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OPTIMISING THE GROWTH CONDITIONS OF WATER HYACINTH FOR BIOFUEL PRODUCTION THROUGH HYDROPONICS

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ABSTRACT

Water hyacinth (Eichhornia crassipes) is an aquatic weed that clogs the river and forms an impenetrable mat leading to the death of an aquatic species. It is a purple flowering plant that grows all over the rivers and ponds within a short period of time. A huge amount of money and efforts have been invested since then for their management. However, it was recently realized that they could be sustainably managed in their natural ecosystem and used in biofuel production. There are number of vegetable oils used which own medicinal values and other important uses rather than the production of biodiesel. As the search for alternatives to fossil fuel and considering being a raw material abundantly available at any time in any place and not applicable for any other purpose rather than biofuel production, water hyacinth holds a strong promise in the biofuel industry. With the low lignin content and more favorable properties of hemicellulose and cellulose quantity water hyacinth yields high amount of biomass. The present work aims to determine the best media parameters and pretreatment effect for efficient biofuel production from Eichhornia crassipes. The plant collected from local water body was cultivated in a hydroponic setup followed by its growth in 2 variants of Mohr's and Chelate medium. The media resulting with best growth of the plant and the optimal pretreatment conditions is analyzed. Also, the effect of time and concentration on acid and alkali treatment on the percentage yield of reducing sugars was identified. Hence, in this study the roles of media and pretreatment process for high biomass production are discussed.

KEYWORDS: Eichhornia crassipes, Biomass production, Media composition, Hydroponics, Bioethanol production.

1.INTRODUCTION

Water hyacinth is a free-coasting oceanic plant with expansive, thick, lustrous, ovate leaves, water hyacinth may transcend the outside of the water as much as 1 meter (3 feet) in stature. The leaves are 10–20 cm (4–8 inches) across on a stem which is gliding through light bulb-like knobs at its base over the water surface. They have long, elastic and bulbous stalks. The padded, unreservedly hanging roots are purple-dark. Water hyacinth fills in a wide range of freshwater conditions. Water hyacinth is generally viewed as the world's most exceedingly awful oceanic weed because of its capacity to shape thick and impervious gliding mats on the water surface. It's anything but a free-coasting, yearly, or lasting amphibian plant. It is local to Brazil and has been presented in India as a fancy plant in West Bengal in mid 20-th century in any case, presently, it is one of the most exceedingly awful weeds of oceanic bodies in India. It is assessed to cover more than 4,000,000 hectares of water surface(DolfGielen, 2019).

It propagates with the aid of vegetative and sexual techniques. The plant is also reproduced by using seeds. A single water hyacinth plant can produce a few to 5000 thousand seeds. The seeds may also sink to the lowest where they could stay possible for up to 20 years. The floating mat's purpose big biodiversity impacts via displacing native plants, lowering mild penetration and stopping birds and different fauna from getting access to the water. Mats additionally boom the amount of decaying plants and prevent oxygen alternate within the water, which results in mistaken habitat for fish and other aquatic fauna. Dense infestations in water garage facilities can motive water losses via transpiration, which can be three instances better than natural evaporation. Infestation can also clog irrigation belongings and intrude with recreational activities consisting of swimming, fishing, and boating. Severe infestations are able to achieving as much as 450 lots of wet weight in step with hectare.

During flood events, heavy floating mats of the weed can dislodge and reason widespread harm to downstream infrastructures which include bridges and fences, and to plants and pastures. Infestations additionally offer favorable breeding conditions for mosquitoes and decrease the aesthetics of waterways. This review is vital as Water hyacinth may be effectively used for biodiesel, bioethanol

production, and pallets as it's miles available in masses. As the raw material is plentiful it may be useful for diverse programs at a cost-effective level (Boteet al., 2020)

Impacts of Water hyacinth

Water hyacinth has a spread of terrible affects once added into a freshwater environment. It forms dense, impenetrable mats which clog waterways, making boating, fishing and almost all other water activities, impossible. It additionally reduces biodiversity by way of crowding out local plant life at the water's floor and underneath. Water hyacinth mats additionally degrade water exceptional by using blocking off the air-water interface and greatly decreasing oxygen levels in the water, disposing of underwater animals such as fish (Adegunloye, 2013).

Water hyacinth is a first-rate freshwater weed in maximum of the frost-unfastened areas of the international and is generally appeared because the maximum troublesome aquatic plant. Despite its unfavorable influences, it's been widely planted as water decorative round the world because of its beautiful, striking flowers. Water hyacinth spreads unexpectedly through generating solons or "daughter" plants. Water hyacinth will in no way be completely eliminated; but management is essential to control its fast boom, because the mats it can double their length in 6-18 days (Anjanabha, 2014).

Water hyacinth is low in lignin content material (10%) and contains high amounts of cellulose (20%) and hemicellulose (33%) (Bolenzet al., 1990), (Poddaret al.,1991), (Gressel,2008). A usual biomass from land flora can have 30-50% cellulose, 20- 40% hemicellulose and 15-30% lignin. In vegetation, lignin (composed of phenylpropanoid organizations) acts as a polymer across the hemicellulose micro fibrils, binding the cellulose molecules collectively and defensive them against chemical degradation. Lignin can't be converted into sugars. Thus, it isn't always realistic in biofuel manufacturing. Their degradation is a high electricity manner. Water hyacinth has low lignin, this means that the cellulose and hemicellulose are extra without problems converted to fermentable sugar as a consequence resulting in vast quantity of utilizable biomass for the biofuel industry. (Masami et al., 2008) advised a brand-new approach of extracting ethanol by means of saccharification with diluted sulfuric acid, and hastening the method by using yeast. Further, water hyacinth grows at a totally rapid pace and includes very high nitrogen content material.

Advantages of hydroponics

It is simple to manage pH and to ensure vegetation are becoming the precise nutrients they need. The systems are closed and recycle the water that isn't always used through flowers. The capability to grow indoors lets in farmers to govern temperatures and lights schedules to enhance plant production(Kushagraet al.,2020). Systems can be designed to utilize vertical space and growth planting density. Hydroponics also allow us to create farms in locations in which soil situations are too bad to support farming, or area is restricted and a farm in any other case couldn't exist. Up to 90% extra efficient use of water. Production will increase three to ten times in the same amount of space. Many crops can be produced twice as speedy in a well-managed hydroponic gadget. Decreasing the time among harvest and consumption will increase the dietary value of the stop product. Indoor farming in a climate-controlled surroundings method farms can exist in places in which weather and soil conditions aren't favorable for classic meals manufacturing. No chemical weed or pest manage merchandise are wanted when working a hydroponic system.

Biofuel

The fuel that is derived from biomass this is plant or algae material or animal waste is called biofuel. Since such feedstock fabric may be replenished easily, biofuel is considered to be a supply of renewable electricity, not like fossil fuels such as petroleum, coal, and natural gas. Biofuel is commonly encouraged as a cost-effective and environmentally benign opportunity to petroleum and different fossil fuels, particularly inside the context of growing petroleum costs and accelerated problem over the contributions made by means of fossil fuels to global warming(ChVidyaSagar , 2013).

First and 2nd-generation biofuels derived in the main from agricultural vegetation, like corn, sugar, oil seed plant life, palm oils and residual crop be counted and forestry products are constrained in their sustainability to attain the goal for petroleum oil substitution. Though their net gain in phrases of the discount of greenhouse gasoline emissions and achieving power balance has been identified, Eichhornia crassipes (water hyacinth) has received interest because of its alarming reproductive ability, which finally results in severe ecological damage of water sources in many eutrophic lakes around the world. In Egypt, water hyacinth grows very rapid in particular in summer time months in all water bodies and purpose severe problem to navigation, irrigation and deterioration of ingesting water quality. Studies have been directed in the direction of making use of these hydrophytes for the manufacturing of bioactive materials, which exhibited antimicrobial, anticancer, antioxidant, and anticorrosion of metals and alloys sports.

2.MATERIALS AND METHODS

Sample Collection

Fresh water hyacinth (Eichhornia crassipes) was gathered from Velachery Lake as proven in fig.1 and it turned into washed to take away adhering dust. The flowers have been grown in four exceptional kind media and the media with high biomass yield become decided on for pretreatment optimization. After pretreatment the plant tissues have been chopped into small portions (about 1 cm in duration), and air-dried. The samples were ground, and the particles of duration among 0.45 and 0.9 mm have been organized for the subsequent pretreatments. The flowers used were all wholesome and at a comparable diploma of increase, they'd roots of the equal length and leaves of the identical coloration. The experiments were performed as follows: Four 2-L flasks isolated from each different the plant growth at three diluent pH tiers (5.5 to six.0, 6.7 to 7.3 and 8.0 to 8.5) turned into evaluated. Three ion concentrations have been used: 0, five and 10 mg/L, in remarkable chemical forms: Mohr salt Fe (NH4) 2(S04)26H20 and Chelate (Ethylenediamine-di-o-hydroxyphenylacetic acid HFe) further to the answer

Fig.1 Collection of leaves of water hyacinth

Effect of Sample pre-treatment and Biomass loading

Various pre-hydrolysis treatments were investigated, along with dilute acid (H2SO4, HNO3, HCl), alkali (NaOH), and warmth treatment or combinations of two of them applied consecutively (Novia et al., 2013). 10 g of biomass and either dilute acid (2 %) or NaOH (2 %) were blended at a strong/liquid ratio of 1:10 and stored at room temperature (40 °C) for 60 min. The acid- or alkali-soaked samples were drained, washed with distilled water to neutralize the pH, and then air-dried. Additionally, distinct pre-treatment methods were blended by way of treating the biomass individually with acid and alkali under steam treatment at a steady temperature (121 °C) for 60 min. Following steam remedy, the samples were washed with water as earlier than. Biomass loading in the course of pretreatment became also optimized by using adjusting diverse stable liquid ratios (2–15 %, w/w).

Lipid Extraction

10 gram of each ground air dried water hyacinth became combined one at a time with the extraction solvent mixture; chloroform/methanol (1000 mL, 2:1, v/v) and sonicated for 20 min (the usage of a micro top of Micro son Ultrasonic cell disrupter),observed by using the addition of mixture of chloroform/water (500 mL, 1:1, v/v) then, filtered and the pattern residue become extracted 3 instances with the aid of 1000 mL chloroform at room temperature (25 °C) observed via filtration after which the chloroform layer become separated and dried over anhydrous sodium sulfate. The chloroform extract changed into evaporated at 40 °C below reduced pressure to dryness and the total lipids have been weighted and stored at −20 °C till used (for biodiesel production and fatty acids evaluation)

Chlorophyll Extraction

The total chlorophyll from the plant tissues have been extracted using hot percolation approach the usage of hexane as solvent. Hexane from the extract become evaporated by concentrating it using a rotary vacuum evaporator below reduced pressure at 40ºC for 6 hrs. The overall chlorophyll content material was envisioned through measuring the OD of the samples at 470nm.

Bioethanol Production

For the manufacturing of bioethanol from the accumulated water hyacinth pattern the residues left after lipid extraction represent the feedstock for bioethanol production after its hydrolysis to the simple fermentable monosaccharide glucose. Fermentation of glucose was accomplished the usage of the yeast Saccharomyces cerevisiae. The gradual decrease of glucose content was observed by way of a boom in bioethanol manufacturing all through the fermentation length. Hydrolysis of carbohydrates inside the residues (by dil.H2SO4), left after lipid extraction, produced variable glucose contents (% by means of Brix-meter) in accumulated Eichhornia samples.

3.RESULTS

Fig.2 Water hyacinth cultivated in different media

TABLE I. pH AND [Fe^{2+}] CONCENTRATIONS IN THE TEST SOLUTIONS

Chemical forms of iron	[Fe^{2+}] (mg/L)	pH
Mohr salt $Fe(NH_4)_2(SO_4)_26H_2O$	0	5.5-6.0 6.7-7.3 8.0-8.5
	5	5.5-6.0 6.7-7.3 8.0-8.5
	10	5.5-6.0 6.7-7.3 8.0-8.5
Chelate (EDDHA-HFE)	0	5.5-6.0 6.7-7.3 8.0-8.5
	5	5.5-6.0 6.7-7.3 8.0-8.5
	10	5.5-6.0 6.7-7.3 8.0-8.5

Fig.3 Media composition used (0.5X and 1X Mohr salt and chelate medium)

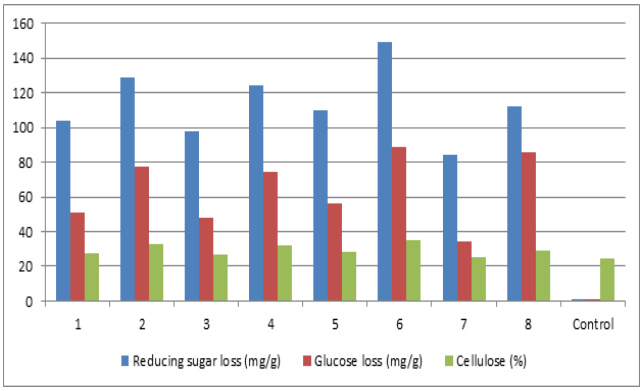

Fig.4 The Effect of different Pre-treatment on biomass

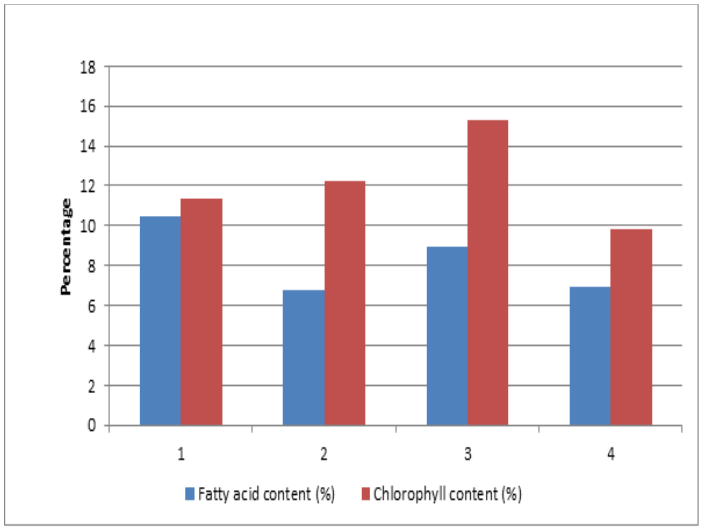

Fig.5 The fatty acid and chlorophyll yield in various media

Media	Medium	Fatty acid content (%)	Chlorophyll content (%)
1	Mohr's 0.5X	10.45	11.34
2	Mohr's 1X	6.79	12.26
3	Chelate 0.5X	8.97	15.32
4	Chelate 1X	6.9	9.86

Fig.6 The fatty acid and chlorophyll yield in various media

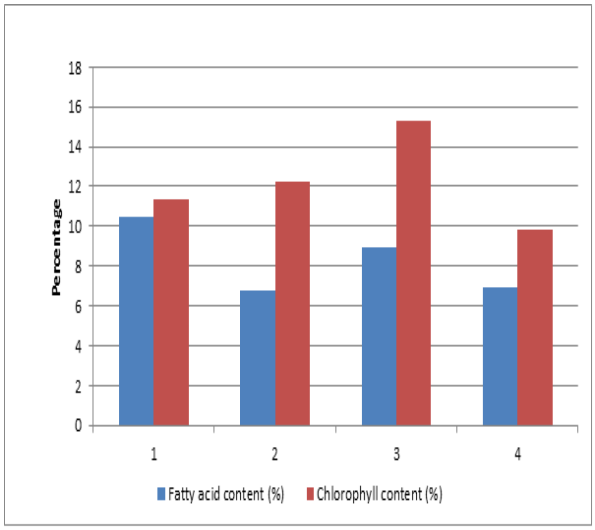

Fig.7 The fatty acid and chlorophyll yield in different media

Time in min	30	60	90	120	150	180
Media	Relative percentage yield of bioethanol					
1	30.77	37	46.9	58.6	64.3	68
2	23.08	28	37.06	46.25	53.8	58.4
3	16.7	20.9	26.1	32	41	51.25
4	20	24	29.8	37.25	42.8	51.2

Fig.8 The relative bioethanol produced in various media with respect to time

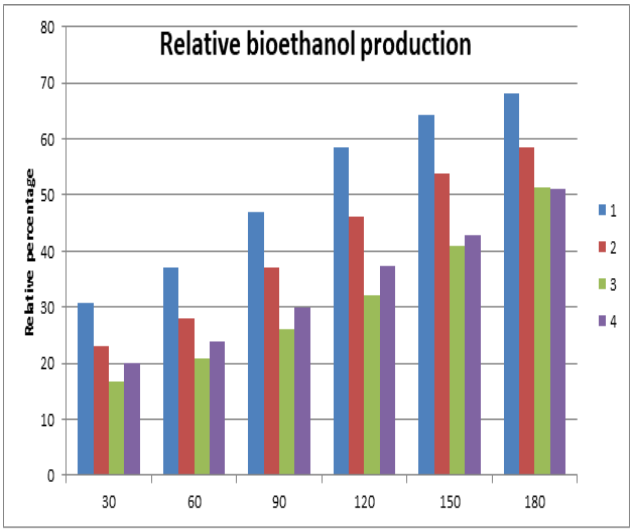

Fig.9 The relative bioethanol produced in various media with respect to time

4.DISCUSSION

Water hyacinth represents a promising source for biofuel production and other bioactive compounds because of their high availability and high biomass yield. There are few important qualities of water hyacinth which can be utilized to produce biofuel i.e., Bioethanol to power vehicles and motor, biogas to generate electricity. The optimum benefit could be achieved from the by-products of water hyacinth with minimum processing. Tremendous progress has been made technologically within the last few years in the region of biofuel manufacturing, fuelled by way of ever-increasing charge and lack of fossil gas. There also are worries approximately global weather change and severe food shortage. Biomass is the least costly and most globally available aid. Therefore, priority have to be shifted closer to utilising biomass, leaving apart food for human intake. New methodologies of fermentation and hydrolysis of biomass have become available, in conjunction with development of transgenic varieties amenable for biofuel production. Now is the time to search for new cloth assets of biofuels, which might be naturally amenable to processing at some point of extraction of biofuel, thus lowering expenses substantially and substituting fossil fuels in all components. Water hyacinth has lengthy been visible as an invasive species all over the globe and massive amount of assets were spent for his or her control. The modern examine goals to perceive the premier media composition for developing water hyacinth for efficient biofuel production.

5. CONCLUSIONS

There are few important qualities of water hyacinth which can be utilized to produce biofuel. The optimum benefit could be achieved from the by-products of water hyacinth with minimum processing. Water hyacinth can be considered as the best alternative to cope up with the progression of regional and global environmental change as the depletion of fossil fuel depletion. However, the methods of cultivation and fermentation well documented. Research focused on this topic would help us identify the best practical methodologies for maximum biofuel yield from Water hyacinth.

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