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FERMENTATION STUDIES OF WATER HYACINTH, CATTAILS AND DUCKWEEDS OBTAINED FROM AMRAVATI REGION

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Abstract: The effect of dilute acid pretreatment and alkali pretreatment on the various aquatic weeds viz. Water hyacinth, Cattails and Duckweeds found in the Amravati region were studied. A common yeast *Saccharomyces cerevisiae* was used for the fermentation studies. The utilization of these aquatic weeds for the production of bioethanol adds value by saving the consumption of petroleum products in the country. The use of bioethanol reduces the emission of greenhouse gases. The aquatic weeds were first subjected to pretreatment processes using dilute sulphuric acid and sodium hydroxide to remove the lignin barrier followed by fermentation of the sugars into ethanol. Approximately 80 % of theoretical ethanol yield was obtained during this investigation. Dilute acid pretreatment was found to be a better choice than alkali pretreatment as it results in higher ethanol yield.

Keywords: Acid Pretreatment, Alkali Pretreatment, Aquatic Weeds, Bioethanol, Fermentation

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INTRODUCTION

Alternative and renewable energy resources have recently become a high priority worldwide. These renewable energy resources have become quickly popularized due to their lack of environmental risks and pollution; they are favorable alternatives to fossil fuels and their derivatives. In addition to their sustainable favorability, they are, in general, more evenly distributed over earth's surface than fossil fuels and may be exploited using expensive technologies. Hence they increase the scope for diversification and decentralization of energy supplies and the achievement of energy self-sufficiency at a local, regional, and national level [1]. Lignocellulosic biomass represents a renewable source of raw feedstock for conversion into liquid and gas fuels, [2].

A fundamental characterization of biomass as a feedstock is required for bio-fuel and chemical production, which exhibit very different properties with respect to traditional fossil fuels and their derivatives [3]. However, all biomass differs greatly in their composition depending on the climatic conditions and seasonal variation. Furthermore, characterization of biomass is imperative as the chemical composition of biomass affects the conversion processes differently. Biomass feedstock composition determines the theoretical yield from a biochemical conversion, and can thereby have a significant impact on conversion process.

The aquatic plants under consideration as lignocellulosic biomass source in this investigation are Water hyacinth, Cattails and Duckweeds. These weeds occur worldwide and are considered as the worst weeds due to their enormous rate of growth.

These plants pose a variety of problems to the environment and therefore numbers of mechanical, chemical, biological eradication methods are being adapted worldwide to control the growth of these weeds.

These aquatic weeds are abundantly available worldwide. The availability of biomass of the world is 220 billion oven-dry ton (odt) per year or 4500 EJ (1018 J) [4]. It is the world's largest and most sustainable energy resource. Increased utilization of bioethanol produced from biomass can reduce the fossil fuel consumption. The advantages of this process are to reduce the greenhouse gases in compared to fossil fuels and also solve the difficulties of the dependence of imported fossil fuels for many countries [4]. Biomass refers to plant derived organic matter that is available on a renewable basis.

Lignocellulosic biomasses includes agricultural crop waste, forest residues, aquatic plants, energy crops residues etc and are about 50% of the all biomasses. It is mainly consist of cellulose, hemicellulose, and lignin. Cellulose is composed of monomers of glucose, a six sugar linked by β (1–4) glycoside bonds. Hemicellulose is a highly branched carbohydrate and is composed of both hexose and pentose sugar. Lignin is a macromolecular in nature with phenolic character; it is helical and contains ether and carbon–carbon linkages. Lignocellulosic biomass is one of the promising renewable feedstocks for production of biofuels.

2. MATERIALS AND METHODS

Water hyacinth plants were collected from the *Purna* river tributary near Kholapur, Amravati (20N56 77E20), Cattails and duckweeds were collected from a pond located at Kathora road, Amravati (20N58 77E50), Maharashtra,India .

The plants stems were cut near to root and the whole plants were used for the experiment. The plants were washed with tap water several times to remove any adhering dirt and were cut in to pieces of 2-3 cm size.

The plant biomass were allowed to dry in sunlight .The dried biomass was cut in to pieces of 2-5cm size and further pulverized in a grinder (Bajaj Electricals, India) to the size range of 0.5 to 0.75 mm. The powdered biomass was again dried in sunlight for 1month to remove left over moisture. The moisture free samples were further used in this study.

The chemicals used in the experiments were reagent grade. All the experimental procedures were repeated three times. The experimental data presented are the average of the three such readings. The overall experimental steps are presented in Fig. 1.

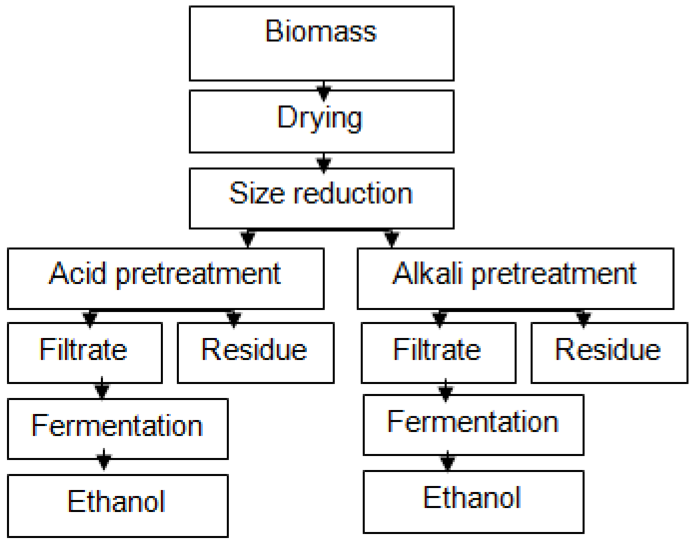


Fig 1 schematic diagram of biomass pretreatment

100 gram raw dry powdered samples of each biomass i.e. Water hyacinth, Cattails and Duckweed were mixed with 2% (v/v) solution of Sulphuric acid and Sodium hydroxide. The biomass to reagent ratio was maintained at 1:10. All the samples were soaked in acid and alkali for 30 minutes then these samples were heated to 150^{0}C for about 10 minutes.

The treated biomass samples were filtered to a double layer muslin cloth and further washed with water until neutral pH is obtained. The residue is subjected to SEM analysis to study the effect of pretreatment methods on the morphology of the biomass samples. The filtrate is autoclaved at 121^{0}C, 15psi for 30 minutes. After autoclaving, the pH of the hydrolysate in adjusted to 5.0 by adding small amount of dilute sulphuric acid. The hydrolysates are fermented by S. *cerevisiae* culture medium containing (in g L^{-1}): yeast extract, 3; malt extract, 3; peptone, and glucose, 5.

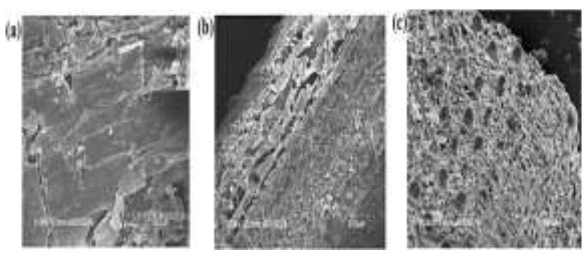
After 3 days of fermentation all samples were subjected to distillation. The concentration of ethanol obtained was determined spectrophotometrically.

Table 1: sugar release from biomass samples

Method	Sugar release mg/g		
	W.Hyacinth	Cattails	Duckweed
Acid treatment	136 ± 0.69	2 ± 0.51	11 ± 0.24
Alkali treatment	19 ± 0.61	1 ± 0.12	9 ± 0.60

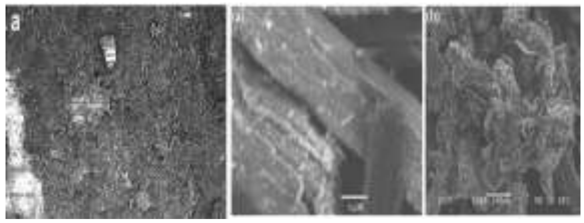
Table 2: ethanol yield from biomass samples

Method	Ethanol yield g/L		
	W.Hyacinth	Cattails	Duckweed
Acid treatment	18 ± 0.69	2 ± 0.69	10± 0.69
Alkali treatment	11± 0.69	1 ± 0.69	7 ± 0.69



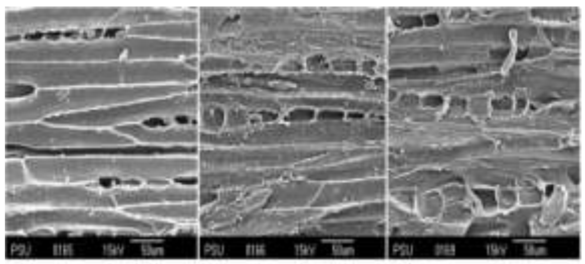
(a) (b) (c)

Fig 2: SEM images of (a) raw Water hyacinth, (b) after acid pretreatment (c) after alkali pretreatment.



(a) (b) (c)

Fig 3: SEM images of raw Cattails (a) (b) after acid pretreatment (c) after alkali pretreatment



(a) (b) (c)

Fig 4: SEM images of raw Duckweeds (a) (b) after acid pretreatment (c) after alkali pretreatment

3. DISCUSSION

Figure 2, 3 and 4 show, respectively, the SEM micrographs of the Water hyacinth, Cattail, and Duckweed for the untreated specimen, after pretreatment with H2SO4, and after pretreatment with NaOH.

The untreated specimen exhibit higher order and compact fiber structures, while both the pretreated samples reveal higher degrees of porosity and external surface area. The pretreatment process thus could effectively decrease crystallinity of the cattail fiber similar to that reported for corn leaf [5]. This indicates that a large fraction of lignin and hemicellulose can be removed by acid and alkali pretreatment.

As shown in Figures, the porosity of the pretreated biomass was obviously increased and breakdown of irregular materials that tightly wrapped the biomass was also observed after the pretreatment.

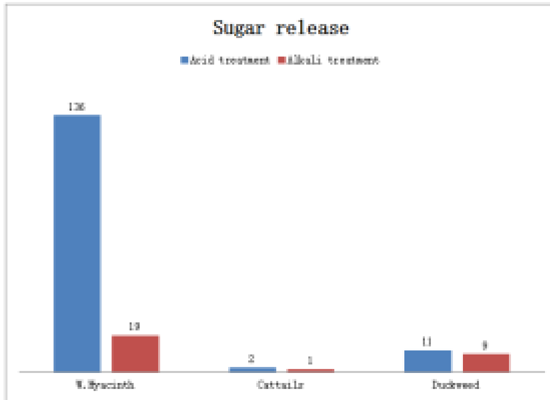


Fig 5: Sugar release after pretreatments

The biomass samples were fermented by *S. cerevisiae.* The initial total sugar of the Water hyacinth, Cattails and duckweed was 136 ± 0.69, 2 ± 0.51 and 11 ± 0.24 mg/g respectively after acid treatment and 19 ± 0.61, 1 ± 0.12, 9 ± 0.60 for alkali treatment. The corresponding ethanol yield was 18 ± 0.69, 2 ± 0.69 and 10± 0.69 g/L respectively after fermentation of the respective acid hydrolysate whereas for alkali hydrolysate fermentation it was 11± 0.69,1± 0.69 and 7 ± 0.69 g/L respectively.

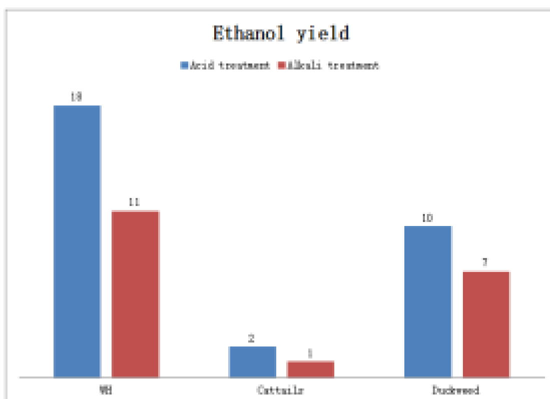


Fig 6: Ethanol yield after pretreatments

The ethanol productivity rate, fermentation efficiency is higher for acid treatment for all the biomass samples than the corresponding alkali treatment.

4. CONCLUSIONS

As shown in this research, Water hyacinth, Cattails and duckweed are abundant raw material, is a potential and novel resource for ethanol production. The pretreatment conditions can further be optimized by changing the reaction parameters like concentration, soaking time and temperature for both the pretreatment methods.

This work is an effort to use the novel renewable feedstock for ethanol production. Nevertheless, the ethanol concentration obtained with the optimized pretreatment conditions is still low for an industrial ethanol process, and further studies are necessary to achieve an economical process.

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