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RESEARCH ARTICLE

ASSESSMENT AND DEVELOPMENT OF WATER HYACINTH *(EICHORNIA CRASSIPES)* AS A COMPONENT MATERIAL FOR BIOPLASTIC

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Abstract

Traditional plastic pollution presents a substantial menace to our ecosystem. This study examines the capacity of water hyacinth (*Eichhornia crassipes*), a rapidly proliferating aquatic plant, to serve as a constituent material in bioplastics. The study investigates the viability of using water hyacinths to create environmentally friendly substitutes for disposable plastics. The study investigates the optimal techniques for converting water hyacinth into bioplastic. The study also examines the mechanical properties and biodegradation rates of the generated bioplastics compared to traditional plastics. Additionally, the project intends to help decrease plastic waste and its negative impact on ecosystems by advocating using water hyacinth, a widely available and renewable resource. Moreover, biodegradable bioplastics made from water hyacinths can reduce the release of greenhouse gases linked to conventional plastic manufacturing. Moreover, research establishes a foundation for advancing water hyacinth bioplastics, which presents a hopeful resolution for addressing plastic pollution, promoting sustainable economic progress, and moving towards a more ecologically conscientious future.

Keywords: *water hyacinth (eichhornia crassipes), bioplastic*

Introduction

In recent years, there has been increasing concern about the detrimental effects of conventional plastics on the environment. Consequently, there has been a transition towards creating and utilizing bioplastics, which are made from sustainable sources and can be broken down naturally or turned into compost. Bioplastics have become increasingly popular in diverse packaging, agriculture, automotive, and textiles sectors. Nevertheless, there is a significant amount of knowledge to be acquired regarding the forthcoming developments in bioplastics and their potential ramifications on the environment, economy, and society.

This research capstone aims to examine the present patterns and forthcoming trajectories of bioplastics. This project will thoroughly analyze literature, industry data, and expert opinions to examine the possible benefits and difficulties associated with bioplastics. It aims to understand better how bioplastics might help reduce plastic pollution and contribute to sustainable development. Furthermore, there is a clear trend towards advancing and utilizing bioplastics, which are made from renewable resources and can be broken down naturally or turned into compost. This shift is driven by increasing concerns regarding the detrimental effects of conventional plastics on the environment (Ahmed et al., 2021; Al-Sabahi et al., 2018). Due to their distinctive chemical makeup containing abundant amounts of starch and cellulose, water lilies have been recognized as promising candidates for the synthesis of bioplastics (Muniyasamy et al., 2021; Singh et al., 2019).

Nevertheless, a significant amount of knowledge remains to be acquired regarding the present patterns and future trajectories of bioplastics derived from water lilies. This includes understanding their characteristics, uses, advantages, and constraints as well as the obstacles and possibilities for expanding production and infrastructure (Kanmani et al., 2020; Kumari et al., 2021).

Therefore, it is necessary to enhance labeling rules to align with the consumption of raw materials, energy, production emissions, and usage. In order to enhance the long-term sustainability of materials and processes, bioplastics must continue to rely on integrated and environmentally conscious technology. Bioplastics should not be substituted for conventional plastics in order to decrease long-term reliance on non-renewable resources. Using bioplastics facilitates the advancement of a circular economy, wherein waste is minimized, and resources are utilized more efficiently. Bioplastics mitigate dependence on fossil fuels and the adverse environmental impacts of plastic manufacturing and disposal by utilizing renewable resources for plastic manufacture (BioFed, 2022).

This research examines the present patterns and future prospects of bioplastics derived from water lilies. The primary objective is to investigate their potential contribution to reducing plastic pollution and advancing sustainable development. Furthermore, it aims to provide insights into the market demand, projected growth, and technological advancements in the bioplastics industry and identify potential and challenges associated with bioplastics, including the need for enhanced sustainability, scalability, and affordability. In addition, the research may prove beneficial to legislators, investors, business leaders, and other stakeholders with a vested interest in the bioplastics industry. Informing decision-making processes and facilitating the development of strategies that encourage the growth and adoption of bioplastics can be beneficial (Atiwesh, 2021).

Lastly, this study aims to enhance comprehension of the prospective trajectory of bioplastics and their significance in promoting sustainable development. The findings derived from this research will be pertinent to legislators, industry moguls, and other individuals with a vested interest in advocating for sustainable materials and mitigating plastic waste.

Research Questions

Specifically, this study sought to answer the following questions:

1. Can water hyacinth (Eichhornia crassipes) be a viable component material for bioplastics, and if so, what properties (strength, degradation rate, etc.) can be achieved through its incorporation?
2. How does the proportion of water hyacinth in a bioplastic composite affect its mechanical properties (flexibility, tensile strength) compared to conventional bioplastics?
3. Is water hyacinth an effective reinforcing agent in bioplastics, and can it improve the durability and performance of bioplastics compared to existing formulations?
4. What is the most efficient and environmentally friendly method to extract and process water hyacinth for bioplastic production?

Literature Review

A variety of plastic products are necessary for everyday use on the market. Bond (2018) identifies the most often utilized types of plastic in the market as PE (polyethylene), PP (polypropylene), PVC (polyvinyl chloride), PET (polyethylene terephthalate), and PS (polystyrene). The worldwide output of plastic has risen significantly, going from 1.5 million tons in the 1950s to 335 million tons in 2016, as reported by Li et al. (2016), Lebreton et al. (2017), and Statista (2018). The escalation of plastic manufacture inevitably results in plastic pollution. The quantity of plastic being deposited in landfills or the natural environment rises in tandem with the scale of plastic production.

Furthermore, councils' increased adoption of plastic bottle recycling has raised concerns among environmentally aware shoppers regarding supermarkets supplying free plastic carrier bags (Goodship, 2007). Disposable plastics such as bottles, straws, bags, and cutlery have become an integral part of our daily lives and are a substantial cause of the escalating issue of plastic pollution. Individuals often opt for disposable plastic because of its convenience, resulting in a growing volume of plastic garbage deposited in landfills and the natural environment.

Moreover, the main contributors to plastic pollution were essentially diverse human activities. Hence, inadequate handling of plastic waste can result in plastic infiltrating terrestrial, marine, and atmospheric ecosystems via various pathways. This may give rise to potential hazards to the environment, as well as to human health.

Composting can improve environmental and human health by reducing the release of hazardous compounds into the environment, mainly by reducing the excessive use of chemical fertilizers (Ayilara et al., 2020). Today, there is a noticeable problem with improper waste management that can harm public health, the environment, and natural resources. However, this issue can be addressed by implementing composting practices. Composting, as recommended by the United Nations Environment Programme (UNEP), offers several benefits, such as reducing the reliance on chemical fertilizers, improving soil fertility, and enhancing water retention and nutrient delivery to plants.

Promoting the utilization of bioplastics is advocated as a substitute for conventional, non-biodegradable polymers derived from petroleum. The current state is deficient, as it comprises items derived from sustainable sources (bio-based, such as Bio-polyethylene, Bio-PE), materials designed to decompose naturally (biodegradable, like polybutylene succinate, PBS), or a combination of both (such as polylactic acid or PLA) (Lambert & Wagner, 2017, as cited by Zimmermann et. al., 2020). According to European Bioplastics (2018), bioplastics are categorized as comparable commercial products to starch blends. They are designed to fulfill the same function as plastic materials and appear to customers as such. According to the Department of Environment and Natural Resources (DENR), the proliferation of water lilies in a specific area of the Pasig River may be attributed to residential waste and the use of fertilizers in aquaculture farming. This phenomenon is particularly noticeable during the rainy seasons (De Vera-Ruiz, 2020).

The DENR office has called on the people to adopt ecologically responsible practices to prevent further pollution of the Pasig River (De Vera Ruiz, 2020). The researchers intend to substantiate the assertion using water lilies instead of conventional plant-based components like starch. This choice is motivated by the fact that the unchecked proliferation and encroachment of water lilies can lead to significant water drainage issues, in addition to serving as a food source for wildlife (Sampson & Canright, 2017).

Oxo-biodegradable and hydro-biodegradable are the two main categories of biodegradable bioplastics, distinguished by their respective degradation methods. Oxo-biodegradable plastics are typically derived from naphtha, a by-product of oil or natural gas. The decomposition of these plastics typically occurs over months to years. Hydro-biodegradable plastics disintegrate more rapidly than oxo-biodegradable polymers by hydrolysis and can be transformed into fertilizers. This phenomenon can be observed in the production of bioplastics derived from plant-based materials and polylactic acid (PLA) (Atiwesh et al., 2021).

Furthermore, biodegradable bioplastics can undergo microbiological processes, leading to their decomposition into natural substances that can safely integrate with the soil, facilitated by oxygen and water. When a bioplastic manufactured from cornstarch is composted, the cornstarch molecules gradually take in water and expand while being buried. Consequently, the starch bioplastic breaks down into tiny fragments that bacteria may efficiently metabolize (Atiwesh et al., 2021).

Methodology

The materials and equipment required for producing bioplastics from water hyacinth include a range of both basic and advanced items, depending on the specific process and outcomes desired.

Water Hyacinth

Freshly harvested water hyacinth (*Eichhornia crassipes*) is the primary raw material. It should be collected and then cleaned using distilled water to remove any impurities.

Bioplastic Components

The essential components for the bioplastic formulation will vary based on the chosen recipe but typically include natural plasticizers such as glycerin or vegetable oil, and starch, which could be cassava or corn starch. Optional ingredients may involve natural reinforcing agents like cellulose fibers, and vinegar or another mild acid to modify the starch properties for improved plasticity.

Additional Materials

Sodium hydroxide (NaOH) solution may be used for the delignification process, which is optional but can help in removing lignin from the water hyacinth fibers, improving their compatibility with the bioplastic matrix. Safety gear including gloves, goggles, and a mask is essential to protect against potential hazards during the process.

Basic Processing Tools

Tools like a sharp knife or pruning shears are necessary for harvesting the water hyacinth. Drying trays or screens are used to dry the plant material, while a grinder or blender is required for size reduction. Mixing bowls and utensils will be needed for combining ingredients, and molds are used to shape the bioplastic into desired forms. For faster drying, a drying oven can be employed, although it is optional.

Advanced Processing Equipment

If a more advanced approach is taken, a compression molding machine might be used to create bioplastic sheets or films. An extrusion machine could also be required for producing filaments or more complex shapes. A grinder may also be utilized for turning the bioplastic into pellets for easier storage or further processing.

Testing Equipment

To assess the properties of the bioplastic, testing equipment may include a tensile strength tester for evaluating the material’s strength, a biodegradation test chamber to measure the rate at which the bioplastic decomposes, and a scanning electron microscope (SEM) to analyze the microstructure of the final product.

Treatment/ General Procedure

The experimental investigation employed four treatments and completed three trials. The water lilies were gathered before being used, thoroughly cleansed, sliced into small fragments, and boiled extensively for 30 minutes to obtain water lily extract. Various proportions of the extract were blended with specific amounts of glycerin, and the concoction was heated moderately until it reached a sticky consistency. The adhesive mixture is deposited and allowed to harden on a stainless steel tray for a duration of three days. After a three-day drying period, tests were conducted to evaluate the water lily's tensile strength and biodegradability to determine its potential and acceptability as a bioplastic source.

Results and Discussion

The following section presents the data collected in this study on developing water lily-based bioplastic. The data were analyzed using descriptive statistics and presented as graphs/figures. From the three trials with different treatments that were performed, the mean was collected, and the results are as shown:

Figure 1 shows that in terms of the tensile strength, T2 got a mean of 400g, T3 got a mean of 630g, and T4 got a mean of 900g, comparable to the T1 (control) commercial plastic that can hold 2000 gms. It shows that the more glycerine it has, the heavier it can carry.

Figure 1: *Result of tensile strengths*

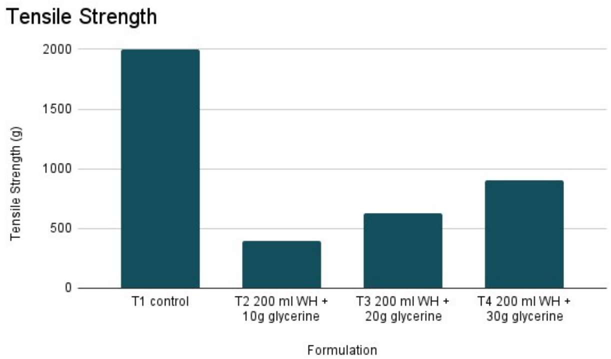
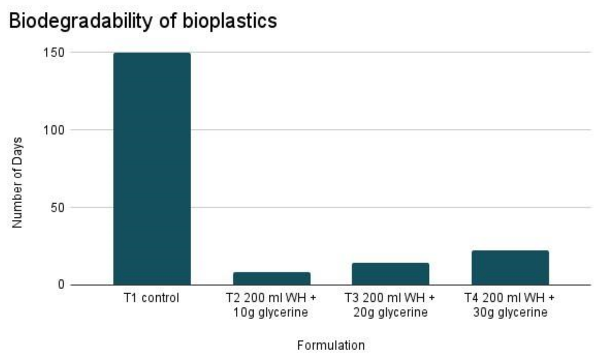


Figure 2 shows that in terms of biodegradability, T2 got a mean of 8 days, T3 got a mean of 14.6 days, and T4 got a mean of 22.6 days. This means that biodegradable plastics can decompose faster than (T1 control) commercial plastics that can decompose for 150 days or more.

Figure 2*: Biodegradability of bioplastics*



This section shows the results and findings gathered from the product's making, categorized by their tensile strength and biodegradability. Three trials were performed with four different treatments, and the mean from the three trials was collected. The treatments differed depending on the ratio of water lily extract to glycerine.

As shown in Figure 1, the standard tensile strength of a plastic is 2000 gms, which was the control or the first formulation (T1). T2, with 10 g of glycerine, resulted in a mean of 400 gms, while T3, with 20 g of glycerine, resulted in 630 gms, and lastly, T4, with 30g of glycerine, resulted in a tensile strength of 900 gms, making T4, with the highest amount of glycerine the one that is closest to the usual tensile strength of plastic which is 2000 gms.

Moreover, as seen in Figure 2, the standard biodegradability of plastic in days is 150 days, which was the first formulation (T1). T2, with 10 g of glycerine, resulted in 8 days, while T3, with 20 g of glycerine, resulted in 14.6 days, and finally, T4, with 30 g of glycerine, resulted in a mean of 22.6 days with regards to its biodegradability, making T2, with the least amount of glycerine the one that has the least days in terms of its decomposition.

Conclusion

This research highlights the promising potential of bioplastics derived from water hyacinths (not water lilies) as a sustainable alternative to single-use plastics. This development offers a significant step forward in tackling the critical environmental issues associated with traditional plastic pollution.

The readily available and fast-growing nature of water hyacinths presents an abundant and renewable resource for bioplastic production. Compared to conventional plastics, water hyacinth-based bioplastics boast several advantages. Primarily, their biodegradability allows for natural decomposition in the environment, unlike traditional plastics with centuries-long lifespans. This characteristic positions water hyacinth bioplastics as a powerful tool for minimizing plastic waste and its detrimental impact on ecosystems.

Furthermore, water hyacinth bioplastics have the potential to contribute to reduced greenhouse gas emissions. Unlike conventional plastics from fossil fuels, these bioplastics utilize a renewable plant source - water hyacinth. Combining biodegradability, suitable mechanical properties, and a renewable source material makes water hyacinth-based bioplastics an attractive solution for tackling plastic pollution, lowering carbon emissions, and promoting sustainable economic growth. Continued research and investment in this field are crucial to unlocking the full potential of water hyacinth bioplastics and paving the way for a more environmentally responsible and socially conscious future.

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