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Water Hyacinth Feedstock: A Renewable Source for Bio-Ethanol Production

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Abstract - *Sustainable and renewable energy as well as coastal preservation are important to all over the world. By managing water hyacinth in rivers, canals and lakes, the Water Hyacinth of this fast growing aquatic plant to be problematic for slowing down of the water flow and flooding increasing evapo-transpiration but can reduce coastal erosion by absorbing wave energy, and contaminants of waste water absorb through bio-processing, while also providing a source of bio-fuel. However the bio-fuel production through water hyacinth needs some pretreatment processing with chemicals before the further conversion to ethanol. In this research article providing optimizing pretreatment process with different acids and alkalis for into simple sugars fermentable for ethanol production. The pretreatment with 1, 2, 3, 4, 5% v/v of acids (HCOOH, HCl and H_2SO_4) and 1, 2, 3, 4, 5% v/v of bases (NaOH and KOH) was carried out individually. The best results for sugar estimation were 4% v/v H_2SO_4 and 3% v/v with KOH, NaOH, HCl and HCOOH. The results show the potential of water hyacinth as feedstock for production of ethanol.*

1. INTRODUCTION

Sustainable and renewable biofuels are important to world like as India. Energy consumption has accrued steady over the last century because the world population has grown up and more countries became industrialised [1].Bioenergy is renewable energy and is made by using numerous biological organisms. Bioenergy is expected to resolve the global warming drawback by decreasing the greenhouse emission levels within the atmosphere [2]. A considerable quantity of analysis is presently being conducted on the assembly of bioenergy due to the increasing demand for fuel and its restricted quantities in reserve. Bio-ethanol is one of the foremost promising replacements for fuel since its renewable and emits 85% less greenhouse gases compared to gasoline [3]. There are various sources are renewable energy such as geothermal, solar, wind, hydropower and biomass. Biomass in the form of energy third largest used in the world after coal and petroleum because it is clean non-toxic, biodegradable and abundantly available. Moreover, in addition to this, it is release less amount of nitrogen and sulphur oxides [4].

Recently, a lot of analysis has focused on exploitation non-edible biomass as raw materials including lignocelluloses, celluloses, and marine algae rather than the primary generation biomass like starch and sugar biomass [5].Lignocellulosic feedstock is considered as a pretty raw material due to its availability in massive quantities at low cost [6] not only for the liquid transportation fuel but also for the production of chemicals and materials, i.e. the development of carbohydrate-based bio-refineries [7].The biofuels production for renewable resource from different type of lignocellulosic biomass such as wood; aquatic plants (algae, water hyacinth); energy crops (Babool seed, Neem seed); forest products (Pine needle); agriculture and food waste (domestic and municipal) as well as terrestrial plants [8].

Compared to woody plants of every kind and compared to several grasses structural analysis shows water hyacinth to be comparatively low in lignin and high in cellulosic sugars [9].Theoretically 1000 grams of a sugar can manufacture 580 grams of fermentation alcohol, and 420 grams of carbon dioxide, however the yeast should consume a number of the sugar for reproduction therefore the actual alcohol yield is a smaller amount than 100% [10].Cellulosic biomass has 4 parts, cellulose, lignin, hemicelluloses, and extractives. Reaction may be a pretreatment methodology that may be utilized in order to separate these elements. Strategies of hydrolysis embrace catalyst hydrolysis, and chemical reaction using acid [11]. By breaking glycosidic bond hydrolysis fractionates hemicelluloses and celluloses into readily fermentable hexoses and pentoses.

Water hyacinth (Eichhornia crassipes), also known as water Buchón, Taruya, Camalote, Mop, Water Violet, is an aquatic plant native to the rivers of the Amazon Basin in South America [12]. Eichhornia crassipes is a floating aquatic weed, pop-rooted with rhizomes or stolons. The plant is variable in size and may grow in poor nutrient concentration, up to 0.05 and 0.01 ppm of nitrogen and phosphate [13,14,15]. Water hyacinth generated by seed propagation or vegetative reproduction. Water hyacinth rate of grow is high its length approximately up to 30 cm the intensity of spreading by these means can result in a doubling of the infested area from 6 to 15 days. Studies suggest that water hyacinth increases biomass up to 12% per day and biomass accumulation rate can range from 7.7 to 60 g/m2/day [12].Water hyacinth is considered an important raw material for agricultural fertilizers, animal feed, biogas, paper, cardboard, building materials and in the absorption of some heavy metals in water. The present concern is production of ethanol from water hyacinth [16]. Ethanol is an alternative source of fuels its produce from biomass via hydrolysis and sugar fermentation process. Biomass is a complex mixture of carbohydrate polymers, its content cellulose, hemicellulose and lignin. Due to the use of water hyacinth relieving problems associated with this plant that because of its rapid growth and spread in the absence of controlling species has nowadays created an imbalance condition in wetlands area of the country. This aquatic weed invades in a short time the waterway, restricts the generation of power, irrigation, navigation, fishing, the passage of light to the underwater environment and depletes oxygen levels [17, 18]. The percentage composition of Cellulose, hemicellulose and lignin for WH is given in table 1.

Table1. Average biomass composition of water hyacinth [19, 20].

Components	% composition
1. cellulose	18 - 35
2. hemicellulose	18 - 49
3.lignin	3.5 - 9

In this research article, discuss the pretreatment with different acids and alkalis and analyzed the optimum composition of pretreatment method and sugar estimation during the utilization of water hyacinth for ethanol production.

2. MATERIALS AND METHOD

[A] Collection of water hyacinth & feed stock processing.

Whole, fresh Water Hyacinth plants were collected from Kshipra River in Ujjain district in Madhya Pradesh (Latitude 23.218456 N and Longitude 75.773194 E) in the month of April 2018. Harvested water hyacinth was kept in a plastic container and transported to college laboratory. Then water hyacinth were washed with multiple times with tap water and dried in sunlight along with roots. Many cuts were made in the stems to dry the stems. Dried plants was ground in a mixer and grinder thereby reducing the particle size and stored in air tight containers at room temperature until required for use. Some photograph of water hyacinth and dried sample given in fig.1.

(a) Water hyacinth sample collection (b) Dried sample (c) Sample after grinding

Fig.1. Photograph of water hyacinth in Kshipra river (a), collected and dried sample of water hyacinth (b) and powdery form of dried sample (c).

[B] Pre-treatment and Optimization

(i) Pretreatment with Acid.

Pretreatment was carried out by 3g of the dried water hyacinth mixing with different acids i.e. HCl/H_2SO_4 /HCOOH (1 to 5 % v/v each) in Erlenmeyer flasks (250 ml). The prepared solution was put in autoclaved at 121 °C, 15 lbs for 15 min and after that cooled down to room temperature. The unhydrolysate material was removed from hydrolysed material using Whatman filter paper No.1. The hydrolysate material was collected and analyzed for the reducing sugar content by using dinitrosalicylic acid (DNS) test. The optimum concentration (i.e yields the maximum sugar concentration) of each pretreatment solution was analyzed by varying the concentration (1,2,3,4,5% v/v) and estimating the sugar concentration. The flow chart of this procedure is shown in fig.2.

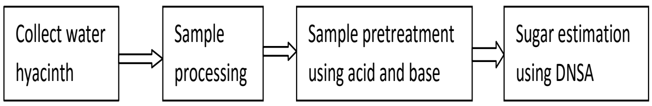

Fig.2. A flow chart showing the process of sampling and pre-treatment procedures

(ii) Pretreatment with Alkali

Following the similar procedure the dried water hyacinth was treated with alkalis i.e. NaOH and KOH which had also the concentration of 1 to 5% (v/v each).

[C] Sugar estimation

Total reducing sugar was estimated by using dinitrosalicylic acid (DNS) reagent. The DNS method was used for the measurement of total reducing sugar contents [21]. 3 ml of DNSA reagent was added to 3 ml of hydrolyzed sample in a test tube. The mixture was heated at 90ºC for 5-15 min to develop the red brown colour. Further 1 ml of 40% Potassium tartarate (Rochelle salt) solution was added to stabilize the colour. After cooling at room temperature in a cold water bath, record the absorbance with a spectrophotometer at 575 nm.

3. RESULTS AND DISCUSSION

Water hyacinth sample were pretreated with different acids and alkalis using different composition for sugar estimation and analyzed optimum composition for bio-ethanol production. The pretreatment result with NaOH and KOH alkali 1to 5%v/v composition shows Sugar concentration (mg/gram) of sample in table 2 and graphical representation in fig 3.

Table-2: Sugar concentration achieved after pretreatment with alkalis.

Reagents used	Absorbance at 575nm	Sugar conc. (μg/ml)	Sugar conc. (mg)/100 ml of filtrate	Sugar conc. (mg)/gram of sample
1%NaOH	0.0588	102.6667	10.2666	3.422
2%NaOH	0.1023	175.1667	17.5166	5.838
3%NaOH	0.1176	200.6667	20.0666	6.688
4%NaOH	0.1036	173.3333	17.7333	5.911
5%NaOH	0.1016	174	17.4	5.8
1%KOH	0.0423	75.16667	7.516667	2.505556
2%KOH	0.0824	142	14.2	4.733333
3%KOH	0.1036	177.3333	17.73333	5.911111
4%KOH	0.1003	171.8333	17.18333	5.727778
5%KOH	0.0998	171	17.1	5.7

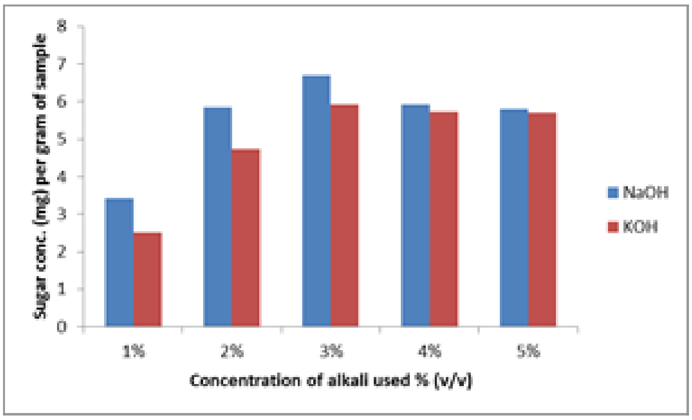

Fig.3. Sugar concentration of water hyacinth after pretreatment with varying concentration of alkalis.

The pretreatment result with HCOOH, HCL and H_2SO_4 acids 1to 5%v/v composition shows Sugar concentration (mg/gram) of sample in table 3 and graphical representation in fig.4.

Table-3: Sugar concentration achieved after pretreatment with acids.

Reagents used	Absorbance at 575nm	Sugar conc. (μg/ml)	Sugar conc. (mg)/100 ml of filtrate	Sugar conc. (mg)/gram of sample
1%HCOOH	0.0231	43.16667	4.316667	1.438889
2%HCOOH	0.0462	81.66667	8.166667	2.722222
3%HCOOH	0.0588	102.6667	10.26667	3.422222
4%HCOOH	0.0528	92.66667	9.266667	3.088889
5%HCOOH	0.0508	89.33333	8.933333	2.977778
1%HCl	0.0842	145	14.5	4.833333
2%HCl	0.1082	185	18.5	6.166667
3%HCl	0.1272	216.6667	21.66667	7.222222
4%HCl	0.1078	184.3333	18.43333	6.144444
5%HCl	0.1068	182.6667	18.26667	6.088889
1%H_2SO_4	0.1902	321.6667	32.16667	10.72222
2%H_2SO_4	0.1962	331.6667	33.16667	11.05556
3%H_2SO_4	0.1982	335	33.5	11.16667
4%H_2SO_4	0.2194	370.3333	37.03333	12.34444
5%H_2SO_4	0.1994	337	33.7	11.23333

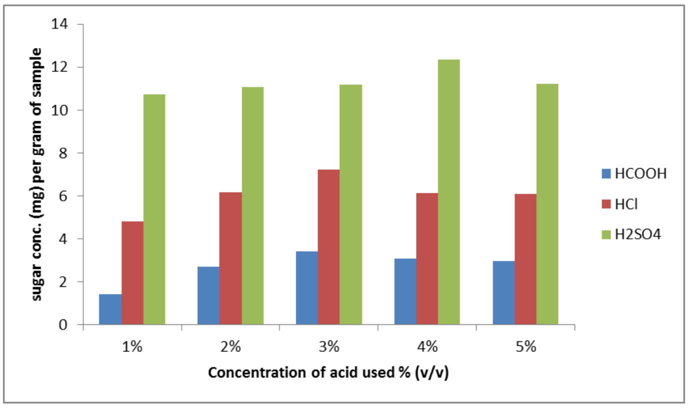

Fig.4. Sugar concentration of water hyacinth after pretreatment with varying concentration of acids.

The optimum pretreatment result with different acids and alkalis shows Sugar concentration (mg/gram) of sample in table 4 and graphical representation in fig.5.

Table-4: Comparative yield of sugars using different reagents.

Reagents used	Absorbance at 575nm	Sugar conc. (µg/ml)	Sugar conc. (mg)/100 ml of filtrate	Sugar conc. (mg)/gram of sample
3%NaOH	0.1176	200.6667	20.0666	6.688
3%KOH	0.1036	177.3333	17.73333	5.911111
3%HCOOH	0.0588	102.6667	10.26667	3.422222
3%HCl	0.1272	216.6667	21.66667	7.222222
4%H2SO4	0.2194	370.3333	37.03333	12.34444

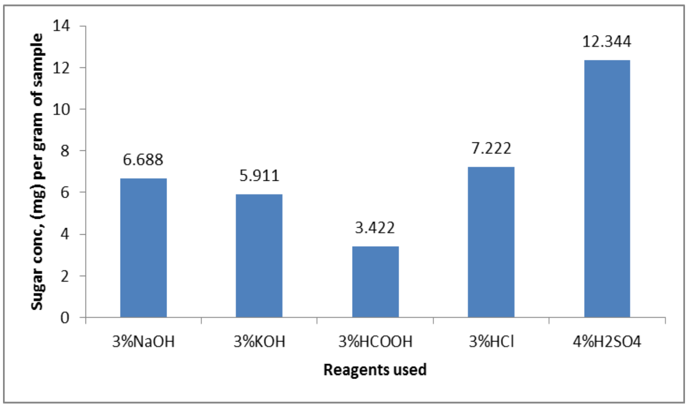

Fig.5. Sugar concentration of water hyacinth after pretreatment with selected acids and alkalis.

4. CONCLUSION

Water hyacinth Feedstock abundantly and sustainability are the main limitations of bio-ethanol production via bioconversion process. It was explored as next generation bio-fuel resource due to its rapid growth. In the present study Water hyacinth sample were pretreated using different alkalis (Sodium hydroxide and Potassium hydroxide) and acids (Hydrochloric acid, Sulphuric acid and Formic acid) treated with 1, 2, 3, 4 and 5%v/v each. Sulphuric acid treated with 4%v/v shows the best result for Sugar estimation as compared to other pretreatment chemicals which was 12.34 mg of sugar per gram of Water hyacinth sample.

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