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Development of Biodegradable Pots from Water Hyacinth Wastes for Plant Growth

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Abstract

This research aims to utilize harvested water hyacinth from community wastewater treatment systems to produce biodegradable pots, reducing water pollution and adding value to water hyacinth waste. The dried water hyacinth was processed into three forms: long pieces, short pieces, and shredded pieces. An 8-inch bio-pot was formed through cold pressing, using starch paste as a binder. The bio-pots were tested for physical properties, soil biodegradability, and marigold growth performance, compared to plastic pots under controlled water and fertilizer conditions. The results showed that the shredded water hyacinth form, in the optimal ratio of water hyacinth: starch paste: water of 1:2:1 (by weight), provided the best properties, with a porosity of 59.54% and the highest density of 0.35 g/cm^3. After 60 days of marigold cultivation, the shredded bio-pot produced stronger stems and a higher flower count than plastic pots, while also demonstrating the fastest biodegradation rate than other forms. In conclusion, biodegradable pots made from shredded water hyacinth pieces exhibit suitable characteristics for plant cultivation, presenting a viable alternative to plastic pots. These eco-friendly pots have potential for reducing plastic waste and adding value to water hyacinth waste.

Keywords: Biodegradable pots; Water hyacinth; Waste Utilization

1. Introduction

Domestic wastewater, generated from daily activities such as washing, cooking, and using restrooms, is predominantly contaminated with various organic substances and nutrients present in the water (Pollution Control Department, 2002). Simple community wastewater treatment methods, such as phytoremediation using aquatic plants, are widely recognized as appropriate technologies for treating domestic wastewater. Water hyacinth, a floating aquatic plant, offers numerous benefits, including providing adequate nutrients to serve as animal feed, particularly for ruminants such as cattle, goats, and pigs (Hossain *et al.,* 2015). Additionally, it can be used to produce compost. Floating plants, which have roots and stems suspended in water, are also popular for wastewater treatment due to their ability to float on the water surface or employ structures that enable buoyancy (Sutthida *et al.,* 2021).

Water hyacinth, a widely used plant for wastewater treatment, must be harvested after reaching full growth and losing its treatment efficiency. Once removed from the system, the harvested plants may decompose, emitting unpleasant odors and creating environmental challenges in nearby areas. However, repurposing these water hyacinths can mitigate disposal issues, reduce associated environmental impacts, and produce value-added products.

Nowadays, planting trees has gained popularity, and biodegradable pots have presented as an environmentally friendly option. These pots are easily degradable, can be buried in soil without toxic, prevent root damage, retain water, and provide good aeration. Once buried, biodegradable pots naturally decompose into the soil, enriching its structure, enhancing porosity, and promoting root development. Water hyacinth contained with nitrogen (N), phosphorus (P), and potassium (K) contents of 2.77%, 0.60%, and 3.20%, respectively, can effectively support plant growth (Niphon *et al.,* 2022). Based on these properties, this research aims to study the characteristics and utilization of water hyacinth biodegradable pots. These pots can enhance soil quality, promote plant growth, and serve as an innovative approach to repurposing waste without causing environmental harm.

2. Methodology

2.1 Preparation of Equipment and Materials for Producing Biodegradable Pots

Biodegradable pots were produced from water hyacinth using different preparation methods. The water hyacinth was processed into three forms: long pieces (chopped pieces approximately 3 cm in length), short pieces (chopped pieces approximately 1 cm in length), and shredded pieces (shredded approximately 6 cm in length). The preparation of each type of raw material was conducted as follows;

2.2.1 Preparation of Water Hyacinth

In this study, mature water hyacinths were harvested from a floating aquatic plant-based wastewater treatment system at the King's Royally Initiated Laem Phak Bia Environmental Research and Development Project. The roots were removed, leaving only the stems and leaves for use. The water hyacinth was then processed into 3 forms: long pieces, short pieces, and shredded pieces. These prepared materials were subsequently sun-dried until completely dry to ensure suitability for use in producing biodegradable pots.

2.2.2 Preparation of Starch Paste

The starch paste was prepared by boiling a mixture of 100 grams of tapioca starch and 1,000 milliliters of water. This glue served as the adhesive in the production of biodegradable pots from water hyacinth.

2.2 Study of Biodegradable Pot Molding Techniques

The biodegradable pots were produced with a diameter of 8 inches at the rim and a height of 10 inches from the base to the rim. The water hyacinth used for the production was prepared in three forms: (A) long pieces (B) short pieces (C) shredded pieces

The production step was start with weigh 300 grams of water hyacinth material, then add 150 grams of starch paste and mix until uniform. Place the mixture into an 8-inch diameter mold and press the material into shape using a manual cold-pressing method. After that remove the molded pot and create drainage holes at the base and left for air-dry in a shaded area for one week to ensure complete drying before next experiment.

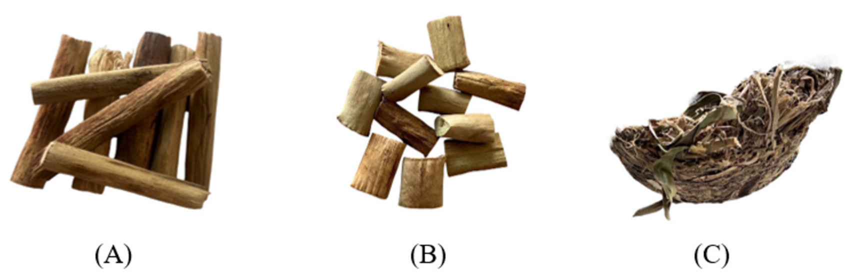

Figure 1. Preparation of Water Hyacinth (A) long pieces (B) short pieces (C) shredded pieces

2.3 Physical Quality Testing of Biodegradable Pots

2.3.1 Porosity Test

Porosity was calculated using the bulk density (Db) and material density (Ds), with the following formula.

$$\text{Porosity (\%)} = [1 - \frac{Db}{Ds}] \times 100 \quad (1)$$

Where; Db = Bulk density. Ds = Material density.

2.3.2 Water Absorption Test

Water absorption was determined by calculating the percentage increase in pot weight after soaking in water for 24 hours compared to its dry weight, using the formula.

$$\text{Water Absorption Test (\%)} = \frac{WwxWs}{Ws} \times 100 \quad (2)$$

Where; Ww = Weight of the pot after soaking. Ws = Dry weight of the pot.

2.3.3 Bulk Density Test

Samples measuring 5 × 5 cm were randomly cut from three pots for each type. The mass (m) and volume (v) of the samples were measured, and the bulk density was calculated using the formula

$$\text{Water Absorption Test (\%)} = p = m / v \quad (3)$$

Where; p = Bulk density (g/cm³ or kg/m³).m = Mass of the sample (g or kg). v = Volume of the sample (cm³ or m³).

2.4 Testing the Use of Biodegradable Pots for Growing Marigolds

The experiment included three types of biodegradable pots; (A) long pieces (B) short pieces (C) shredded pieces, and use plastic pot as control, with three pots per type for three replicates. All conditions were controlled and conducted in a plastic greenhouse measuring 180 cm in length, 90 cm in width, and 118 cm in height. Marigolds were grown following cultivation guidelines from the Department of Horticulture, Faculty of Agriculture, Kamphaeng Saen (2017). Data on marigold growth, such as stem height, leaf count, and flower count, were recorded.

2.5 Biodegradability Testing

The three types of biodegradable pots were buried in soil, simulating in-ground planting with lemongrass as a test plant.

Figure 2. Preparation of Starch Paste

Table 1. Mixing ratio for forming bio-pots from water hyacinth

Water hyacinth Form	Water hyacinth weight (g)	Starch Paste (g)	Water (g)	Pot weight (g)
shredded pieces	500	1000	500	2000
short pieces	1200	1000	300	2500
long pieces	1400	1000	300	2700

The pots were left in the soil for one month. After this period, the pots were excavated to assess the extent of their biodegradation in the soil.

3. Results and Discussion

The experiment was described the molding biodegradable pots using three forms of water hyacinth: long pieces, short pieces, and shredded pieces, with starch paste as the binding agent. The results of the study are as follows;

3.1 Molding Techniques

The study on molding techniques revealed that all three forms of water hyacinth could be successfully molded into pots. The ease of molding ranked from the easiest to the most difficult as follows: Shredded pieces, Short pieces and Long pieces respectively, which were the most challenging to mold.

3.2 Physical Quality Testing

The physical properties of the biodegradable pots were tested, including moisture content, porosity, density, and water absorption. The results are as follows;

3.2.1 Water Absorption Test

When the biodegradable pots were submerged in water:

- Pots made from shredded pieces disintegrated after 60 minutes
- Pots made from short pieces disintegrated after 30 minutes
- Pots made from long pieces disintegrated after 60 minutes

The physical testing of the biodegradable pots showed that pots made from shredded pieces had the highest density (0.35 g/cm^3), while pots made from long pieces had the lowest density. In terms of moisture content, shredded fiber pots exhibited the lowest percentage 59.94%. Additionally, long pieces pots also had the highest porosity (64.47%), which enhances aeration and supports biodegradation.

3.2.2 Application in Marigold Cultivation

The biodegradable pots were tested for their effectiveness in growing marigolds. Growth data, including stem diameter, stem height, number of leaves, and number of flowers, were collected for marigolds grown in the three types of biodegradable pots and in plastic pots under control conditions. The results, as shown in Figure 5, when used for growing marigolds, plants cultivated in biodegradable pots demonstrated growth similar to those grown in plastic pots indicate that the biodegradable pots supported plant growth effectively.

3.2.3 Biodegradability Testing

To evaluate biodegradability, the three types of pots were buried in soil for one month, simulating natural conditions with lemongrass planted in the pots. The results showed.

- Pots made from shredded pieces degraded almost completely, with lemongrass roots integrating well into the pot fragments.

Figure 3. Water Hyacinth biodegradable pot (A) long pieces (B) short pieces (C) shredded pieces

- Pots made from short pieces degraded by approximately 90%, with some remaining fragments still visible, though lemongrass roots had penetrated these fragments.
- Pots made from long pieces degraded by approximately 80%, leaving more visible fragments. Lemongrass root penetration was less pronounced compared to the other types.

The results suggest that porosity significantly influences aeration, enhancing the natural biodegradation of the pots (Nipon *et al.*, 2022). This is visually represented in Figure 6.

These findings highlight the potential of using biodegradable pots made from water hyacinth as an eco-friendly alternative to conventional plastic pots, contributing to waste management and sustainable horticultural practices.

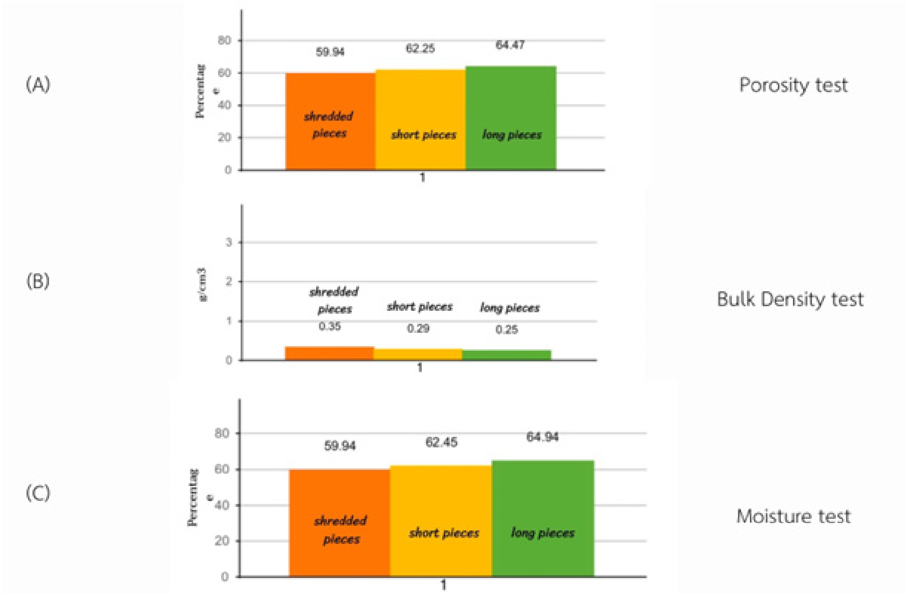

Figure 4. Physical test results of water hyacinth bio pots (A) Moisture (B) Density (C) Porosity

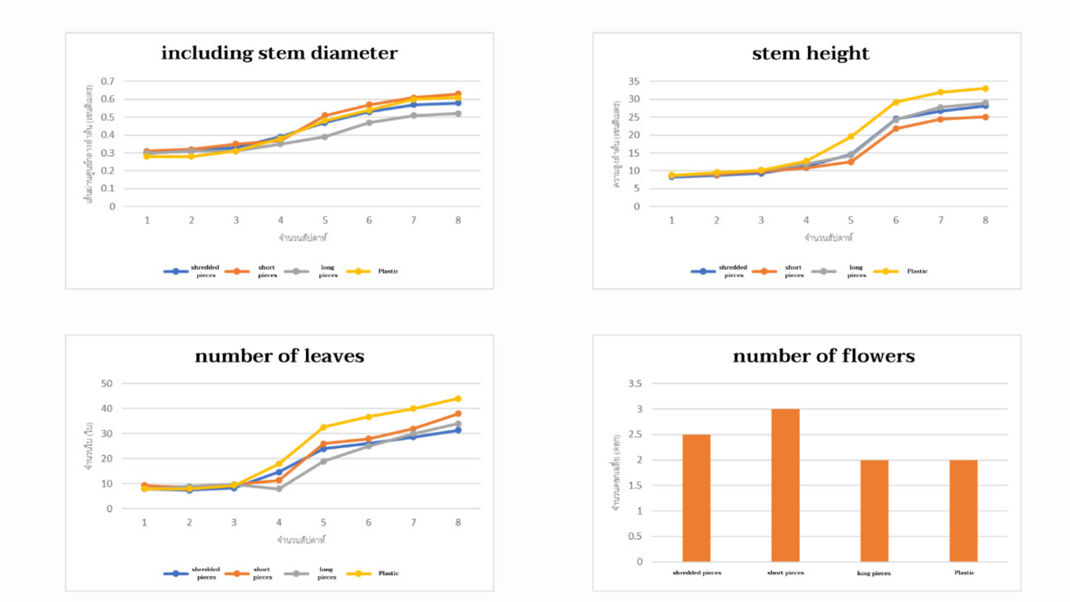

Figure 5. Growth results of marigolds in each type of pot

Figure 6. The decomposition test of bio-pots made from water hyacinth (A) shredded pieces (B) short pieces (C) long pieces.

4. Conclusions

This research focused on developing biodegradable pots from water hyacinth for plant cultivation. Three forms of water hyacinth: long pieces, short pieces, and shredded pieces were used as the material, with starch paste as the binding agent. The study on molding techniques revealed that shredded water hyacinth pieces was the easiest to mold, with an optimal ratio of water hyacinth: starch paste: water as 1:2:1 compared to the other forms. In contrast, long pieces were the most challenging to mold.

The physical testing of the biodegradable pots showed that pots made from shredded pieces had the highest density, lowest moisture content percentage and also had the porosity more than 50% which enhances aeration and supports biodegradation which relate to the result of marigold cultivation due to marigolds in biodegradable pots produced more flowers than those in plastic pots and showed good growth rate.

The biodegradation study found that shredded pieces pots decomposed most effectively, with nearly complete degradation observed after one month. This suggests that shredded fiber pots are the most suitable form for molding biodegradable pots.

In conclusion, biodegradable pots made from water hyacinth are highly effective for plant cultivation, and pots made from shredded pieces are particularly well-suited for this purpose. This innovation offers an eco-friendly alternative to plastic pots and contributes to sustainable waste management.

Acknowledgement

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References

Anonymous. 2015. Fiber and fabric properties. Available source: http://www.natureworksllc.com/~/media/Technical_Resources/ Fact_Sheets/Fibers/FactSheet_Fabrics_Fiber_FabricProperties_pdf.pdf. November14, 2015.

Ajithram Arivendan, Winowlin Jappes J T, Siva Irulappasamy and Brintha N Chris. 2021. A composite sample is cut into as per ASTM standards and themechanical tests like tensile, flexural, impact test is conducted by using universaltesting machine (UTM), and Charpy impact test machine. Water Hyacinth(Eichhorniacrassipes) PolymercompositesProperties–Aquatic Wasteinto Successful Commercial Product. (1) 28: 2021.

Candido,V.,Castronuouo,D.and Miccolos, V., 2011, The Use of Biodegradable Pots for the Cultivation of Poinsettia, Acta Horticulturae, 1-8.

Methacanon, P., U. Weerawatsophon, N. Sumransin, C. Prahsarn and D.T. Bergado. 2010. Properties and potential application of the selected natural geotextiles. Carbohydrate Polymer. 82: 1090-1096.

Sakorn Chonsakorn, Supanicha Srivorradatpaisan & Rattanaphol Mongkholrattanasit (2019) Effects of different extraction methods on some properties of water hyacinth fiber, Journal of Natural Fibers, 16:7, 1015-1025, DOI: 10.1080/15440478.2018.1448316

Schrader, J.A. 2016. Bioplastics for horticulture: An introduction. In: J.A. Schrader, H.A.Kratsch, and W.R. Graves, (Eds). Bioplastic Container Cropping Systems: Green Technology for the Green Industry. Sustainable Hort. Res. Consortium, Ames, IA, USA 4-5.

Pollution Control Department. (2002). National Environmental Quality Promotion and Conservation Act B.E. 2535 (1992). Related laws, decrees, and regulations on pollutioncontrol. 5th Edition. The Veterans Organization Printing House, Bangkok.

Land Development Department. (2010). Handbook on Chemical Soil Analysis Process. Bangkok, Science for Land Development Division, Land Development Department, Ministry of Agriculture and Cooperatives.

Department of Horticulture, Faculty of Agriculture, Kamphaeng Saen. (2017). Marigold Cultivation for Decoration. Nakhon Pathom, Kasetsart University, Kamphaeng Saen Campus.

Burachat Chatweerath, and Phichai Nimityongsakul. (1994). Application of Water Hyacinth Fiber Reinforcement in Roof Panels. Engineering Journal, Khon Kaen University, Vol. 21 (Issue 1-2), p. 88. ASTM D1037 Standard Test (1994).

Jirachaya Boonyarit, Wutnan Klongthad, Sutira Wityakarn. (2015). Physical Properties of Water Hyacinth Fiber for Spinning O.E. Yarn Mixed with Water Hyacinth and Cotton Fibers, pp. 994-1003. In: Proceedings of the 54th Annual Academic Conference of Kasetsart University (Agricultural Industry Section).

Sutthida Puththaisong, Paweena Aephet, Rwinipa Srimoon. (2021). Effectiveness of Water Hyacinth and Duckweed for Wastewater Treatment in Community-Based Hydroponic Systems. Bachelor’s Thesis, Rajamangala University of Technology Tawan-ok.

Nipon Tanpaiboonkul, Thanaporn Buesnampha, Kanokwanna Sukranant, and Phimphakha Photilangka. (2020). Biodegradable Pots from Water Hyacinth Using Cassava Starch and Cassava Residue as a Binder: Final Research Report for Fiscal Year 2020. Mahasarakham University.

Wikipedia, The Free Encyclopedia. (2022). Water Hyacinth. Source: https://th.wikipedia.org/wiki/ผักตบชวา, August 23, 2022.