IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

REDUCTION OF CO2 USING AZOLLA FERN

GAJANAN BAVISKAR, ABHILASH BAVISKAR, NIRAJ BAVISKAR, AARYA BATKADLI, SARTHAK BAVISKAR
F.Y.B.Tech Students' Engineering Design and Innovation (EDAI1) Project Paper, SEM 1 A.Y. 2022-23
Vishwakarma Institute of Technology, Pune, INDIA.

***Abstract* —This project report presents the potential of using Azolla, an aquatic fern, as a natural means to reduce carbon dioxide (CO2) emissions. Azolla due to its high CO2 absorption rates is a very promising candidate for mitigating climate change. Azolla has a significant capacity for absorbing CO2, with its highest absorption rate observed under high light intensity and low temperature.**

***Keywords*— environmental impact, mitigating climate change, C02 reduction, Azolla fern.**

I. INTRODUCTION

This research paper focuses on the potential of using Azolla, an aquatic fern, as a natural means to reduce carbon dioxide (CO2) emissions and mitigate climate change. Azolla is a fast-growing plant that has a significant capacity for absorbing CO2 from the air through photosynthesis. The rate of CO2 absorption is influenced by light intensity and temperature, and the research conducted suggests that Azolla could be a promising candidate for reducing CO2 emissions from the atmosphere. In addition to its potential as a carbon sink, Azolla has various other uses, particularly in agriculture, which we will explore in detail.

Climate change is a pressing global issue that has far-reaching impacts on the environment and human health. Carbon dioxide (CO2) emissions are one of the leading causes of climate change, and countering these emissions by absorbing excess CO2 is critical to addressing this challenge. As such, exploring alternative solutions to negate CO2 emissions is crucial, and Azolla represents a promising avenue for achieving this goal.

Azolla is a versatile plant that has been utilized for centuries for its beneficial properties. In agriculture, Azolla has various uses, primarily as a natural fertilizer and feed supplement for livestock. As a natural fertilizer, Azolla is rich in nitrogen and other essential nutrients, making it an excellent alternative to chemical fertilizers. Azolla also has the ability to fix nitrogen from the atmosphere and convert it into a form that can be utilized by plants, thereby improving soil fertility and promoting crop growth.

Additionally, Azolla can be used as a feed supplement for livestock, as it is highly nutritious and contains essential amino acids, vitamins, and minerals. Incorporating Azolla into animal feed can improve animal health and productivity while reducing the cost of feed production.

Furthermore, Azolla can be used in wastewater treatment systems, where it acts as a natural filter to remove pollutants from the water. This use of Azolla not only improves the quality of the water but also provides an eco-friendly alternative to conventional wastewater treatment methods.

Azolla represents a promising natural means of reducing CO2 emissions from the atmosphere, and its various uses in agriculture make it a valuable resource. As such, further research into the potential of Azolla as a carbon sink and its uses in agriculture is necessary to promote sustainable and eco-friendly practices.

II. METHODOLOGY

To write a research paper on Reduction of CO2 using Azolla Fern, the following methodology can be used:

The first step is to understand the impact of CO2 on our ecosystem. The problems we face as carbon dioxide levels in our atmosphere rise. Identifying flaws in current solutions to this problem and developing a better solution with the help of Azolla Fern.

The second stage is literature review. A literature review is required to learn about current research on Azolla Fern and its many characteristics. The literature review should concentrate on Azolla's CO2 absorption capability, optimal growth environment, usage of Azolla in agriculture, and the effect of various environmental conditions on Azolla's functioning.

In the third stage, we will generate and evaluate multiple solutions, considering their practicality and sustainability. Through brainstorming, we will identify the most promising options and select one for further implementation. Our aim is to find a solution that effectively addresses the problem of increasing carbon dioxide levels and promotes sustainability in agricultural practices.

The fourth stage is to create a digital prototype of our proposed Azolla pod. After finalizing the design, work on identifying possible flaw points of the current design and keep updating and upgrading it. The prototype's design should compare the affordability, usability, ease of manufacturing and other key characteristics of the Azolla pod.

The fifth stage is to execute the experimental investigation by gathering information about the performance of the Azolla pod, along with carrying out a survey, proposing and explaining our project to farmers and agriculturists and noting down their valuable feedback.

Once the data is collected, analyze it using statistical methods to determine the possible success of the project. The analysis should compare existing agriculture practices to the innovative use of Azolla fern and looking for avenues to improve the project further.

Lastly, a final review of the whole project is carried out, performing a judgmental analysis of the practical application and implementation of the Azolla fern in the proposed fields of C02 reduction and agriculture.

III. LITERATURE REVIEW

A literature assessment of the history of research on Azolla is provided in reference [1] by the authors. The authors present a comprehensive description of the beneficial characteristics associated with the Azolla plant. They highlight at least five notable attributes, which include its ability to fix atmospheric nitrogen, high productivity, rich protein content, and its positive effects on controlling aquatic weeds and NH3 volatilization. In addition, the authors discuss the commonly exaggerated limitations associated with Azolla utilization and propose strategies to help farmers maximize its benefits. The text also mentions various development activities that demonstrate a growing interest in harnessing the potential of Azolla for agricultural purposes. While Azolla's use as a green manure for rice has declined in China and other South Asian countries, numerous initiatives are being undertaken both in these regions and worldwide to explore the productive utilization of this plant. Despite receiving less attention in scientific circles due to their pragmatic goals, some of these programs show great promise. Furthermore, the authors conduct research on how Azolla can contribute to making agricultural practices in South Africa more cost-effective, sustainable, and efficient.

Reference [2] talks about Azolla, it explores the potential of fast-growing Azolla species for sequestering carbon dioxide (CO2). It aims to provide expert analysis on the significance of Azolla in mitigating CO2 emissions and its potential as a sustainable solution for addressing climate change. The study focuses on Azolla's capacity for CO2 sequestration, highlighting its rapid growth and nitrogen fixation abilities. It investigates Azolla cultivation, factors influencing growth and carbon sequestration efficiency, and potential applications across different ecosystems. The review emphasizes Azolla's physiological characteristics that enhance its CO2 sequestration capabilities, such as photosynthetic efficiency, biomass production, and carbon accumulation. The authors delve into the mechanisms of Azolla's carbon fixation process, including the interplay between photosynthesis, nitrogen fixation, and carbon allocation. Various factors influencing Azolla's growth and CO2 sequestration potential are explored, including environmental conditions, nutrient availability, and interactions with other organisms. The review critically analyzes research findings, providing insights into optimizing conditions for maximizing Azolla's CO2 sequestration efficiency. The authors discuss Azolla's potential applications in agriculture, wastewater treatment, and livestock feed. They highlight ongoing research and future directions, such as genetic engineering approaches, to enhance Azolla's productivity and carbon uptake capabilities. Hamdan and Hour's literature review presents Azolla as a promising tool for CO2 sequestration. It emphasizes the plant's unique characteristics, including fast growth, nitrogen fixation, and carbon accumulation. The review synthesizes existing knowledge, identifies research gaps, and suggests future directions for maximizing Azolla's CO2 sequestration efficiency. This research contributes to our understanding of Azolla's potential in mitigating climate change and underscores the importance of further exploration in this field.

Reference [3] provides an in-depth analysis of the biology and utilization of Azolla. The review aims to offer a comprehensive understanding of this aquatic plant, exploring its biological characteristics and diverse range of applications. Wagner delves into the biology of Azolla, highlighting its various names such as mosquito fern, duckweed fern, fairy moss, and water fern. The review discusses Azolla's natural habitat, noting its presence in swamps, ditches, lakes, and rivers, particularly in regions of Asia, Africa, and the Americas. Additionally, Wagner explains the etymology of the name "Azolla," derived from the Greek words "Azo" (to

dry) and "Ollyo" (to kill), reflecting its vulnerability to drought. The review focuses on the symbiotic relationship between Azolla and the endophytic blue-green algae Anabaena zollae. Wagner explains that Anabaena zollae resides within the leaf cavities of Azolla, forming a symbiotic complex. The algae, capable of nitrogen fixation, provide nitrogen for both themselves and Azolla, while the fern supplies a protected environment and a fixed carbon source. The review explores the various applications of Azolla beyond its biological characteristics. Wagner highlights Azolla's role as a biofertilizer and green manure in paddy fields, discussing its ability to enhance soil fertility and nitrogen availability. Furthermore, the review emphasizes Azolla's usage as a feed ingredient for livestock, both in fresh and dried forms. Additionally, Wagner examines other applications of Azolla, such as its medicinal uses, water purification properties, human food source, and its potential in biogas production. Wagner synthesizes existing research on Azolla, collating the findings from previous studies. The review provides a comprehensive overview of the biology and utilization of Azolla, presenting a valuable resource for future research and collaborative efforts. By consolidating research results, the review aims to contribute to a better understanding of Azolla's potential across various fields. The literature review by Gregory M. Wagner provides a comprehensive overview of Azolla, encompassing its biology and utilization. By exploring the plant's biological characteristics, symbiotic relationship, and diverse applications, the review offers insights into Azolla's potential in agriculture, livestock feed, medicine, water purification, and biogas production. This synthesis of research findings serves as a valuable resource for further investigation and collaborative research on Azolla, shedding light on the multifaceted aspects of this aquatic plant.

Reference [4] talks about the impact of CO2 concentration and environmental conditions on the photosynthesis of Azolla, a water fern with a unique ability to absorb CO2 from the atmosphere. The researchers conducted experiments under controlled conditions, varying the CO2 concentration and other environmental factors such as light intensity and temperature to examine their effects on the photosynthesis rate of Azolla. Their results indicated that Azolla has a high photosynthetic rate at elevated CO2 levels, with the maximum rate occurring at a CO2 concentration of 1,000 ppm. At this concentration, Azolla had a photosynthetic rate that was twice as high as that observed at ambient CO2 levels. The researchers also found that light intensity and temperature had a significant impact on photosynthesis, with the optimal values being 600-800 µmol m-2s-1 and 30°C, respectively. Additionally, the researchers observed that the photosynthetic rate of Azolla was not limited by the availability of nutrients such as nitrogen and phosphorus, indicating that Azolla is well-suited for growth in nutrient-poor environments. The study also found that Azolla is capable of acclimating to changes in CO2 concentration over time, suggesting that it has the potential to adapt to changing atmospheric conditions. Overall, the study suggests that Azolla could be a promising tool for mitigating the impacts of climate change, as it has the ability to absorb CO2 from the atmosphere and can thrive in a variety of environmental conditions. However, further research is needed to understand how to best utilize Azolla in real-world applications and how it can be integrated into existing agricultural and ecological systems.

III. IMPLEMENTATION

Here is a way to use Azolla's CO_2 absorbing capability to reduce the atmosphere's CO_2 concentration:

First, we need to set up an Azolla production farm to effectively produce Azolla without the need of any external intervention.

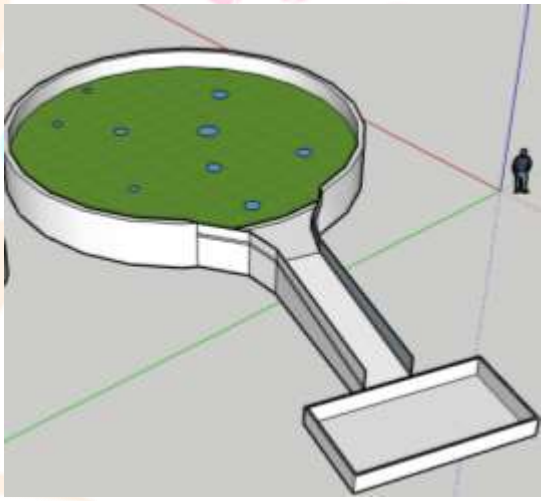

Fig. 1

This is the 3D model of the Azolla production farm. With the help of this we will be able to produce Azolla effectively.

Construction of the Azolla production farm: As shown in the model, the container's depth is small in comparison to its radius. Since Azolla grows solely on the water's surface, only a shallow enough depth is necessary to support its growth. However, the depth cannot be too shallow because water availability is one of the most important elements influencing Azolla development.

Azolla is a plant that requires highly particular circumstances to flourish and will not grow if those criteria are not met. Azolla requires a constant supply of fresh water to thrive, so it's essential to check the water level regularly and refill as necessary. In addition to providing adequate water, it's also important to ensure that the water is nutrient-rich. Nutrients such as Phosphorus and Potassium are needed to be added to the water regularly as they are essential for the growth of Azolla and cannot be found in water. The water temperature must be regularly monitored because Azolla demands a water temperature of 20ºC to 30ºC to grow properly and function at

its best. Azolla fern cannot sustain temperatures below 5ºC or above 45ºC. Azolla is a plant that enjoys shade but requires sunlight for photosynthesis; 30% to 50% light is ideal for Azolla growth.

There is a possibility that wind or turbulent water could fragment Azolla and kill it. So, the walls of the container have been made high in comparison to the water level so that the Azolla within the walls can be protected. The container will be having a cover on its top providing partial shade for Azolla and giving it optimal sunlight.

In the first phase, we will fill the container with water and add required nutrients to the water to help Azolla grow. After that, the container will be filled with 500g of Azolla culture for per square meter of the farm, which will be allowed to flourish. Because Azolla doubles its biomass every 1.9 days, Azolla will fill the farm in 1-2 weeks. The amount of Azolla culture can vary depending onto your needs.

In the upcoming phase, we will proceed with the extraction of the mature Azolla fern. This process will commence once the production plant has reached full capacity with Azolla fern. The growth of Azolla fern will be closely monitored using underwater LDR sensors positioned throughout the container. These sensors will track the light penetrating the water from the spaces between the Azolla fern. Upon detecting a drop in the amount of light below a predetermined threshold, it will indicate that the Azolla is ready for extraction.

To extract the Azolla fern, we will increase the water level in the container by introducing water through a dedicated pipe located on one side.

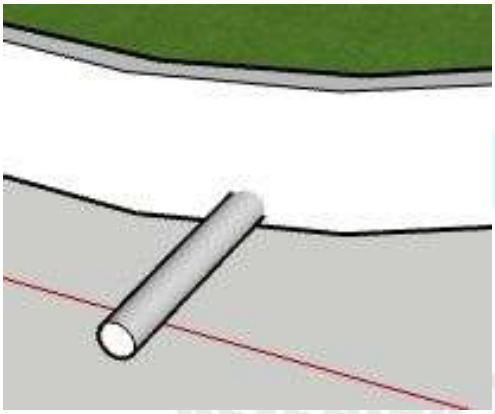

Fig. 2

A water pump, connected to the container via the pipe (as depicted in Figure 2), will facilitate the water supply. As water is supplied, the water level inside the container will gradually rise, causing the floating Azolla to flow through the opening and collect in the designated container illustrated in Figure 1. The rate of water supply will be matched to the flow rate through the opening.

In the upcoming phase, the Azolla fern that has been extracted will be utilized to manufacture Azolla pods. Azolla pods are small containers designed to house the Azolla fern while it floats on water. The dimensions of the pods will maintain the same ratio as those of the Azolla production container. A 3D model representation of the Azolla pod is depicted in Fig. 3. These pods will be strategically distributed throughout the city to aid in the reduction of atmospheric carbon dioxide.

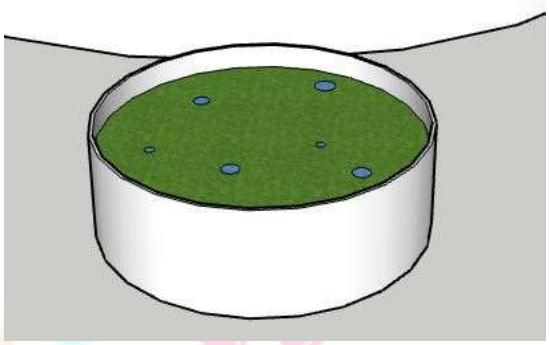

Fig. 3

Since Azolla will also grow within the pods, any excess growth will be collected every 1-2 weeks. Additionally, the water will be refreshed, and new nutrients will be added. This regular maintenance will ensure that the Azolla within the pods continuously aids in the reduction of carbon dioxide levels in the atmosphere.

The surplus Azolla fern will be utilized for the construction of additional Azolla production facilities and Azolla pods, thereby facilitating the rapid expansion of the system and contributing to a reduction in carbon dioxide emissions. A portion of the excess yield will be made available to farmers at a discounted price, particularly to those who require Azolla but lack the resources or time to produce it independently, thus further accelerating the expansion process.

IV. RESULT

1. Creating a streamlined method for mass-producing Azolla with high efficiency and maximum resource utilization.

2. The implementation of strategies focused on actively reducing the concentration of carbon dioxide in the Earth's atmosphere.

3. The gradual and sustained decrease in Earth's average temperature, coupled with the comprehensive and effective mitigation of the climate change crisis.

4. Facilitating the provision of ample quantities of Azolla fern to farmers, thereby meeting their agricultural requirements and supporting their farming endeavors effectively.

5. Create employment opportunities for skilled workers in Azolla collection and management, utilizing their expertise in sustainable agriculture and resource utilization to harvest, process, and distribute Azolla effectively.

6. Carry out further research to delve deeper into the wide-ranging possibilities of incorporating Azolla into diverse fields, extending beyond its proposed applications in carbon dioxide reduction and agriculture.

V. CONCLUSION

In conclusion, utilizing Azolla's CO2 absorbing capability to reduce the atmosphere's CO2 concentration is an innovative and sustainable solution to mitigate climate change. The Azolla production farm, as illustrated in the 3D model, is a viable approach to produce Azolla efficiently without external intervention. The construction of the farm and the maintenance of Azolla growth require careful consideration of various factors, such as water level, nutrient supply, temperature, and light exposure. The extraction of mature Azolla fern and the production of Azolla pods are crucial steps in the process, which will aid in reducing atmospheric carbon dioxide. The surplus yield from the Azolla farm can be utilized to construct additional Azolla production facilities and Azolla pods, which can help accelerate the expansion process and further contribute to the reduction of carbon dioxide emissions. This approach shows promise in reducing the atmospheric concentration of carbon dioxide, playing a crucial role in mitigating the negative impacts of climate change.

VI. ACKNOWLEDGEMENT

We express our sincere gratitude to our esteemed director, Prof. (Dr.) R.M. Jalnekar, for granting us the opportunity to undertake this project as part of the Capstone Project 2 (CP2) Course. We would also like to extend our thanks to Prof. (Dr.) Chandrashekhar Mahajan, Head of the Department of DESH, for providing us with the necessary resources and unwavering support. Additionally, we would like to convey our heartfelt appreciation to our Project Guide, Prof. Rupali Sadashiv Deshpande, for her invaluable guidance, insightful vision, unwavering support, and constant encouragement throughout the completion of our project.

WE WILL STRIVE HARD TO ENSURE THAT THIS PROJECT IS UNDERTAKEN TO THE HIGHEST POSSIBLE STANDARD AND THAT THE END RESULT MEETS AND EXCEEDS YOURS EXPECTATIONS. OUR TEAM IS COMMITTED TO DELIVERING A QUALITY PRODUCT IN A TIMELY MANNER, AND WE LOOK FORWARD TO WORKING WITH YOU FOR YOUR CONFIDENCE IN OUR WORK.

VII. REFERENCES

[1] Azolla research and development: recent trends and priorities. (Aug 1999) By: Andre Lejeune, Arsenia Cagauan and Charles Van Hove. Presented at the 8th congress of the African Association for biological nitrogen fixation,SA.

[2] CO2 sequestration by the propagation of the fast-growing Azolla ssp. (Oct 2021) By: Hamdan Z. Hamdan, Ahmad F. Hour

[3] Azolla: A review of its Biology and Utilization. (March 1997) By: Gregory M. Wagner.

[4] Interactive effects of CO2 and environment on photosynthesis of Azolla. By:Allen, S. G., Idso, S. B., Kimball, B. A., & Anderson, M. G. (1987).