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Water Hyacinth Remover

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Abstract: *The aquatic plant identified as the water hyacinth spreads fast and has entered water bodies all around the world. Whenever it expands unchecked, it clogs lakes and rivers, affects local ecosystems, and produces complications for people by being in the means of transportation, boating, and fishing. Conventional removal techniques, including chemical treatments and hand extraction, have shown to be labour-intensive, harmful to the environment, and frequently ineffective over time. A more long-term solution to this issue is provided by mechanical water hyacinth removers, whose development and efficacy are examined in this article to address the challenges posed by water hyacinth infestations, we are developing a mechatronic system designed for the efficient removal of aquatic plants using a combination of conveyor belts and cutters. In this paper, we have designed and fabricated a prototype of a water hyacinth remover. The design process involved creating and analysing key components such as the shaft, conveyor system, floaters and cutters. We also designed both the primary frame and the secondary conveyor frame. The motor selection was based on detailed design calculations to ensure optimal performance. Additionally, we have integrated a wireless Wi-Fi connection to enhance operational control and monitoring of the system.*

Keywords: *Water hyacinth, conveyor system, mechatronics system, IoT, Wi-Fi*

I. INTRODUCTION

Worldwide, water hyacinth is a major issue in rivers, generating ecological disruption and making it more difficult to navigate waterways. The current techniques for getting rid of this invasive species are frequently time-consuming and ineffective. The water hyacinth, a perennial aquatic plant that floats freely and is classified as a hydrophyte, is indigenous to tropical and subtropical South America. Water hyacinth may have large, thick, glossy, ovate leaves up to one meter (three feet) above the water's surface in height. On a stalk, the leaves are 10-20 cm in diameter and float thanks to buoyant nodules that resemble bulbs at their base that are above the water's surface. Their lengthy, sponge-type hair is bulbous stems. The plump, freely-dangling purple roots dark. A solitary 8-15'' spike is supported by an upright stalk strikingly beautiful blooms, primarily lavender to pink in hue, containing six petals. Water hyacinths were introduced as an ornamental crop to numerous nations over a century ago due to its beautiful appearance and aesthetic significance in the landscape. But its elegance is superficial and has evolved into an invasive species as a due to their adaptability to a range of freshwater surroundings and how they interfere with human activity. Thus, it has a negative image of being among the world's worst aquatic weeds. Known as the "Florida Devil" in South Africa and the "German weed" in Bangladesh, India's "Terror of Bengal," and the "Japanese". A full prototype must be made and extensively tested, either within a controlled environment or through real-life scenarios. The analysis will also reveal the ease of deployment and retrieval, how well each system performs at removing trash from waterways, and what effect they have on boat stability. Links to improvement in the design will be considered on the basis of these results. This project not only aids environmental conservation initiatives to maintain canals for tourism & recreation and the welfare of aquatic ecosystems, but also introduces a logical economic in removing water hyacinth infestations. This research presents a new system mounted on a boat that effectively removes water hyacinth from waterways. The design, development, and performance assessment of the system will be the main focus of the research. Optimizing removal devices (like cutting blades and conveyors), efficient storage options (like mesh containers or bins), and safe boat attachments are essential elements. The selection of materials will be thoroughly thought out and supported by their robustness and usefulness. The building of a working prototype will be described after the design stage, emphasizing pertinent instruments and production techniques.

II. LITERATURE REVIEW

Prof. Sunil S. Lembhe, Ms. Rutuja Vikas Kenjale, Ms. Shweta Anil Nikam, Ms. Pallavi Pandurang Khatmode, Mr. Vinayak Anil Pawar, Mr. Arun Dashrath Chavan, and Mr. Pranav Ganpat Gole 2022. This paper presents a mechanical tool that will remove *Eichhornia crassipes*, or water hyacinth, from the water features of Ganpati Ghat, Wai.

The invasive species known as water hyacinth is detrimental to the atmosphere because it clogs flows, lowers oxygen levels, and harms aquatic life. The removal techniques used today are frequently pricey, ineffective, or harmful to the environment. The suggested gadget has a straightforward but functional design with a conveyor belt, DC motors, PVC pipes for flotation, a frame, and a battery. It improves the dissolved oxygen content of the water and is energy-efficient and lightweight. Particularly useful in rural locations where resources for water hyacinth eradication are scarce, is this economical decision [1]

Mr. M. Umashankar, et al. – 2022, has presented the design and the development of an automated system to remove waste materials from ponds, rivers, and lakes, including plastic, algae, and other pollutants, is presented in this work. The system's goal was to increase the effectiveness of waste removal in water bodies by substituting a machine-controlled mechanism for manual labor. By lifting garbage from the surface of water into the storage tank, the suggested machine's conveyor mechanism contributes to the reduction of water pollution and its detrimental effects on the environment and aquatic life. The system can be easily operated using a mobile phone, is portable, and can be tailored and scaled for different uses. [2]

Prof. Rahul Udata et al. collaborated on publication in 2021. Their paper addresses the invasive spread of water hyacinth. Using GIS (Geographic Information System), Google Earth, and QGIS, the study estimates the cost and area for its removal. The objectives include mapping the distribution of water hyacinth, creating a cost-area factor, and suggesting removal strategies. Additionally, the paper explores the reuse of water hyacinth in industries like briquette production, biogas generation, and paper manufacturing, emphasizing its potential for environmental and economic benefits. [3]

Mr. Patange Ravikiran Vilas- 2024 has proposed a remote-operated tool called the Water Floating Trash Cleaning Machine (WFWM), is intended to effectively clear plastic trash, detritus, and floating debris from bodies of water. It incorporates a number of essential parts, such as a conveyor system operated by a chain, propellers, receivers, and DC motors. Solid waste is caught by metal teeth-based jaws fixed on a frame, which let water pass through. Using a motorized shaft, the waste is periodically raised and emptied into a filter basket. By automating the cleaning process, this device improves safety and efficiency over the labor-intensive traditional techniques. In order to lessen the negative effects of waste management operations on the environment and health hazards associated with them, the design places a high priority on eco-friendliness, low power consumption, and convenience of use in rivers, gutters, and drains. [4]

Ms. A. Sujatha Reddy et al. have designed a system with the least amount of human involvement possible. The Water Cleaning Boat initiative aims to reduce pollution in water bodies by eliminating trash and suspended particles. The technology gathers garbage from water surfaces and stores it in a container on the boat using a conveyor belt that resembles a treadmill and is powered by a battery. The RF transmitter and receiver are used to control the boat. It has a camera to track movement, and users can control the boat with a smartphone app. The Arduino UNO, DC motors, a motor driver, PVC pipe, and a Bluetooth module are important parts. The project's objectives are to lower labor expenses, health hazards, and environmental damage from manual cleaning techniques while simultaneously improving water quality. It provides a scalable, environmentally friendly cleaning solution. [5]

Prasad V. Shastri, Abhishek V. Bende, et al. 2017. The difficulty of eliminating aquatic weeds, which have detrimental effects on freshwater resources both environmentally and economically, is the subject of this article. The authors investigate mechanical techniques, such as a cutter system and conveyor belt, to get rid of water hyacinth instead of using chemical solutions that might taint water and harm aquatic life. [6]

Omofunmi, O. E., S. A. Ebifemi, and A. B. Eweina- 2016

To stop the water hyacinth's rapid growth in freshwater environments, the researchers built a harvester. They created a device driven by a 2.0 hp electric motor by applying scientific ideas and the anatomy of the plant. A mower disk weighing 100 x 70 x 7.36 mm and a shaft with four stainless steel blades measuring 26 mm in diameter serve as vital parts. The harvester has a capacity of 10,646 tons per hour and runs at 3.04 m/s. Using local resources to fabricate it could improve water hyacinth management techniques already in place. [7]

S. Rezaia, M. Ponraj, Amirreza Talaiekhazani, et al. published in Journal of Environmental Management-2015. The paper reviews the potential of using water hyacinth for the removal of organic, inorganic, and heavy metal pollutants from wastewater, while also discussing the potential byproducts that can be derived from water hyacinth and the need for sustainable management of this invasive plant species. [8]

Farah Amalina, et al. published in the Journal named Hazardous Materials Advances-2022. Water hyacinth can be used as an adsorbent to remove organic contaminants, especially organic dyes, from water, and future research in this area could aid in water resource management. [9]

- L. Madikizela, Journal of Environmental Management-2021. This paper reviews the use of water hyacinth, an invasive aquatic plant, for the remediation of water resources through the removal of organic pollutants, particularly organic dyes, using phytoremediation and adsorption. [10]
- A. Basu, A. Hazra, S. Chaudhury, A. Ross, S. Balachandran Informatics-2021. This paper presents a systematic bibliometric and text mining analysis of research on the invasive aquatic weed water hyacinth to understand the trends, themes, and future directions of this research domain. [11]
- P. Galgali, Supriya Palimkar, A. Adhikari, R. Patel, J. Routh International Journal of Phytoremediation - 2022. Water hyacinth, a prevalent aquatic weed, serves as an efficient agent for the removal of potentially toxic elements (PTEs) and other contaminants from wastewater. This is achieved through the environmentally sustainable and economically viable approach of phytoremediation, utilizing either the live plant or its derivatives, including dried powder, biochar, or activated carbon. [12]
- V. Guna, M. Ilangoan, M. Prasad, N. Reddy- 2017. Water hyacinth, a ubiquitous weed, has many unique and advantageous properties that can be leveraged to develop a variety of sustainable materials and products. [13]
- A. Degaga Journal of Natural Sciences Research-2019. Water hyacinth is an invasive aquatic weed that is challenging the ecological stability of freshwater ecosystems, with negative impacts on biodiversity, the economy, and human well-being, and the best approach to control it is prevention through education and legislation. [14]
- F. Karouach, W. Ben Bakrim, and colleagues published a paper in Frontiers in Environmental Science in 2022 that offers an extensive review of current strategies for managing the spread of the invasive water hyacinth. The authors assess the benefits and limitations of the primary control techniques and advocate for a combined strategy that integrates biological and physical methods, identifying it as the most sustainable and economically viable solution. [15]
- Nagassa Dechassa Journal of Environment and Earth Science- 2020. Water hyacinth is recognized as one of the most problematic invasive species globally, having expanded from its indigenous habitat in South America to numerous tropical and subtropical areas. This expansion has led to considerable economic and environmental consequences. However, its proliferation can be addressed through a range of control strategies, including manual, mechanical, biological, and chemical methods. [16]
- Habtamu Yigermal, Kelemu Nakachew, F. Assefa Journal of Research in Weed Science-2020. This paper reviews the allocation, challenges, and strategies for management of the invasive aquatic weed water hyacinth in Ethiopia. [17]
- L. B. Carvalho, W. R. C. Junior Communications in Plant Sciences-2019. Water hyacinth is an invasive aquatic weed that is difficult to control, but mechanical, chemical, and biological methods have been used with varying degrees of success and tradeoffs. [18]
- Anuja Sharma, N. Aggarwal, A. Saini, A. Yadav-2016. Water hyacinth, an invasive aquatic weed, can be utilized in various applications rather than just being controlled through conventional methods. [19]
- M. A. Bote, V. R. Naik, K. Jagadeeshgouda-2020. The paper reviews the research on using water hyacinth, an aquatic weed, as a potential biofuel crop to produce useful sources of energy, given the nuisance caused by the proliferation of this plant. [20]
- C. Mahamadi-2012. Water hyacinth has potential as a biosorbent for removing heavy and precious metals from aquatic environments. [21]
- Zhi Wang, Zhiyong Zhang, et al. have described the massive use of water hyacinth can effectively remove nutrients from eutrophic Lake Dianchi in China with minimal impact on macro zoo benthos and zooplankton. [22]
- N.M. Dushan Nalaka, H.H. Disal Buddhima, A.B.D. Priyasad, Jr. Gamage, Lu Subasinghe Moratuwa Engineering Research Conference-2024. The paper presents the development of a water hyacinth removal machine that uses a cutting mill and screw press to improve the efficiency of mechanical removal and reduce reformation of new plants. [23]
- M. Djihouessi, M. Olokotum, Louis Claude Chabi, F. Mouftaou, M. Aina Environmental Challenges-2023. The paper reviews the challenges in sustainable management of the invasive water hyacinth plant and highlights the need for an integrated, ecosystem-based approach that considers economic analysis and research innovation. [24]
- H. M. Saleh. 2016. This review covers the use of water hyacinth as a biological agent for remediating hazardous pollutants, including heavy metals and radioactive wastes. [25]

III. METHODOLOGY

The process of designing a water hyacinth removal and prevention machine involved several key steps:

We understood the characteristics of water hyacinth and assessed its impact on the environment and water bodies.

After that, we have reviewed existing methods and solutions for cleaning water hyacinth to identify their limitations and strengths. Further, we have explored ways to enhance the mechanical efficiency of current machines used for similar purposes. After the exploring process, we have chosen standard parts that meet the design requirements. Selected appropriate materials for constructing the machine to ensure durability and effectiveness. Decided on the basic mechanisms and principles that would drive the machine's operations. Created a detailed model of individual components for the machine. Conducted force analysis on the components to ensure they can withstand operational stresses. Finally, we built a prototype to test and refine the design for full-scale implementation.

The water hyacinth removal's design consists of different parts such as: Conveyor, Floaters, Propeller, Storage Tank, Microcontroller, Motor Driver, Cutter, DC Motor.

Conveyor: Function: The conveyor system is responsible for transferring the collected water hyacinth from the collection point to the storage tank. Working: Typically, conveyors in such applications are designed with durable materials resistant to water and plant matter. They use a continuous belt or series of paddles to move the biomass efficiently. The conveyor is powered by the machine's motor, ensuring a steady flow of the collected weeds towards subsequent processing or disposal areas.

Floater: Function: The floater provides buoyancy and stability to the machine on water surfaces. For floaters we have used fin Olex pipes. Working: Floater design involves materials and construction methods that ensure sufficient buoyancy to support the weight of the machine, including the harvested biomass. It prevents the machine from sinking, even when laden with water hyacinth, and helps maintain stability during operation.

Propeller: Function: The propeller generates thrust to propel the machine through the water. Working: Connected directly to the motor, the propeller converts the rotational energy from the motor into forward or reverse thrust. Its design and size are optimized to provide sufficient propulsion force to move the machine effectively through various water conditions, including areas with dense water hyacinth coverage.

Storage Tank: Function: The storage tank temporarily holds the collected water hyacinth biomass. Working: It is designed to accommodate large volumes of biomass efficiently. The tank's capacity and construction materials are chosen to withstand the weight and potential decomposition of the biomass without compromising the machine's buoyancy or stability. It allows for continuous operation by providing a place to store the collected weeds until they can be unloaded or further processed.

Microcontroller (e.g., ESP 8266 NODEMCU) Function: Acts as the brain of the machine, controlling various operations such as motor control, data collection, and communication. Working: Programs can be written to automate the movement of the machine, monitor sensors, and control actuators.

Motor Drivers (e.g., L298N) Function: Interfaces between the microcontroller and motors, allowing control of motor speed and direction. Working: Controls the propeller motors and conveyor system motors based on signals from the microcontroller.

Cutter Function: The ramp cutter cuts and gathers floating water hyacinth, guiding it into the collection system. Working: Positioned at the front of the machine, the ramp cutter features sharp blades or paddles that slice through dense mats of water hyacinth. As the machine moves forward, the ramp cutter collects the cut weeds and channels them towards the conveyor or directly into the storage tank. It is designed to effectively manage and control the accumulation of water hyacinth, ensuring efficient collection and removal from water bodies. **DC Motors (e.g., 12V DC Motors)** Function: Provides the necessary power to drive the propellers, conveyor, and other moving parts of the machine. Working: Propels the machine through water and operates the conveyor system.



Fig. 1. Model of Water Hyacinth Remover

The water hyacinth remover illustrated in Fig. 1, consists of three primary sections: the front assembly and the back assembly and power supply.

1) Front Assembly:

A storage tank for gathering and keeping the moved hyacinths is intended to be housed in the front portion. To make moving water hyacinths into the storage tank easier, a conveyor system is included between the front and back sections. L298N motor driver powers the conveyor system, guaranteeing effective material transportation.

2) Back Assembly:

The electronic control system, which is based on the ESP8266 microcontroller, is incorporated in the back part. This assembly communicates with the motor drivers and control system functioning. To give the front body structural support and allow for directional control, stabilizing fins are installed at the right and left side of model, while fin Olex pipes are employed as a floater at the bottom. 12V DC motors with a rated speed of 100 RPM are used to operate the fins, enabling the gadget to move forward and backward. In addition to this, an upper part cutter is used to cut the incoming water hyacinths.

3) Power Supply:

The system is powered by a 3.7V Lithium-ion rechargeable cells. To ensure compatibility with control electronics, an inbuilt voltage regulator present in L298N motor driver is used to cut down the 12V supply to 3.3V because the ESP8266 microcontroller operates at the lower voltage 3.3V.

Water hyacinths may be removed and collected efficiently because to the integrated design, which skillfully blends mechanical and electronic components.

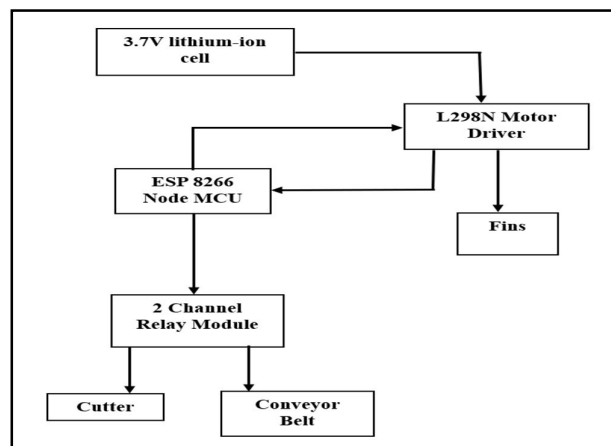


Fig.2. Block Diagram of Water Hyacinth Remover

The water hyacinth remover system runs by three 3.7V lithium-ion cells connected in series, leading to a total voltage around 12V, as shown in Fig. 2. The L298N motor driver module takes power from this 12V source of power. Then motor driver processes signals and gives output to ESP8266 which interacts with the interface in mobile on the user type IP address 192.

168.4.1 and connects wi-fi; the ESP8266 operates as the brain, controlling the motors. The 12V DC motors that power and move the fins positioned on the two sides of the boat is one of this motor driver's main duties.

Additionally, the L298N module includes a built-in voltage regulator that steps down the voltage to 3.3V. This regulated voltage is used to power the ESP8266 microcontroller, which serves as the central control unit of the system. The ESP8266 generates control signals for a relay module, which is responsible for starting the conveyor belt and the cutter mechanism. These components work together to collect and cut water hyacinth efficiently during operation.

IV. DESIGN CALCULATION

A 12V, 100 RPM DC motor is a highly versatile motor suitable for various applications, including propeller drive, cutting mechanisms, and conveyor systems. With its optimal speed and torque, it provides an efficient solution without requiring modifications. Below, we analyze its performance for each application and demonstrate why it is the best choice.

Voltage: 12V Speed: 100RPM

Angular velocity (ω) is given by:

$$\omega = 2\pi N / 60 \quad N = 100 \text{ RPM} \quad \pi \approx 3.1416$$

$$\omega = 2 \times 3.1416 \times 100 / 60$$

$$\omega = 628.32 / 60 = 0.174 \text{ rad/s}$$

Electrical power is given by:

$$PE = V \times I \quad PE = 12V \times 5A = 60W$$

Torque is calculated using:

$$\tau = P / \omega \quad \tau = 60 / 0.174 \quad \tau = 344.82 \text{ cm}$$

The motor offers an effective combination of speed and torque, rendering it appropriate for a range of applications, including the operation of a propeller, cutter, or conveyor.

V. TESTING AND RESULT

We tested the water hyacinth removal in a genuine water body once it was constructed to assess how well it worked. Without becoming stuck, the model collected and removed floating hyacinths by moving efficiently across the water.



Fig.4. Tested Model

As shown in Fig.4, water hyacinth remover model is successfully tested at 'Pawna River', Chinchwad, Pune, India.

We managed to guide it into areas of the plant through its remote operation, thus rendering control simpler. The collection mechanism collected the plants and placed them in the relevant compartment with ease. The model successfully removed a sizable area of the water's surface during several test runs, signalling that it would be a workable way to deal with invasive water hyacinths.

VI. CONCLUSION

The creation of the water hyacinth remover shows how mechanical design and electronic control systems may be successfully integrated to solve the problem of removing aquatic vegetation. The system achieves operational efficiency by fusing a well-structured bottom assembly for mobility and control with a sturdy upper assembly for collecting and storage. The use of the ESP8266 microcontroller, L298N motor drivers, and 100 RPM DC motors ensure precise automation and movement. Powered by a 12V Lithium-ion cells with a regulated voltage supply, the system is reliable and adaptable for real-world applications. This work provides a practical solution to managing water hyacinth infestations, contributing to improved waterway maintenance and environmental management.

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