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Building an AI-Enhanced Organic Island with *Brassica Juncea* Seeds to Counter Eutrophication

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ABSTRACT

Decontaminating water bodies has always been a problem in terms of developing and maintaining solutions. Our eutrophication solution is an organic island made of coconut husk(*Cocos nucifera*) and Indian Mustard(*Brassica juncea*) plants. It uses remediation techniques, such as phytoremediation and adsorption. Eutrophication primarily stems from human-induced causes such as poor sewage treatment and fertilizer overuse, which results in excess phosphate and nitrate ions accumulating in water bodies. This can have severe consequences, including algal bloom, and a reduction in aquaculture. Our investigation was done over a 21-day period, during which the concentration of phosphate ions was reduced, alleviating one factor that causes eutrophication. There were 3 tanks (A, B, and C): A contained the island and the plants, B contained only the island, and C was a control that contained neither. A Phosphate ion water testing kit was used to measure phosphate ion concentration in the sample contaminated water over a 21 day period. Each phosphate ion test produced a color of a different wavelength. Using a Vernier colorimeter, the percentage of transmittance was measured for each trial. Using the Beer-Lambert Law, the concentration values were obtained, which supported our hypothesis: A and B experienced a substantial increase in transmittance levels, whereas C experienced no change. The Pearson correlation test showed a positive correlation, hence phosphate ions were absorbed at a constant rate. Our solution also uses AI (Bellman equation) to analyze regions with the greatest phosphate ion concentration, where sensors and motors are present for maneuverability.

Introduction

Background Information

Eutrophication is the process by which the concentration of certain nutrients - specifically nitrate and phosphate ions - increases substantially, usually due to an anthropogenic cause. This process is often characterized by excessive plant growth and algal blooms due to the increased availability of one or more limiting growth factors needed for photosynthesis. In particular, it is the excess deposition of chemicals such as nitrogen and phosphorus. The existing algae in these lakes absorb phosphorus and nitrogen in their immediate vicinity. The algae utilize this absorption in various cellular processes essential for the process of making cell membrane lipids, nucleic acids, ATP, and coenzymes. As the population of these cyanobacteria increases, the biomass of dead organic matter increases, thereby allowing decomposers to break down more matter while respiring at unsustainable rates and depleting dissolved oxygen. Eutrophication is abundant in countries with relatively poor aquatic management, such as India.

The island primarily consists of coconut husk, an organic material that displays adsorbent properties. Adsorption is where molecules of gases, liquids, or solutes accumulate on the surface of a solid as a thin layer.

This phenomenon occurs when the two bodies are in contact. The coconut husk will act as the solid in this case, adsorbing any excess ions present in a water body. The island also enhances microbial remediation. By developing a cheap, organic, implementable model, the solution has the potential to impact lakes in India greatly.

Ever since the mid-20th century, the exponential growth of industrial activity has led to an increasing volume of chemical effluents. Coupled with this, farm runoff due to excess usage of fertilizers has also been a predominant factor for eutrophication across the world. Other factors such as natural calamities and changes in aquatic conditions, aquaculture, and CAFOs (Concentrated Animal Feeding Operations) also lead to relatively high aquatic nutrient concentrations. The existing algae in these lakes absorb the chemical phosphorus and nitrogen in their immediate vicinity.

Anthropogenic Causes

Some anthropogenic causes involve overuse of artificial fertilizer, lack of sewage treatment systems, and urban discharge of effluents rich in chemical compounds rich in phosphates and nitrates. When artificial fertilizer is utilized in excess, the osmotic gradient between the root cells and the soil is disrupted. Excess water will accumulate in the soil, and this leads to runoff into nearby water bodies. This runoff carries the fertilizers which contain the phosphate and nitrate ions responsible for eutrophication. Untreated or poorly planned sewage systems, especially in rural areas such as Bangalore, are abundant. Combined with a rapidly growing population and lack of government regulation, the final result entails an excessive amount of sewage containing nutrients such as phosphate and nitrate ions.

Consequences

This can have severe ecological effects such as increased sedimentation and nutrient deposits and overall depletion of dissolved oxygen concentration. Hypereutrophication can also affect complex aquatic food webs involving species of fish, which can no longer sustain themselves on the limited supply of dissolved oxygen. Due to weaker water mass circulation, dead zones are also created. Dead zones are areas in water bodies where aquatic life cannot survive due to low oxygen levels. Due to this, the biodiversity of species also decreases. As algal growth increases, there is an increase in light reflectivity and albedo. Noxious toxins such as microcystin and anatoxin-a, neurotoxins, and biotoxins(HABs) are produced in the process. Due to algal growth in water bodies, the water quality tends to get worse. This also makes livestock and human health worse off. Along with this, as more fish die, commercial fisheries and aquaculture also decrease in size. Recreational activities and tourism also decrease as these water bodies are not as appealing anymore.

Current Maintenance Methods for Controlling and Combating Eutrophication

To combat eutrophication, the U.S. Environmental Protection Agency has advocated using less fertilizer to reduce runoff. The Water Act 1974 of India attempts to control sewage effluents and other chemical contaminants from entering water bodies. Despite these efforts, eutrophication is currently still a widespread environmental issue that is in dire need of cheap, feasible solutions.

Since eutrophication proves to be a serious threat, many organizations around the world have tried various methods to control and restrict the growth of algae and eutrophication. With climate change and growing human populations looming over our heads, there is an immediate need to preserve aquatic ecosystems. Some methods include diversion of excess nutrients, altering nutrient ratios, physical mixing, shading water bodies with opaque liners or water-based stains, and application of potent algaecides and herbicides. However, these methods prove to be expensive, impractical, and ineffective, especially for larger ecosystems. As excess nitrogen and phosphorus are major causes of algal blooms, reducing their inputs in the water body could work towards improving water clarity. Nutrient reduction and control can be difficult to control, though, specifically in agricultural areas where the nutrient sources are non-point. The AI model takes this into account, and can work with both point and non-point sources. The usage of Copper sulfate as an algaecide is effective at reducing Harmful algal blooms but also poses serious risks and threats to humans, livestock, and wildlife and can harm non-target aquatic organisms as a side effect. Biomanipulation has also been experimented with in these water bodies, where the food web is altered to restore the health of the aquatic ecosystem. This includes the replacement of secondary consumers with tertiary consumers so that large-bodied, generalist grazers can control the growth of phytoplankton. Overgrowth of phytoplankton is also known as an algal bloom. The effects of fish-based biomanipulation are, however, short-lived.

Literature Review

Research paper by Ansari et al. regarding the causes and consequences of eutrophication[2]. Anoxic conditions and an increase in turbidity are the most common occurring consequences of eutrophication. A reduction in available oxygen causes competition between organisms for respiration. A study in 2004 recorded multiple phytoplankton, macroalgae seagrass, freshwater, and several other mixed phytoplankton and macroalgal species showed that phytoplankton increases the concentration of nitrate and phosphate ions in water than compared to those macrophytes.[3] Corn cub can be used as an absorbent with an efficiency of 40% BOD (Biochemical Oxygen Demand)[4]. Floating remediation islands housing vegetation to combat eutrophication and excess concentrations of ions sourced from fertilizers[7, 8]. Adsorption of organic chemicals (phosphorus, nitrates) in soils[10]. A study in 2018 investigated the correlation between nutrient content in soil and plant production as depicted by GPP - Vegetation gross primary productivity. The nation averaged around 1.11mg/g for leaves, 0.31mg/g for stems, and 0.47mg/g for roots. The phosphate concentration in the plant's stem and roots were much more receptive to an abiotic environment than those compared to leaves. The study also demonstrated the carbon sequestration of biome-dependent regulation by nutrients in the soil[6].

This paper intends to review our experiment that showed statistical significance in determining that our island had positive effects on the simulated environment, by decreasing the phosphate ion concentration. It also contains a further exploration of the application of Artificial Intelligence and Embedded Systems to our island, to increase its efficacy when practically implemented.

Methods

Materials

Indian Mustard seeds were sprinkled on the island before the beginning of the experiment. 100 grams of coconut fibers extracted from the outer husk of coconuts were also purchased prior to conducting the experiment. The primary constituent of this is coir, the fiber responsible for its coarse texture.

Predominantly, the ions that give rise to eutrophication (as discussed previously) are phosphate ions. Therefore, to create a simulated environment of a eutrophic lake, two specific chemicals that contained phosphate ions were chosen. 12 grams of Tricalcium Phosphate [$Ca_3(PO_4)_2$], a white amorphous powder, and 16 liters of room temperature (23°-25°C) distilled water was sourced from a high school chemistry lab. Additionally, phosphate water testing kits(with reagents) were used to test the presence of phosphate ions respectively. Three 6-liter cylindrical glass tanks, an electronic weighing balance, thirty test tubes (15ml), four test tube stands, two spatulas, two Petri dishes (90 mm), and one colorimeter were provided by a high school biology lab.

Experimental Setup

The first cylindrical tank (Tank A) was a control tank; it contained 4 grams of tricalcium phosphate powder in a distilled water solution. It did not contain the organic island, nor did it contain the mustard seeds. The second cylindrical tank (Tank B) was another control tank, which contained 4 grams of tricalcium phosphate and just the organic island without the mustard seeds. The third cylindrical tank (Tank A) was the experimental group; It contained 4 grams of tricalcium phosphate powder, the organic island, as well as the mustard seeds. The seeds were organized in clusters of 4. There were 7 rows and 7 columns of seed clusters on the island. Twelve wooden frames were purchased and constructed into three 0.20-meter by 0.20-meter island base frameworks. These dimensions were finalized based on size, to maximize adsorption, absorption, and efficacy. Lastly, an organic mesh was manually attached to the finished island frames with nails using a hammer.

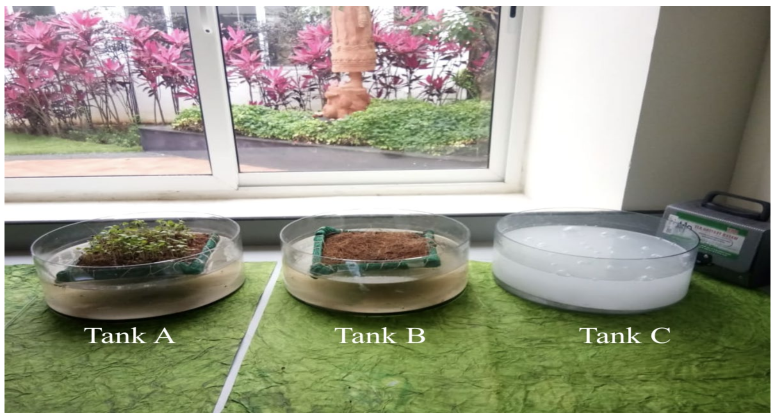


Figure 1. Experimental Setup

Table 1. Controlled Variables

Variables Controlled	Method of Controlling	Effect of control variables
Mass of Tricalcium phosphate added to each tank	The mass of each chemical was measured on a digital weighing scale and ensured to be 12±0.01 grams.	A different mass would result in a different concentration of Tricalcium Phosphate between each tank.
Volume of water in each tank	The mark was measured and placed on each tank and water was filled to that level. 6000±0.1 millimeters	Varying volumes of water for each tank would again result in different concentrations of Tricalcium Phosphate between each tank.
Mass of coconut fiber used on each island	The mass of each coconut fiber was measured to be 30±0.01 grams for each island using a digital weighing scale.	Higher masses of coconut fiber would result in a greater volume, thus increasing the overall capacity of absorption.
Access to sunlight for each tank	Each of the tanks was kept next to the same windowsill, with equal exposure to sunlight.	Variable access to sunlight would affect the growth of individual plants on each of the tanks, thereby

		affecting the rate of phosphate ion uptake.
pH of initial water sample	The pure, distilled water from each of the tanks was obtained from the same water source and had a pH of 7.3.	The pH of the water may affect the rate of plant growth, thereby affecting the rate of phosphate ion uptake.
Area of the tank where test samples were retrieved from	The test samples for all trials of each tank on all days were retrieved from an equal distance from the island(10cm).	The distribution of phosphate ions throughout the tank would be uneven due to the affinity of the phosphate ions toward the coconut husk. By keeping this constant, the transmittance levels would be measured with respect to that specific point in the tank.

Procedure

A sample of 10 ml was taken from tanks A, B, and C using a dropper and test tube. Each sample was placed in 3 separate test tubes. The presence of Tricalcium Phosphate [$Ca_3(PO_4)_2$] was tested in the water sample. 5 different water samples were taken for each chemical for each tank: this makes a total of 30 samples. To test for phosphates, 5 drops of phosphate reagent-1 were added to the water sample and placed in a test tube. 1 drop of phosphate reagent 2 was added to the same solution. The solution was stirred constantly for 3 minutes and was left to rest until a color change from white to blue was observed. A blue solution indicates the presence of Tricalcium Phosphate [$Ca_3(PO_4)_2$]. This same procedure was repeated 5 times for each tank, making a total of 15 samples. Repeat these tests 1 day, 5 days, and 21 days after initiating the experiment.

Results

Table 2. Raw Data

Light Transmittance Levels in Tank A, B, and C (5 Trials)								
Day	**Transmittance (±0.01 %)**	**Test Tube 1**	**Test Tube 2**	**Test Tube 3**	**Test Tube 4**	**Test Tube 5**	**Average**	**Standard deviation**
Day 1	**Tank A**	9.46	9.48	3.81	4.71	5.56	6.60	2.40
	Tank B	9.90	8.73	4.42	6.98	6.33	7.27	1.90
	Tank C	7.31	6.42	8.31	5.45	4.99	6.50	1.21
Day 5	**Tank A**	71.65	77.61	75.15	72.01	73.01	73.88	2.22
	Tank B	49.87	47.06	56.43	55.15	56.29	52.96	3.80
	Tank C	8.22	7.66	4.34	5.99	6.76	6.59	1.36

Day 21	**Tank A**	92.38	95.67	98.99	97.63	98.11	96.56	2.35
	Tank B	93.59	92.27	93.20	94.76	95.83	93.93	1.24
	Tank C	6.22	7.86	8.71	3.11	2.76	5.73	2.42

The transmittance tests were conducted in order to quantify the intensity of light that passed through each phosphate ion mixture. Manually calculating the phosphate ion concentration via titration was not feasible. Light transmittance values can be mathematically converted to concentration values through an equation called the Beer-Lambert Law.

Processing Raw Data

Using Beer - Lambert's Law, (A is the Absorbance, T is the Transmittance, C is the Concentration, L is the length of light path, Ɛ is the Extinction Coefficient)

$$A = -log\ T$$

$$A = C * L * \varepsilon$$

A is directly proportional to C, leaving $-log\ T$ directly proportional to C.

$$A \propto C$$

$$\Rightarrow -log\ T \propto C$$

$$\Rightarrow -log\ T = kC$$

Since 12g of Tricalcium Phosphate was dissolved in 6L of water,

$$Initial\ Concentration = \frac{mass\ of\ Tricalcium\ Phosphate}{volume\ of\ water}$$

$$Initial\ Concentration = 12g/6000\ cm^3$$

$$Initial\ Concentration = 0.002\ g/cm^3$$

Using known concentration and transmittance values from Day 1 in Tank A,

$$-log\ T = kC$$

$$\Rightarrow -log\ 0.066 = k \times 0.002$$

$$\Rightarrow k = 590.23$$

Using the proportionality constant to convert the transmittance value to concentration on Day 5 in Tank A,

$$-log\,T \;=\; 590.23C$$

$$\Rightarrow\; C \;=\; \frac{-log\,0.739}{590.23}$$

$$\Rightarrow\; C \;=\; 2.27 \times\; 10^{-4}\; g/cm^3$$

By repeating these steps for the respective days for each tank, the transmittance values from the raw data table are converted to get the concentration, which gives us the processed data.

Uncertainty calculations for concentration:

Uncertainty of transmittance = $\pm$0.01

$$\frac{C}{\frac{-log\,0.066}{590}} = \frac{0.01}{-log\,0.066} + \frac{0}{590}$$

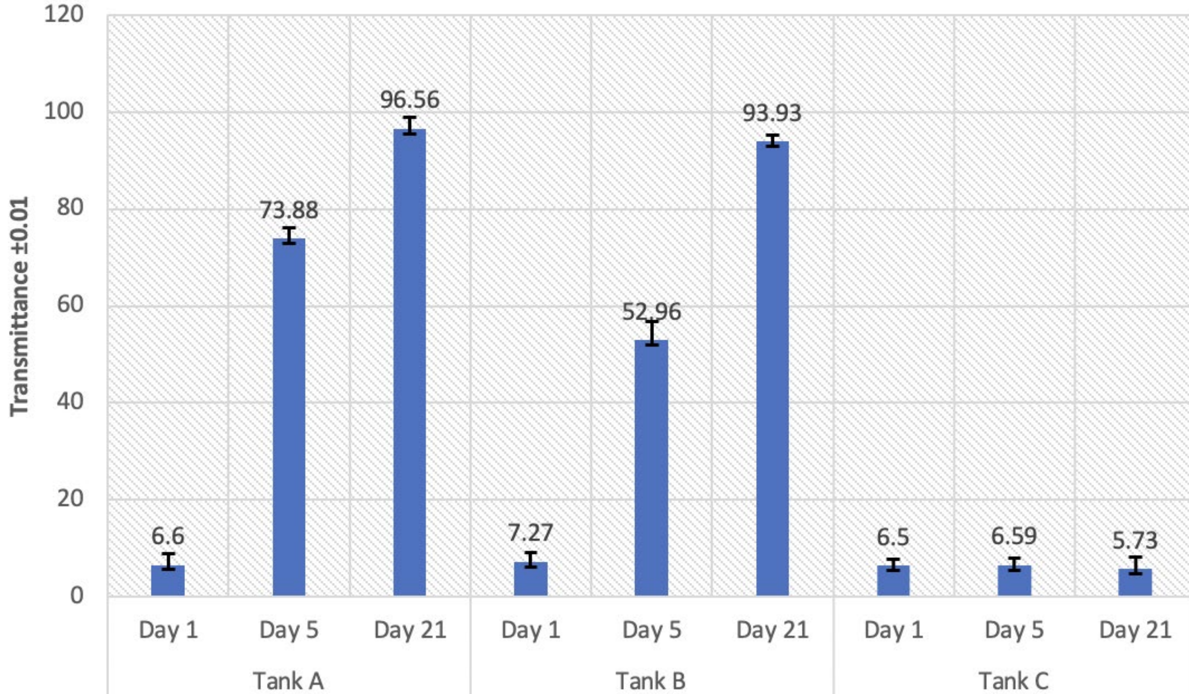
C = 0.002 $\pm$0.00002 g/cm^3

Every concentration value for each tank has a similar uncertainty value to the one above, hence this has been used as the standard uncertainty across all readings.

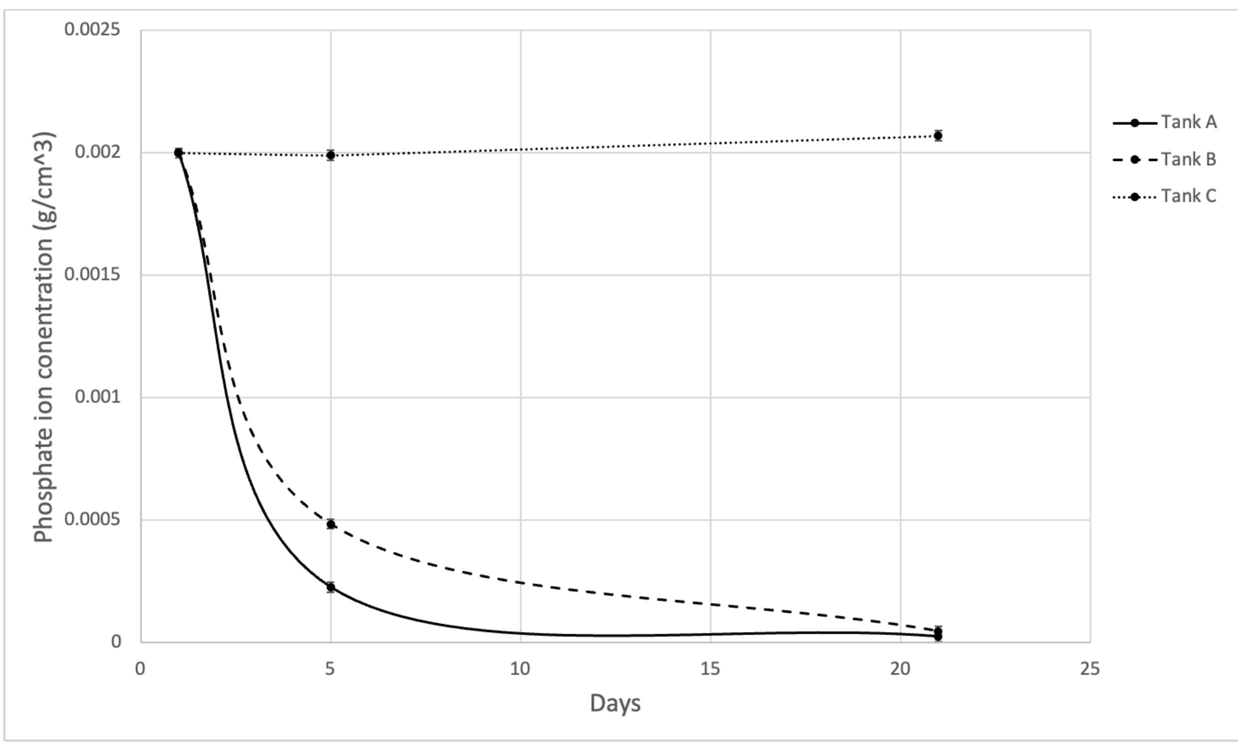
Table 3. Processed Data of Phosphate Ion Concentration

Day	Tank	Concentration ($\pm 2.00 \times 10^{-5} g/cm^3$)
Day 1	**Tank A**	2.00×10^{-3}
	Tank B	2.00×10^{-3}
	Tank C	2.00×10^{-3}
Day 5	**Tank A**	2.27×10^{-4}
	Tank B	4.85×10^{-4}
	Tank C	1.99×10^{-3}
Day 21	**Tank A**	2.55×10^{-5}
	Tank B	4.81×10^{-5}

	Tank C	2.07×10^{-3}



Graph 1. Phosphate ion transmittance levels across a period of 21 days for Tanks A, B and C



Graph 2. Phosphate ion concentration levels across a period of 21 days for Tanks A, B, and C

Qualitative Data

For reference (and as a verifying parameter), the data of the colors of the solutions was collected after performing the phosphate ion test. The range of wavelength for the blue light of all the trials of each tank was noted as dark blue, mild blue, and light blue. (Using a color spectrum, these 'broad' categorizations can be denoted as 460 nm to 490 nm.) The lighter blue colors indicate lower phosphate ion concentrations. They would have higher wavelengths and, therefore, higher transmittance values. The darker blue colors, on the other hand, would have lower wavelengths and thus lower transmittances.

Figure 2. Phosphate Ion Test Colors for Day 5

Pearson Correlation Test

To compare the transmittance values over the 21 days for each tank, the Pearson correlation test can be used to see whether there's a strong positive correlation between data points. A strong positive correlation suggests that the phosphate ions are decreasing while time increases. There is an inverse relationship between time and phosphate ions. The ANOVA test and T-test were considered, but this experiment focuses on the correlation between data points rather than its statistical significance; hence the Pearson test is the most valid form of analysis. Using the Pearson test also allows us to see whether the transmittance rate has a linear or exponential relationship by observing the r^2 values. The regression values for each tank are shown below. A value closer to 1 suggests a strong positive correlation, while a value closer to 0 suggests no correlation at all. Regression value squared suggests the amount of variability in the transmittance rate in reference to linearity.

Table 4. Pearson Correlation Values

Tank	Regression Value (r)	Regression Value Squared (r^2)
A	0.8184	0.6698
B	0.9339	0.8723

From the table above, both tank A and B show a regression value (r) close to 1. This indicates that the transmittance percentages have a strong positive correlation to time. However, Tank B suggests a higher variability of transmittance rates compared to A. This could suggest that the variation of transmittance in tank B follows a more linear relationship; thus the adsorption rate of phosphate ions in tank A is more exponential, resulting in a higher ion adsorption per unit time. As both Tanks A and B have strong positive correlations, it is safe to conclude that the island is capable of absorbing phosphate ions at a constant rate over an elongated period of time (21 days as per testing).

Discussion

For Tanks A and B, as shown by the graph and verified by the Pearson Correlation Test, there is a positive correlation between transmittance values and time. This conclusion indicates that over the period of 21 days, the transmittance values constantly increased, almost reaching 100%. As mentioned before, transmittance is a mathematical ratio of the intensity of light hitting the phosphate ion test solution and the intensity of light leaving it. The role of the phosphate ion test is to show that a higher concentration of phosphate ions will produce a darker color of a shorter wavelength. As the role of the island - through adsorption, absorption, and microbial remediation - was to remediate the simulated aquatic environment by absorbing the phosphate ions, over time, the number of phosphate ions in the tanks would gradually decrease. Phosphorus in plants is utilized in a variety of plant processes: transferring energy, photosynthesizing, transforming starches and reducing sugars, moving nutrients and translocation, regulating protein synthesis, as well as transferring genetic information down generations from parents to offspring. During the beginning of the experiment, the seeds would also absorb nutrients for their growth and development. Next, the coconut husk was responsible for adsorption. The husk acted as the adsorbent, and the phosphate ions acted as adsorbates. The molecules on the outer region of the husk interact with the phosphate ions via intermolecular forces. Over time, the island developed an environment with warm and damp conditions, suitable for microorganisms to thrive. A population of microorganisms would also help contribute to the uptake of the ions via microbial remediation. This is why, over time, the colors of the phosphate ion tests would gradually decrease in intensity, increase in wavelength, and increase transmittance percentages. After 21 days, the measured wavelengths of light that left the solution were close to 490 nm, as opposed to 460nm after the first day.

After 21 days, Tank A had an average transmittance level of 96.6%, over 16 times greater than that of Tank C-the control tank-which was a mere 5.9%. Tank B had an average transmittance level of 93.9%, over 15 times greater than that of Tank C. Tank A's transmittance level on Day 21 was also greater than that of Tank B by a mere 2.7%. Compared to Tank B, Tank A's average transmittance levels were greater for the first 5 days. However, after day 5, the average rate of increase of transmittance values up to day 21 was significantly lower for Tank A than those of Tank B. From day 5 to day 21, transmittance levels increased 22.7% from 73.9% to 96.6% for Tank A. For Tank B, transmittance levels increased 40% from 53.0% to 93.9% from Day 5 to Day 21. Using the rate of reaction analogy, the rates increase on a decreasing curve, eventually reaching a plateau. At this point, the rate of reaction would have been completed. Analogously, the processes collectively exhibited by the island would occur at higher, more efficient rates at the beginning of the 21 days but would decrease with each day. During the initial few days, there would be a relatively high abundance of phosphate ions in Tanks A and B. For Tank A, after this short period(wherein the phosphate ions were taken up by the remediating processes relatively efficiently), the remaining phosphate ions would be in a smaller quantity. This is why the rate of uptake each day would gradually decrease.

Since the island is entirely made of biodegradable and organic materials such as coconut husk, the decomposition of the island would cause no harm to the aquatic ecosystem. The island combines the concepts of absorption, phytoremediation, and adsorption, not only to decrease the relative concentration of the phosphate ions around the island but also to allow plant growth, making the solution unique. This process has no harmful side effects; other solutions primarily utilize chemicals to decrease the causes and consequences of eutrophication, which may have severe short-term and long-term ecological and economic consequences. For example, Wang et al. conducted an investigation to find chemicals that can serve as potential solutions to eutrophication. Additionally, Xie et al. conducted a study to show the effect of Magnesium Hydroxide from Diatomite on the removal of phosphates in eutrophic lakes. This study also showed an increase in the pH of the environment. Side effects like these, for example, may have direct or indirect consequences on the aquatic environment. Therefore, using artificial chemicals as a basis of solutions to eutrophication can have unintended, detrimental effects.

Mechanism of the AI components

Understanding The Mobility of the Island

The island is equipped with ‘y number of sensor x’ on each corner. These sensors have the function of reading and monitoring phosphate ion concentrations at their current location. Using the 2 motors installed on each side, the island randomly moves to different parts of the lake using an algorithm and artificial intelligence. Based on data from the sensors and artificial intelligence, the island will maneuver to parts of the lake where there is a higher concentration of phosphate and ions. The island will then effectively absorb the phosphate ions and reduce them to an optimal level. Based on trends and patterns, the AI will learn which parts of the lake have a relatively higher concentration of ions compared to other regions. This process will maximize the efficiency and effectiveness of the island.

Workings of AI

Artificial intelligence works based on reinforcement learning. This is a training model where desired actions are awarded, and unsought ones are punished. In this scenario, the AI is awarded when the island detects a region of high concentration of ions and is punished in the presence of low concentration regions of ions. By doing these actions, the AI will explore the environment and understand which actions lead to desired outcomes.

Reinforcement learning is modeled by a mathematical equation called the “Bellman Equation.”
It is given by:

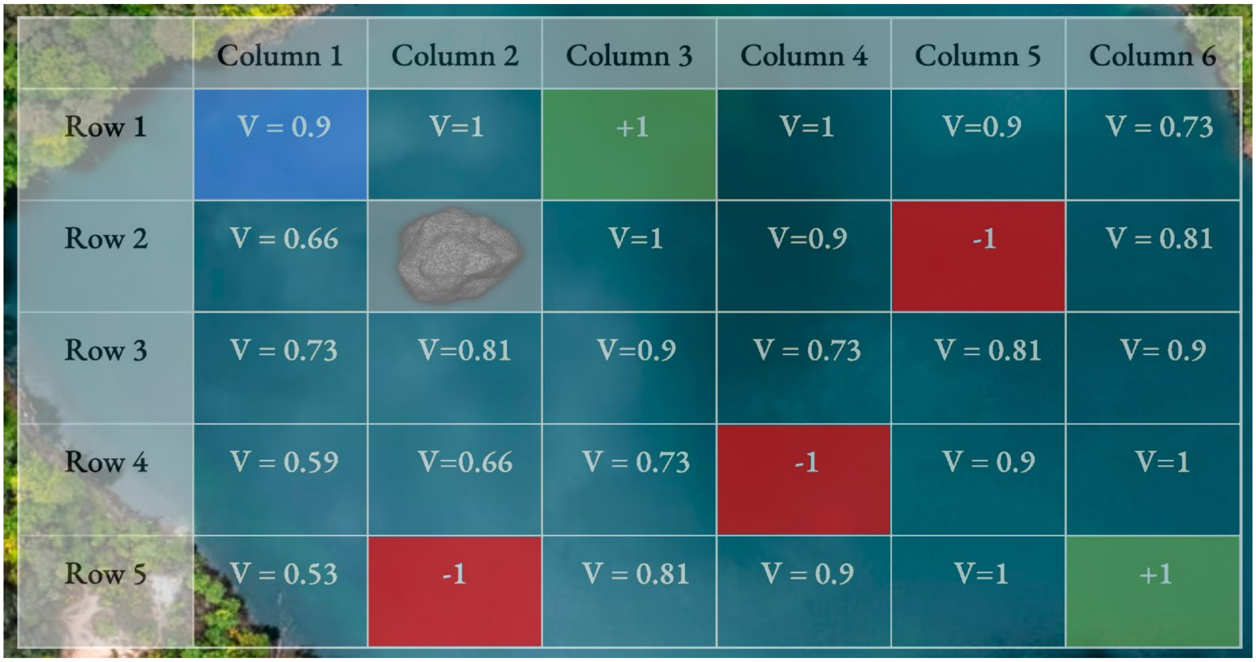
$$V(s) = max_a(R(s,a) + \gamma \sum_{s'} P(s,a,s')V(s'))$$

V(s) = Value of state
V(s’) = Value of next state
R(s, a) = Reward for current state after performing the action (a)
P(s, a, s’) = Probability of moving to another square
γ = A value determining between short term and long term awards

V(s) represents the value of the state, a value closer to 1 suggests a more favorable action and vice versa. R(s, a) is the reward gained by the model for performing an action (a). max_a represents the most favorable action among all the possible actions that can be done. This is refined through every consecutive step taken by the model. γ represents the value for determining the duration of “rewards” the action will gain. A value closer to 1 suggests actions that have a favorable long-term effect, while a value closer to 0 suggests favorable short-term effects. V(s') suggests the value of the next possible state when executing a specific action. P(s, a, s') indicates the probability of the model moving to another square. For the sake of simplicity, the probability of moving to any of the boxes represented below is the same; hence it will be ¼).

A hypothetical scenario of how this model would function is shown below. Each cell contains a value state and represents a region in the lake.

In this table, the actions performed can only be (UP, DOWN, LEFT, RIGHT):



	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Row 1	V = 0.9	V=1	+1	V=1	V=0.9	V = 0.73
Row 2	V = 0.66		V=1	V=0.9	-1	V = 0.81
Row 3	V = 0.73	V=0.81	V=0.9	V = 0.73	V = 0.81	V= 0.9
Row 4	V = 0.59	V=0.66	V = 0.73	-1	V = 0.9	V=1
Row 5	V = 0.53	-1	V = 0.81	V = 0.9	V=1	+1

Figure 3. Value State Matrix

<u>Legend:</u>
Red - Indicates a "punishment"
Green - Indicates an "award"
Gray - Indicates an obstacle
Blue- Starting Point

As shown in the table above, green boxes indicate regions of higher ionic concentration while red boxes indicate lower ionic concentration. Boxes closer to the green box have a higher value of state, encouraging the mechanism to move to those regions. Red boxes are discouraged as the value of state is lower. Gray boxes indicate possible obstacles such as rocks or vegetation that might be present.

A sample calculation of how the values of "V" are determined is shown below. Since there is no difference when the island is in R5 C6 or R5 C5, the value 1 will be taken as it directly leads to the reward.

Table 5. Sample Calculation for Value State Matrix

	Row 5	**Row 4**
Column 4	V = 0 + (0.9)(1)(1) V = 0.9	Punishment

Column 3	V = 0 + (0.9)(1)(0.9) V = 0.81	V = 0 + (0.9)(1)(1) V = 0.9
Column 2	Obstacle	V = 0 + (0.9)(1)(0.73) V = 0.66

There are multiple real-world situations where this AI model would prove to be useful. In the first scenario, a lake might have a common source of phosphate ions, such as fertilizers being dumped at a particular region of a lake (Take R1 C3 as this region). Using reinforcement learning, the model will be trained to recognize this area (R1 C3) as a common source of phosphate ions; hence, it will visit those areas more frequently and absorb the phosphate ions in excess quantities. Another situation is where there are common recurring objects such as a boat or a rock present on the lake (Take R2 C2 as this region). The AI will learn to avoid those areas to minimize the possibility of getting trapped within the perimeter of those objects. If the AI were at the box R3 C1, the AI would essentially move to R3 C2 rather than R2 C1 since R3 C2 has a larger value than R2 C1, successfully avoiding the obstacle. It would then follow a series of boxes such that it lands R1 C3 (a region with a high concentration of phosphate ions).

Limitations and Further Research

In this investigation, the experiment was conducted by building a simulated environment, and 5 trials were conducted for each phosphate ion test per tank. To reduce random error and uncertainty, 8(or more) trials could have been conducted. In order to hone the best results with the island, it can be effectively used in conjunction with a mathematical model of the amount of phosphate and nitrate ions. Apart from data collection, this paper explored - rather than building and testing - the computational and AI aspect of the island. A further investigation may involve constructing the island with the computational and AI aspect.

A further extension of this paper could be to estimate the number of islands required for a particular water body. The number of islands that will vary for each water body will be based on a range of variables such as the size of the water body and the positioning of inlets, and the number of industrial effluents entering the water body. Furthermore, there may be a further investigation to estimate the amount of time required to reduce the concentration levels of ions in water. The size of the islands could be modified to suit the conditions of the water body and, therefore, the amount of time required for the operation.

Extreme weather conditions such as heavy rain may affect the structure of the island, causing parts of the island to disintegrate. When rain was simulated by placing the island prototype under a shower, the island was found to have endured slight structural damage. This could be prevented by implementing an 'island umbrella' to cover our island. It would be made of a transparent sturdy material that would stop the harsh weather from tearing down the island fiber bed. Moreover, organisms living directly under the island may not receive sunlight which will affect their ability to respirate. To prevent this, the sensor and motor would utilize and ensure that the island is not stagnant and enable enough sunlight to penetrate.

Conclusion

The excessive phosphate ions present in a water body cause eutrophication to occur as it augments algal growth. Our experiment involved an organic, phytoremediation island made of coconut husk and *Brassica juncea* seeds; together, they adsorb and absorb any excess phosphate ions present. It can be discerned from the results that there was an increased transmittance rate with respect to time that was reflected on the graph. The Pearson correlation test proves that there was a positive regression between the transmittance of each tank throughout

Days 1,5 and 21. Additionally, using sensors, motors, and Artificial Intelligence, the island's efficiency and effectiveness are increased by learning which areas of a water body have excessive phosphate ion concentrations and acting accordingly. Overall, this paper is experimentally successful and effectively solves the problem on hand.

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