The Environmental Impacts and High-Effective Solutions of Invasion of Water Hyacinth

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Abstract. Water hyacinth is a fast growing and floating aquatic plant native to South America. Water hyacinth is extremely invasive and its high reproduction rate causes water pollution, waterway closure, and death of aquatic organisms. Based on past studies linked to water hyacinth invasion, this paper first analyzes the features of water hyacinth and the effects of excessive growth. Then, they synthesize and assess the effective and efficient solutions to the ecological hazard of water hyacinth invasion from the domains of technology, government, human, and enterprises. In terms of technology, they recommend the authorities adopt water hyacinth removal machines that may also be utilized for animal feed production. The adoption of anaerobic methods to convert water hyacinth leaves into biogas for power generation is also appropriate, as is replacing existing traditional herbicide types with novel herbicide structures. The government should strengthen legal restrictions, prohibit commercial water hyacinth trafficking, and minimize industrial wastewater discharge. Finally, the research revealed that these methods may effectively decrease the environmental destruction caused by the water hyacinth invasion. Therefore, people should enhance the treatment of water hyacinth invasion hazards in order to control the ecology of the watershed and minimize wastewater discharge.

1. Introduction
Aquatic plants are an important part of the watershed ecosystem and have been contributing to the purification of water and air, but more and more changeable environmental problems have appeared in human sight with the rapid and unrestrained development of humanity and society. The discharge of industrial and domestic waste into the water body causes the water body to eutrophicate and degrade water quality [1]. However, eutrophication is not only an anthropogenic problem because any change in a watershed has an impact on the biological health of its lakes and rivers [2]. Eutrophication of water bodies causes rapid blooms of algae and other planktonic organisms [3].

Water hyacinth invasion is one of the most representative representatives of aquatic plants that are affected by eutrophication of water bodies. Furthermore, there are hundreds of similar studies, but they all seem to be incomplete overviews of what may be done to combat the threat of water hyacinth invasion, and a pitiful number of research papers include a more extensive review and analysis. Most of the solutions to water hyacinth so far have been through biochemical and other means, as well as converting water hyacinth invasion hazards into renewable energy sources that appear to be accepting and transforming the hazards posed by water hyacinth.

The current solutions to the problem of water hyacinth invasion wreaking havoc on the environment and diminishing aquatic life are far from ideal. Technology, government, and human enterprises will all need to work together to develop effective water hyacinth invasion solutions. This is because the thorny
issue of the water hyacinth's extraordinarily fast reproduction is controlled by these four major sectors. Because eliminating water hyacinth involves significant leachate costs, the proper technology must be designed to transform the huge volume of water hyacinth into a contributing source to the development of a clean energy source. Hence, the purpose of this research paper is to organize and analyze the environmental damage caused by water hyacinth as a fast-growing aquatic plant, how the government and people should deal with the invasion of water hyacinth effectively, and to achieve the process of using water hyacinth as a renewable energy source as a direct raw material through some technological methods.

2. Water Hyacinth

2.1 Character
Water hyacinth is a flowering, free-floating aquatic plant with six purple and pink petals. Its height varies from a few inches to about a meter. The stems and leaves contain air-filled sacs, which help them stay afloat in the water [4]. The most basic role as an aquatic plant is to absorb carbon dioxide and emit oxygen. And water hyacinth not only enriches heavy metals in the water, but also removes suspended matter from the water body. This facilitates the purification of wastewater produced in human life and factories. That is why it has been introduced to many countries. However, warm climates and sunny places are particularly suitable for water hyacinth, which is why tropical watershed areas are filled with water hyacinth.

2.2 Influence
Water hyacinth, a green aquatic plant, has the characteristic of absorbing carbon dioxide for photosynthesis, thus providing fresh oxygen. It is well known that plants photosynthesize by the formula $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ [5]. And along with the light, carbon dioxide meets water to produce sugar and release oxygen. However, the introduction of water hyacinth, as the most damaging, disruptive, and invasive aquatic plant, has had an influence on waterways, making it impossible for coastal residents to properly farm the waters, hunt fish, and obstruct navigation. Then, water hyacinth's entrance to the United States, where it originated in South America, has been a major source of concern. The fast spread of water hyacinth due to significant anthropogenic impacts has severely hampered the reception of sunlight and oxygen by other native underwater creatures, diminishing biodiversity.

The reason for the abundance of water hyacinth is that it acts as a catalyst through sexless reproduction, high survival adaptations, and stimulated rapid growth in waters rich in nutrients such as organic matter. It grows on the water surface and absorbs sunlight and oxygen directly, hindering the absorption of sunlight and oxygen by aquatic organisms, resulting in a significant reduction in the dissolved oxygen content of the water [6]. When the water is polluted and dissolved oxygen is not replenished in time, anaerobic bacteria in the water body will multiply rapidly, leading to the indirect killing of microorganisms and organisms in the water. In addition, the industrial wastewater discharged from many factories contains large amounts of organic matter, which likewise greatly stimulates the reproduction of water hyacinth, leading to its spread in many countries. Therefore, researchers have developed and applied some very effective and proven techniques to address the challenges of rapid growth of water hyacinth and damage to the water.

3. The Solution Technology of Water Hyacinth

3.1 Technology

3.1.1 Removal machines
Water hyacinth removal machines, as one of the mechanical control aspects, are the most acceptable and accessible to workers and farmers. Since then, mechanical removal of water hyacinth is seen as the common direct external solution to the proliferation of the plant. Water hyacinth is an example of a
product that can be cut into powder and used to make animal fodder or fish feed [7]. When dried, the moisture level of the water hyacinth is reduced by ten to twelve percent. Dried water hyacinth was powdered in the lab and utilized as pelleted feed for carp, tilapia, and catfish to replace other traditional sources of protein. Water hyacinth roots also collect a significant quantity of inorganic nitrogen and phosphate, making it an excellent compost or inorganic fertilizer [8]. Although weeding machines are a highly effective external physical solution, the construction of the machinery is too expensive. Conversion to poultry feed can effectively reduce the cost of equipment consumption. And water hyacinth, which absorbs abundant nutritional elements, can improve the nutritional value of animal feed and reduce the research and development of feeds produced from highly nutritious raw materials, so it is a feasible solution.

Because of its high nitrogen, phosphorus, and potassium content, water hyacinth is used as one of the key components of fertilizer. Furthermore, the cost of using water hyacinth as compost will be quite low, making it an excellent choice both economically and environmentally. When semi-solid cow dung is put into a compost pile, the extra water that sticks to the plants dilutes the layer below and mixes nicely with the water hyacinth layer below after drainage [9]. After that, it’s fermented for 3-5 months. This type of water hyacinth compost is not only inexpensive to create, but it also has a large amount of potassium, which has a high value for use.

The nitrogen, phosphoric acid, potash, lime, and C/N ratio in water hyacinth compost is higher than both town compost and farmyard manure, according to the data in the table (Table 1). In particular, the potash, with a ratio of 2.50%, is three times higher than the potash content of urban compost. The ratio of 2.50% is three times higher than the potassium content of urban compost and eight times higher than that of farmyard manure. Composting water hyacinth has obvious benefits. This method of treating water hyacinth not only makes it less hazardous, but it also increases its commercial value, lowers production costs, promotes nutritional content, and improves fertilizer profitability for farmers.

| No. | Material                  | Water hyacinth compost (%) | Town compost (%) | Farmyard manure (%) |
|-----|---------------------------|----------------------------|-----------------|---------------------|
| 1.  | Nitrogen                  | 2.05                       | 1.0             | 0.50                |
| 2.  | Phosphoric acid (P₂O₅)    | 1.10                       | 1.0             | 0.25                |
| 3.  | Potash (K₂O)              | 2.50                       | 0.80            | 0.30                |
| 4.  | Lime (CaO)                | 3.91                       | 3.0 to 5.0      | 0.20                |
| 5.  | C/N ratio                 | 13                         | 10              | 12 to 13            |

3.1.2 Anaerobic Method

The leaves of water hyacinth are converted into biogas by an anaerobic method, and then electricity is generated using biogas instead of non-renewable fuels. Water hyacinth can be used as a source of energy. Although the procedure is relatively technical, it might be a terrific way to save energy if done carefully. The water hyacinth is then dried and allowed to ferment in the cellar, yielding methane, a biogas. Biogas control put a proposition that converts water hyacinth into methane and approves it through anaerobic digestion. Water hyacinth leaves that contain cellulose, nitrogen, essential nutrients, and high fermentation content can be used for biogas production [10]. Generating electricity through biogas derived from water hyacinth as a sustainable renewable energy source can reduce a portion of non-renewable energy consumption for humans, thus protecting the environment and reducing carbon as well as oil emissions. According to the research by Nugraha and other researchers, they demonstrated two methods of producing biogas from water hyacinth – the Liquid anaerobic digestion (L-AD) method and the Solid-state anaerobic digestion (SS-AD) method.

Nugraha and his colleagues demonstrated cumulative biogas yields per gram of different total solids (TS) with very high biogas yields for both Liquid anaerobic digestion (L-AD) method and Solid-state anaerobic digestion (SS-AD) method. According to his own paper, the difference between the cumulative biogas volumes produced by the two different methods increased significantly over time.
The cumulative biogas yield produced by the solid anaerobic digestion method decreases substantially compared to the liquid anaerobic digestion method, which has a time to cumulative biogas yield of almost 1:1. The cumulative biogas production of the liquid anaerobic digestion method, on the other hand, is many times larger than at any given time, and it grows significantly with time [10]. As a result, utilizing liquid anaerobic digestion to convert water hyacinth to biogas may substantially improve the conversion rate and contribute to biogas output. Humans must commit themselves to the discovery of new energy production and energy transformation due to a scarcity of nonrenewable resources and the threat to the earth's natural ecology. If water hyacinth is used as a technology in biogas power generation, tens of thousands of water hyacinth invasions can be avoided, and new energy development can be accelerated. Certainly, in terms of present technology, converting water hyacinth into biogas power generation still demands a substantial investment, and as such the technology must be improved in the future. This will enhance the biogas conversion rate while lowering capital expenditure and energy usage, which will be a challenge but also with a lot of potential for improvement.

3.1.3 New Herbicide

One of the more widely used chemical approaches to solving the water hyacinth problem is through aquatic herbicides. The restrained use of aquatic herbicides is not a great threat to the ecosystem, which is why it can be recognized. However, due to old-fashioned aquatic herbicides such as 2,4-dichlorophenoxyacetic acid, a new environmentally friendly herbicide, Self-dispersing phenoxy carboxylic acid derivatives, was developed. A one-step reaction catalyzed by I2 was used to design and synthesize a variety of novel self-dispersing phenoxy carboxylic acid derivatives. Some compounds, 3i–3p, displayed excellent herbicidal effects against water hyacinth in preliminary bioassays [11]. This is the design strategy (Fig.1) for the self-developing phenoxy carboxylic acid derivatives. Due to the high self-diffusion and flotation properties of ethylene glycol and hydrophobic phenoxy carboxylic acid. The self-developing phenoxy carboxylic acid derivatives self-diffuse on the horizontal surface, and their chemical bonds react well with the water gourd, causing both to float on the horizontal surface in a relatively stable state. Moreover, they produce a scavenging effect under the surface of low-concentration water bodies. In terms of fresh weight loss rate, new root inhibition rate, and leaf wilt rate, Lv-Yin Zheng and colleagues have developed new herbicides that outperform traditional herbicides, and this new herbicide may be an important alternative for water hyacinth control and removal.

3.2 Government

The benefits outweigh the disadvantages if the water hyacinth is addressed effectively and in a timely manner. However, it is difficult to address the problem of water hyacinth upside down by classifying it as a prohibited aquatic plant without a legal document. At the same time, the work on abolishing treatment and water purification is a very big workload as well as a tricky problem. The solution to water
hyacinth is to reduce the amount of conventional and toxic substances in the water. By enacting laws on wastewater treatment, the government can reduce the rate of reproduction and absorption of substances that already exist in the waterways. The Clean Water Act (CWA), for example, is the fundamental law governing pollution control and water quality in the nation's waterways, as revised by the Congress of the United States in 1977 [12]. Moreover, the CWA defines performance standards for municipal sewage treatment plants to meet in order to avoid the release of hazardous substances from water [13]. Therefore, the government plays a crucial role in dealing with water hyacinth. The government must strengthen its control over the rapid proliferation of water hyacinth and wastewater treatment for the sake of the stability of aquatic ecosystems and the biosphere of the entire country and the planet.

3.3 Human
Methods of what humans can do to prevent the growth of water hyacinth include prohibiting the planting for commercial sale. People would like to enjoy the pretty and ornamental flowers and plant them in their own water gardens and park forests, since water hyacinth is a kind of very beautiful aquatic plant. In fact, as an aquatic plant, water hyacinth is also a photosynthetic plant that absorbs carbon dioxide and converts it into oxygen for human consumption. If water hyacinth is used effectively, it can clear and cool the water, and it will have an oxygen effect on humans. For example, by planting water hyacinth in limited quantities in each person's water pond, both for aesthetic purposes and to capture small amounts of carbon dioxide and convert it into usable oxygen. Therefore, people buy and sell a lot of water hyacinth in the market. In addition, if water hyacinth is only planted in personal gardens, it will not cause water hyacinth to be invasive to the environment as long as it is not allowed to flow into water bodies such as rivers and lakes. Then the damage is very significant. Once in the water, it has also been called the world’s worst weed. However, it is invading and destroying a lot of waterways and fresh water. It absorbs oxygen for human beings as well as murders underwater microorganism.

3.4 Enterprise
The fundamental solution to the problem of the rapid reproduction of water hyacinth is to deal with the discharge of sewage from enterprises and industries. This is because excessive sewage discharge eutrophicates water bodies, which contain organic matter, heavy metals and toxic compounds [14] that stimulate the huge and rapid growth of water hyacinth. For example, heavy metals such as aluminum, zinc, lead and cadmium are toxic metals in sewage. These heavy metals have a negative impact on the growth of aquatic organisms and can cause serious damage in biological sewage treatment plants [15]. Population growth, urbanization and industrialization are the main reasons for the large amount of wastewater discharged into the environment. Therefore, it is necessary to strengthen the regulations of industrial wastewater discharge in order to solve the problem of heavy metals in wastewater from enterprises and industries. Only by reducing the micronutrients or toxic compounds in the water can the irritating reproduction of water hyacinth be reduced.

4. Conclusion
Water hyacinth grows in tropical areas and coastal cities, so the invasion of water hyacinth seriously endangers the quality of the seawater and the economies of coastal cities. This paper discusses how the large amounts of nutrients such as nitrogen attached to water hyacinth are of higher nutritional value as compost than town compost and farm fertilizer, which solves the problem of water hyacinth pollution and brings great benefits to animals and crops. Furthermore, the biogas production from water hyacinth through liquid anaerobic digestion is greater than that from solid anaerobic digestion. The biogas produced by water hyacinth not only tackles the problem of water hyacinth invasion, but it can also be utilized to create electricity, providing significant benefits for new energy generation. Both are quite helpful in alleviating the hazard of water hyacinth invasion. The use of new herbicides rather than traditional herbicides substantially enhanced the lethality and decay rate of water hyacinth, and the new herbicides with 3a-3p compounds were an effective nemesis of water hyacinth. The government should also limit the discharge of industrial and household wastewater to minimize nutrients and hazardous
chemicals in waterways. People should also halt commercial water hyacinth trafficking and restrict the discharge of heavy metal-containing industrial wastewater. Therefore, water hyacinth is a highly hazardous invasive species on the globe, and people should take advantage of its quick reproduction qualities to contribute to the global environment, as well as its wastewater purifying properties and use as a raw material for renewable energy. Through these effective solutions, the invasion of water hyacinth and the environmental problems it creates may be controlled and reduced.

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