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Development of Non-Dissolved Aquatic Plant Absorbent Cubes

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Abstract

Aquatic plants play a vital role in water treatment by balancing ecosystems and improving water quality. This study utilized Limnocharis flava, an abundantly growing aquatic plant from Bukit Gambir, to create an absorbent cube with guar gum as a binder. Unlike powdered aquatic plant absorbents that cannot be removed from water, these cubes offer a practical, retrievable solution.The study aimed to determine the optimal plant-to-binder ratio, evaluate the cube's durability, and assess its phosphorus absorption efficiency. The process involved collecting, drying, and powdering Limnocharis flava, then mixing it with guar gum to form cubes. Immersion tests assessed physical stability, while phosphorus content tests measured nutrient reduction. The ratio of 3:30 guar gum and Limnocharis flava and were the most durable, lasting four days in water while significantly reducing phosphorus levels. The highest reduction, 18.43%, was observed after four days, demonstrating the cubes' effectiveness in improving water quality.To enhance performance, future studies should explore different compositions for optimal nutrient absorption and durability. Extended immersion tests under varying environmental conditions will provide insights into long-term effectiveness. Additionally, used cubes can be repurposed as slow-release fertilizers, promoting sustainable agriculture by gradually releasing phosphorus into the soil. Real-world testing in drain water systems will offer accurate performance data and assess the cubes ability to absorb other nutrients like nitrogen, expanding their potential application in water management and environmental sustainability.

1. Introduction

In the field of water treatment, aquatic plants are priceless resources because they improve the condition and ecological balance of aquatic habitats in a variety of ways. Water plants have the amazing capacity to absorb excess nutrients like phosphorus and nitrogen, which keeps hazardous algal blooms from occurring and upsetting the ecosystem's delicate equilibrium. Excessive amounts of nutrients are frequently introduced into water bodies by human activities like urbanization, wastewater discharge, and agricultural runoff. Eutrophication, a process marked by fast algae growth that lowers oxygen levels in the water and can result in dead zones where aquatic life cannot survive, can be brought on by this nutrient enrichment [11]. By restricting nutrient availability, submerged plants, for example, absorb significant amounts of phosphate and nitrogen, regulating internal loading and promoting phytoplankton variety [1]. The improper maintenance of agriculture earth drains has resulted in high heavy metal concentrations in water, leading to water pollution. Transformation products are produced when pesticides are degraded; they are frequently more mobile and persistent than their parent compounds, which enables them to spread swiftly through the environment and increase environmentally hazardous substances [9]. Improper management practices may also harm farms and soils, destroying the natural landscape [6]. Urban landscape water bodies frequently serve as a common point of interaction with water sources, in severe circumstances, it can even pose concerns to human health when drunk unintentionally [3]. As using powdered aquatic plant to remove excessive nutrient in water it stays in water permanently. When a cube absorbent developed to absorb nutrient, it was taken back after it absorbs the nutrient from the water.

Depending on a number of variables, powdered submerged aquatic plants can be utilised successfully to remove heavy metals [5]. Ecosystems depend on phosphorus as a nutrient, and too much of it in wastewater streams can cause eutrophication, or widespread algae development. Certain species, including water hyacinth and azolla, had the highest absorbing capacity, reaching 90%, other algal species, like chlorella, only removed roughly 70% of the phosphorus [7]. Other than that, by using 15 qualitative and quantitative markers, six aquatic plants which is Alternanthera philoxeroides, Pistia stratiotes, Eichhornia crassipe, Salvinia natans, Ludwigia adscendens, and Myriophyllum aquaticum were thoroughly assessed. Subsequent investigations demonstrated that Alternanthera philoxeroides exhibited good growth status and sewage treatment performance at various nitrogen and phosphorus concentrations in municipal sewage [10]. Therefore, the aquatic plants have can be used in water treatment because it has characteristic to absorb nutrients from the water bodies.

This study aimed to produce an absorbent cube using aquatic plant and binder that can durable in water bodies to treat excessive nutrient in the water at earth drain. This study aimed to find the optimum ratio of aquatic plants and binder, which is essential for improve the absorbent cube's durability and strength. The study looked into how durable the absorbent cube when submerged in water and evaluating its ability to keep its structure and performance over time in water. This study assessed the cube performance by measuring the phosphorus absorption from the drain water. By using aquatic plants in water treatment, it is more eco-friendly and can reduce the pollution of the water by avoiding using chemicals which gives negative impacts to the environment and the aquatic lives.

2. Methodology

2.1 Aquatic Plant Powder Preparation

Site investigation was carried out at surrounding Sawah Ring. The existing aquatic plant at the earth drain around the Sawah Ring area were collected. The aquatic plant used as a raw material in this study. The aquatic plant that collected is Limnocharis Flava. After washed, the aquatic plants were dried in oven with the temperature of 60- degree Celsius for 2 hours. The dried aquatic plant then grinds into powder and sieved to avoid big particles.

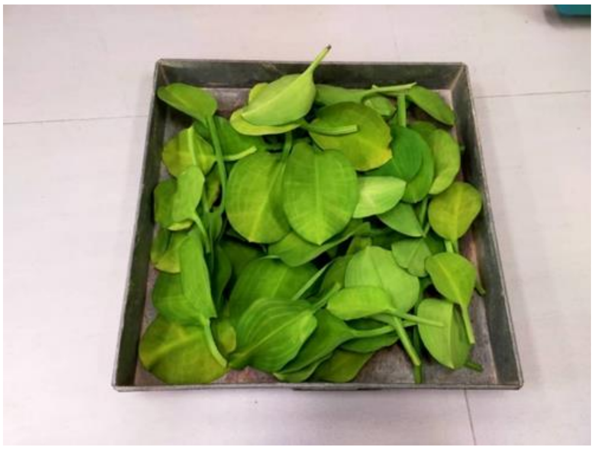

Fig. 1: Limnocharis Flava

2.2 Cube Absorbent Preparation

For identify the suitable binder for this cube, different binders tested to make the cube absorbent and immersed in water to find its durability in water. The three different binders used to make the absorbent cube and it is tested in water to find out its durability in water. Binder that has chosen was guar gum which stay on water for 4 days compared to cement and gelatine powder.

The binder mixed and aquatic plant with distilled water was prepared for the mix design to produce the absorbent cube. The powdered aquatic plant and binder was weighed according to the proportion 30 grams of powdered Limnocharis Flava and 3g of guar gum. The method that used in this study is compressed method and mould. Through these two methods, the products were created using hand compressed and mould size. The mould that used are same size for all the portion. Verify the moulds cleanliness and make sure they are free of dirt or dust. Position the moulds onto a flat, stable surface. After that, the prepared mixture of the aquatic plant and binder put into the mould and fill uniformly and completely in it. After that, the sample removed carefully from the mould once it dried. Lastly, the sample used for the testing.

Fig. 2: Absorbent cube

2.3 Physical Condition Testing

The sample tested in physical condition by immersed the cube in water. This testing was conducted to determine if the product that used aquatic plant and guar gum as the binder is suitable to be used in the application for the water bodies. The parameter that calculated in this testing are weight, height, length and width.

2.4 Immersion Testing

The cube physical condition tested by immerse the cube in water. The samples placed in 500ml beaker and filled up with 300ml of actual drain water. The drain water collected from the same place as the aquatic plant which is Sawah Ring. After sample placed in water the beaker was closed and the beaker were shaken at 150rpm for 5 different contact time that is half an hour, 2 hours, 5 hours and 1 day and 4 days on an orbital shaker.

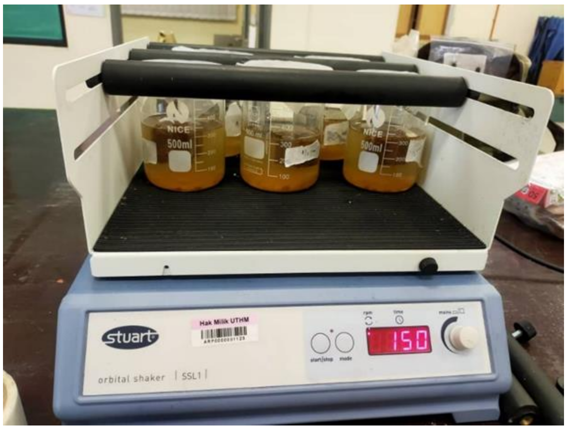

Fig. 3: Sample shaken on linear shaker

2.5 Phosphorus Testing

The DR6000 UV-VIS spectrophotometer were used to test the phosphorus content of the water. The items needed to prepare before start the experiment are Molybdate Reagent, Amino Acid Reagent, sample cells, beaker, filter, and centrifuge tube. Start program 485 P React. Amino.

The sample water filled in two centrifuge tube which one is blank sample water and another is water sample. Then, 1ml of molybdate reagent and amino acid added into the water sample and let it for 10 minutes [4]. The water sample turns blue after 10 minutes in Figure 4. After 10 minutes, the water sample filled in sample cell with 10ml of water sample. The sample cells cleaned before put in the DR6000 UV-VIS spectrophotometer [4]. Insert blank into the cell holder. Push ZERO. The display shows 0.00 mg/l PO43-. Clean the prepared sample cell. Insert the prepared sample cell into the cell holder. Push READ. Results show in mg/l PO43.

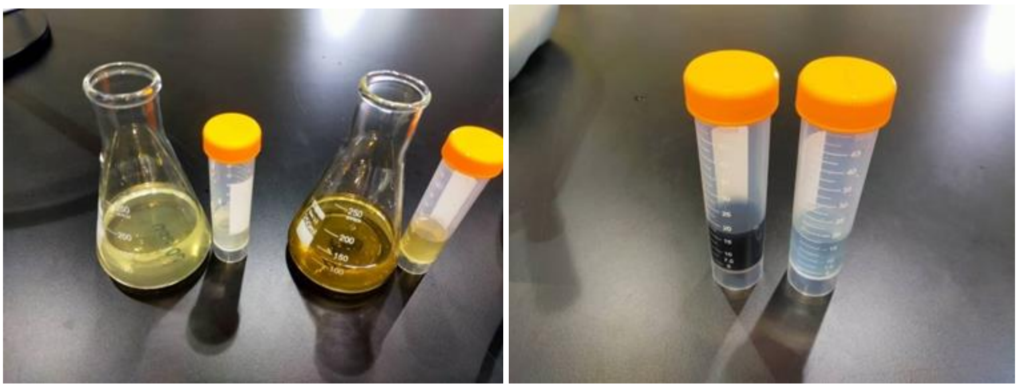

Fig. 4: Water sample before and after added Molybdate reagent, Amino Acid reagent

2.6 Data Analysis

The parameter that was measured is height, length, width and weight of the absorbent cube. The portion of guar gum used to the sample was 3g and aquatic plant was 30g to make the aquatic plant cube. After make the sample, it immersed in water with different contact time. The aquatic absorbent cube dimension was 3cm x 3cm x 3cm. The phosphorus content in drain water is measured after the sample removed from the water. Reading of the phosphorus content were taken three times and the data convert to average data. The percentage removal of phosphorus can be calculated using the formula below:

$$Percentage\ Removal = \left(\frac{Initial\ Phosphorus\ Content - Average\ Phosphorus\ Content}{Average\ Phosphorus\ Content}\right) x\ 100$$

3. Result and Discussion

The data were collected from immersion testing and laboratory testing which is phosphorus content in drain water.

3.1 Optimum portion for the absorbent cube

The grinded aquatic plant and guar gum mixed with different portion to find the optimum portion to this study. The Table 1 shows how different concentrations of the binder guar gum affect the longevity of powdered aquatic plant samples. The durability of Sample 1 with 1 gram of guar gum only lasted 1 day, indicating that a small amount of binder is not enough to improve stability. The durability of Sample 2, which included 2 grams of guar gum, was only 1 day, suggesting that the binding effect was not appreciably enhanced by this increase. However, the durability increased to four days in Sample 3, when the guar gum content was increased to three grams.

Table 1: Different portions of binder and aquatic plant

Sample	Aquatic Plant Powder	Binder (Guar Gum)	Durability Duration
1	30g	1g	1 day
2	30g	2g	1 day
3	30g	3g	4 days

The Table 1 shows that the durability for Sample 1 which contain 30 grams of aquatic plant powder and 1grams of guar gum was 1 day. This suggests that there wasn't enough binder to hold together the aquatic plant powder as a cube. Sample 2 suggests the same durability duration even the guar gum added to 2 grams to the aquatic plant powder. Sample 3, which included 30 grams of aquatic plant powder and 3 grams of gur gum, lasted for 4 days. This addition grams on guar gum to the mixture indicates that using more guar gum created a strong bond in the mixture and also helped it stay longer in the water. Sample 3 chosen for the further testing as it last for 4 days in water. This lower content of guar gum in the cube absorbent controlled any negative impact to the water and also effectively absorb the nutrient in the water.

3.2 Physical condition

The samples with same proportion of aquatic plant powder and guar gum were measured after the sample immersed in drain water. The odour of the cube sample after immersed in the drain water to the contact time were same in day 1. As the cube immersed in the water for 4 days the odour of the water slightly unpleasant. This shows that, the more the sample stay in the water it can make the water odour unpleasant. Moreover, the sample on day 4 looks slightly slimy at the edges of the cubes because of the guar gum characteristics. The Table 2 shows the aquatic cube absorbent, weight before and after immersed in water.

Table 2: Weight before and after immersed in water

Sample	Weight before immersed	Weight after immersed	Contact time
A	25.0 g	27.42g	½ hour
B	25.1g	39.30g	2 hours
C	25.0g	42.82g	5 hours
D	25.0g	43.70g	1 day
E	25.3g	44.15g	4 days

From the Table 2, the gradual rise in weight seen in all samples highlights the clear correlation between the length of immersion and the ability to absorb water. Temperature and humidity have a major impact on water absorption rates, according to research on the moisture absorption aging of plant fiber composites [8]. This implies that samples A through sample E's performance in practical applications may likewise be impacted by the testing conditions.

Next, Table 3 shows the aquatic plant and guar gum samples dimensions following water immersion, which offer important information on their water absorption properties and long-term structural integrity. The findings show that all samples dropped in size as the amount of time they were in contact with water increased, indicating that extended immersion causes these materials' physical characteristics to change significantly.

Table 3: Dimension of cube after immersed in water

Sample	Contact time	Length	Height	Width
A	½ hour	3cm	3cm	2.8cm
B	2 hours	3cm	3cm	2.7cm
C	5 hours	2.9cm	3cm	2.7cm
D	1 day	2cm	2.1cm	1.9cm
E	4 days	2cm	1.7cm	1.5cm

The findings show that all samples dropped in size as the amount of time they were in contact with water increased, indicating that extended immersion causes these materials' physical characteristics to change significantly. Sample A, for example, retained its measurements of 3 cm in length, 3 cm in height, and 2.8 cm in width after immersed for 30 minutes. However, while length and height of Sample B stayed the same, there was a tiny drop in breadth to 2.7 cm when the immersion duration extended to 2 hours. Samples C through E showed more noticeable reductions in size, especially Sample D (1 day) and Sample E (4 days), where the height dropped to 1.7 cm and the length to 2 cm. These notable decreases imply that prolonged contact to water may cause swelling or material deterioration, which could jeopardize the structural integrity of the materials.

Lastly, the drain water colour was observed after the sample immersed in water. The sample A, B, and C has no effects on the drain water colour and its looks same light brown colour as the drain water before the sample immersion. The drain water colour slightly changes to light brown colour on sample D as it immersed in water for 1 day. The sample E that immersed 4 days in the drain water has changed the water to dark brown colour. This shows that, the more the cube absorbent immersed in water the darker the colour changes to the drain water.

3.3 Phosphorus Testing

The nutrient that are the primary focus of this study is phosphorus. Table 4 shows the results of phosphorus content after the sample immersed in drain water with different contact time. The sample immersed in water for four days because the sample starts to be broken on the fifth day.

Table 4: Phosphorus content after the sample immersed in drain water

Sample	Contact Time	First Reading	Second Reading	Third Reading	Average	Percentage Reduction (%)
A	½ hour	45.28	45.14	45.49	45.30	0.72
B	2 hours	41.75	41.80	41.80	41.78	8.44
C	5 hours	38.45	39.93	40.71	39.70	13.00
D	1 day	38.02	38.25	37.92	38.06	16.59
E	4 days	37.11	37.29	37.25	37.22	18.43

The findings regarding the phosphorus content of water from samples A through E show significant patterns related to nutrient levels throughout different contact durations. With a half-hour contact period, Sample A had the highest average phosphorus measurement (45.30 mg/L). The phosphorus content reduced 0.72% from the original phosphorus content which is 45.63. Sample B (2 hours) had an average of 41.78 mg/L which reduce 8.44% phosphorus content from the drain water. Sample C (5 hours) had an average of 39.70 mg/L reduced 13% phosphorus content compared to the Sample A and B. Sample D (1 day) had an average of 38.06 mg/L that reduced 16.59% phosphorus content from the drain water, and Sample E (4 days) had the lowest average of 37.22 mg/L. The highest reduction of the phosphorus content was 18.43% on day 4. The phosphorus levels dramatically dropped as the contact duration rose. Due to absorption by the absorbent material composed of guar gum and aquatic plants, this pattern indicates that extended exposure to water causes a progressive decrease in phosphorus level. The data indicates that the average phosphorus concentration in the water falls with increasing contact time. Longer contact periods enable more efficient phosphorus adsorption onto a variety of adsorbents, according to research. Higher contact periods, for instance, result in higher adsorption effectiveness because they provide the phosphorus molecules more opportunity to interact with the active sites on the adsorbent surface [2].

4. Conclusion

This study explored the development of an absorbent cube using the aquatic plant Limnocharis flava and guar gum to absorb phosphorus from drain water and to test the cube's durability in water. The most durable cube, which lasted up to four days in water, was achieved with a mixture of 30 grams of Lymnocharis flava and 3 grams of guar gum. The absorbent cubes effectively lowered phosphorus levels, with a maximum reduction of 18.43% after four days of contact, demonstrating the potential of these natural materials for improving water quality. Future research should explore different proportions of aquatic plants and binders to optimize nutrient absorption and material stability, conduct longer immersion tests to evaluate long-term performance, and assess cube durability under varying environmental conditions. Additionally, the potential for recycling spent absorbent cubes as fertilizer offers a sustainable approach by slowly releasing absorbed phosphorus and enhancing soil health, aligning with sustainable agriculture practices, and the performance of the cubes can be evaluated in actual drain water systems with the dynamic environments.

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Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

*The authors confirm contribution to the paper as follows: **study conception and design:** Rajaletchumi Kumaran, Fatimah Mohamed Yusop, Nuramidah Hamidon, Hilmi Kosnin; **data collection:** Rajaletchumi Kumaran; **analysis and interpretation of results:** Rajaletchumi Kumaran, Fatimah Mohamed Yusop Nuramidah Hamidon, Hilmi Kosnin; **draft manuscript preparation:** Rajaletchumi Kumaran, Fatimah Mohamed Yusop, Nuramidah Hamidon, Hilmi Kosnin. All authors reviewed the results and approved the final version of the manuscript.*

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