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Biogas Production from Water Hyacinth – A Review

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ABSTRACT
Water hyacinth is an aggressive weed that invades the water bodies. It causes reduction of biodiversity, blockage of rivers and drainage system and depletion of dissolved oxygen. Attempts to exterminate or control this weed using modern technology such as those of mechanical, biological and chemical means of destruction have failed. The plant continues to survive and proliferate. A number of studies have been made on the utilisation of this weed for various applications. This paper presents an overview of the literature collected on the application of water hyacinth as a source of biogas production.

Keywords: Water hyacinth, fermentation, digester, biogas

1. INTRODUCTION
Water hyacinth (*Eichhornia crassipes*) is a free-floating aquatic weed that has attracted worldwide attention due to its fast spread and crowded growth [1]. It is a non-native, invasive, perennial aquatic macrophyte, a monocotyledon, of the family *Pontederiacea* which originated in the rain forests of the Amazon River Basin [2-4] . The mature plant consists of long, fibrous roots, rhizomes, buoyant petioles, stolons, leaves, inflorescences and fruit clusters [2].

Water hyacinth has become a major aquatic problem because of its colossal rate of reproduction [2]. The worldwide distribution of water hyacinth has become a persistent aquatic problem, damaging the environment and irrigation systems. Large, intense water hyacinth mats can corrupt water quality and can obstruct waterways [4]. They are also responsible for a number of other impacts including increased evaporation rates, interference with recreational activities, such as swimming and boating and increased mosquito breeding sites [5, 6].

Water hyacinth is lignocellulosic biomass consisting of a complex mixture of lignin, hemicelluloses and cellulose [7]. Cellulose and hemicelluloses are polymers of sugars, and are thereby a potential source of sugars [8]. As it contains high amount of fermentable matter, it is a viable option for biogas production. This paper reviews the studies made by researchers on the feasibility of biogas production from water hyacinth.

2. BIOGAS PRODUCTION FROM WATER HYACINTH
Investigation was made on biogas production from water hyacinth blended with cow dung by Sugumaran et al.[9] It was found that water hyacinth and cow dung are the two wastes which can be used to generate energy through biogas, which is an alternate fuel. The possibility was explored to determine the efficiency of lignocellosic waste from water hyacinth blended with cow dung for biogas yield.

Studies carried out by EI-Shinnawi et al. [10] also demonstrated the feasibility of biogas production from water hyacinth mixed with cow dung and indicated that cow dung provided enough microorganisms to serve as inoculum.

The study on two phase anaerobic digestion of water hyacinth by Chanakya et al. [11] demonstrated that diphasic fermentation of water hyacinth to biogas was tried by coupling a solid-phase acidogenic system to an upflow, anaerobic packed-bed, methanogenic digestor. Solid-phase fermentation was feasible with the substrates and could reduce digester volume and costs of operation. This process resulted in overcoming problems associated with feeding, control of floating scum and continuous / semi-continuous operation normally encountered when untreated-biomass feeds are used in conventional biogas digesters.

The study on batch anaerobic digestion of water hyacinth by Moorhead and Nordstedt [12] found that the potential productivity of water hyacinth in nutrient enriched waters has led to its selection as a biomass feed stock for methane generation while providing a means for wastewater treatment. Methane yield during anaerobic digestion was found to depend on characteristics of feed stock.

Chanakya et al. [13] indicated that water hyacinth had a high content of fermentable matter and therefore shows a high potential for biogas production, but however the high lignin content can reduce the actual production.

A comparative study was made by Patil et al. [14] on anaerobic co-digestion of water hyacinth with poultry litter and water hyacinth with cow dung in different ratios. The biogas was collected by the downward displacement of water. Anaerobic co-digestion of water hyacinth with poultry litter produced more biogas compared to co-digestion of water hyacinth with cow dung. The overall results showed that blending water hyacinth with poultry waste had significant improvement on the biogas yield.

Studies were made by Santanu Sankar and Saikat Banerjee [15] on biomethanation of water hyacinth in a semi batch digester at different substrate concentration using cow urine as an organic catalyst under controlled pH with a range of 6.9 to 7.2. The rate of biogas production was found to vary with different conditions and parameters like temperature, stirring speed, feed concentration, catalyst concentration, etc.

A comparative study of the effect of different pretreatment methods on biogas yield from water hyacinth was carried out in mesophilic temperature range of 25 to 36^0C by Ofoefule et al. [16]. The overall results showed that treating water hyacinth with chemical did not have a significant improvement on the biogas yield. It also indicated that water hyacinth is a very good biogas producer and the yield can be improved by drying and combining it with cow dung.

Haug [17] indicated that chopping the water hyacinths increases the specific surface of the substrate and thereby enhances the access of microbes to the plant material, which is important for a well-working biogas process.

Moorhead and Nordstedt [12] conducted experiments with different particle sizes, nitrogen content and inoculum volume, in a mesophilic process (35^0C). The total biogas and methane production was largest for water hyacinth when the plant material was chopped into 6.04mm pieces (compared with 1.6 and 12.7mm).

Digestion experiments carried out by Vaidyanathan et al. [18] at ambient temperature of 29±2°C conducted in a batch digester using chopped and groundwater hyacinth showed higher methane production rate and lower digester residence time. The biogas produced from groundwater hyacinth had higher methane content of 77%.

The study made by Almoustapha et al. [19] demonstrated that discontinuous-type facilities were able to produce biogas from a mixture of water hyacinth and fresh rumen residue to meet collective needs in cooking energy. The facility's yield, reported in m^3 of biogas per m^3 of digester per day, was 0.52 during the warm season and 0.29 during the cool season. The yields can however be improved by applying the appropriate pretreatments.

Varying amounts of sawdust waste complimented with a fixed amount of cow dung and water hyacinth was anaerobically fermented in batch-fed digesters, in the laboratory, at an average ambient temperature of 30^oC [20] . The results showed that efficient biogas production rate was maximum (0.045litres/TS fed) when about 11.48g of sawdust waste was digested in a fixed amount of cow dung and water hyacinth (7g).

Co-digestion of water hyacinth and primary sludge was studied in batch reactors for biogas production by Patil et al. [21]. Anaerobic co-digestion was carried out in mesophilic temperature range (30°C to 37°C) with different fermentation slurries of 8% total solids. The overall results showed that blending water hyacinth with primary sludge had significant improvement on the biogas yield.

3. CONCLUSION

The studies made by various researchers on biogas production from water hyacinth indicate the potential of the plant as a source of biogas production. If suitably harvested and subjected to anaerobic digestion with appropriate inoculum and operating conditions, this noxious plant could be beneficially used as a promising source for biogas production.

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