straw from cereal crops, and cottonseed hull fibers for pulp production. However, the biomass requirements may be more. However, effective pooling can satisfy the required quantities.

4. CONCLUSION

With the proximate analysis values, we can conclude that these samples can be proposed as potential sources to complement the conventional ones. They open horizons to explore other weed varieties and also reduce the burden on the trees and thus the environment. They also provide opportunities for better management of weeds and production of value-added products using these sources. A proper awareness about the better utilization of such weeds cum agricultural wastes toward paper production will benefit both farmers as well as the environment. To add value, a community for pooling the potential biomass can be formed, and localized small-scale manufacturing units can be set up. This can provide opportunities for employment and waste management at community level.

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