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Review Article

The Environmentally Conscious Method to Eradicate Cyanobacteria

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Abstract

Cyanobacteria outbreaks in bodies of water are destructive and harmful to aquatic ecosystems. These outbreaks are detrimental in a biological manner as they produce fatal toxins for fish and aquatic life, but also in an economic manner as millions of dollars are spent on cyanobacteria eradication. The constant expense of trying to eradicate outbreaks is financially costly for those who own property along a shoreline or those who own a body of water. These are all problems that must be stopped with an efficient and effective solution. Our team provides a common sense solution to battling these cyanobacteria blooms in order to ensure the safety and productivity of the aquatic ecosystems which are impacted. We utilize robots and aerators, not only to eliminate already formed cyanobacteria, but to also prevent its regeneration. The idea is to be as efficient as possible but also as cost effective as possible, something we aim to accomplish in our solution.

Keywords: Cyanobacteria; Ecosystems; Algal Blooms

Definition and explanation of the problem

Cyanobacteria, commonly referred to as blue-green algae, are prokaryotic organisms that plague bodies of water across the United States and the world [15]. This bacteria produces cyanotoxins [16] which can be harmful and possibly fatal to the organisms they come in contact with. These bacterial organisms also inhibit the strength of the ecosystems they inhabit as they use up key nutrients that surrounding organisms need to survive [3]. They also can act as an opaque substance, not allowing certain organisms in the water to be able to photosynthesize and as a result, survive. These issues increase in magnitude as cyanobacteria usually reproduce very quickly, proliferating the amount of area they take up in a body of water [25]. Cyanobacteria reproduce in slow, moving water that is rich in nutrients, such as phosphorus and nitrogen, eitherfrom soil runoff with remnants of fertilizer or septic tank overflows. This proliferation and growth of cyanobacteria ends up resulting in a phenomenon called cyanobacterial blooms. Due to these blooms, we are posed with a larger challenge of eradicating and preventing a significantrise in these microscopic organisms, which would only exacerbate the negative effects the bacteria yields [9]. Not only do cyanobacteria brutally affect aquatic ecosystems and the health of the organisms they encounter [19], but they also negatively affect the economy as cyanobacterial growth is very expensive to take care of. In the years 2010-2020, over $1 billion were spent on the elimination of cyanobacterial blooms in waters across America. The state of Texas alone spent over $66 million on the elimination of blooms in this time period. In addition to the extraordinary issues already stated, there are societal problems that arise due to the growthof cyanobacteria as well. Recreational activities such as swimming, surfing, diving, walking on the beach, and their respective economic profits may all be taken away from humanity, as blue-green algal blooms encapsulate bodies of water across the nation and planet [8].

Explanation of chosen solution and rejection of other possible solutions

Our final solution would have to cover cost effectiveness, environmental consciousness, reusability, and wildlife friendliness

[5]. We originally thought about using barley straw as a method to stop the growth and regeneration of cyanobacteria. We ended up rejecting this idea due to the fact that it would only stop the growth of new cyanobacteria but it would do nothing tothe bad algae that had already formed [6]. It also would be non reusable and it would take too much time to work. We also considered using ultrasonic technology but there were problems thatthis presented as well. Ultrasonic technology may not be as effective in covering large areas of blooms and may also kill 'good' algae as it cannot differentiate between cyanobacteria and normal algae [7].

We also briefly considered using a vacuum to destroy bacteria. This would involve collecting the bacteria through filtration and creating a vacuum chamber. The bacteria filtrationsystem would work by using a suction to inhale the bacteria that had been extracted by the scrubbers. The algae would then go through the filtration process, with an aluminum strainer, toseparate any form of excess water, and soil particles, with the algae. The collected algae would be killed using ionization. The extracted algae would be contained inside an insulated contraption, and negative ions would be released. These negative ions would attach to the positive ions of the bacteria, and cause it to fall to the surface. The problem with this solution would be that it would only be beneficial to use on bacteria that are airborne, such as COVID.

With the algae bags detached, there would still need to be a way to dispose of the collected bags. Drones would be sent annually to the body of water to collect the cyanobacteria bags. The bags would have a tracking system that would relay signals. The drone would use these transmitted signals to find its location. Once there, the drone would use a claw mechanism to grab the bag and then insert it into a secured space, then would then be enclosed. The drone would then fly back to the set location it started from, and the bag would be disposed of accordingly, or the algae in the bag could be processed into something beneficial. However, thereare multiple problems with this issue. One issue would be the weight, since the cyanobacteria bag would be fairly heavy, and would destabilize the drone. Also since the drone is flying above a body of water, in case the bag falls off, or the drone falls into the water, there would be major casualties.

Final solution

Our final solution is one that has some components of the rejected solutions but is highly efficient, safe, and cost effective. We will have a two part system which consists of an oxygen aerator [2] and 2 robots. The cyanobacteria will not only be eradicated but turned into something beneficial for the environment through the process of transesterification which will be done on land.

One system of our solution will only have one aerator and two robots, so multiple systems may be implemented if there is a larger bloom that is being combatted or there is a largerbody of water. The first step of the solution is placing an oxygen aerator [14] at the surface of thewater body. The aerator will then jut out oxygen in a cyclical motion as it reaches the bottom of the water body and comes back up. The oxygen will then prevent the regeneration of cyanobacteria. The robots will be completely identical as they will perform the same tasks. The robot will release a pumice liquid, which will repel fish, and is unharmful to the environment [18]. The robots will move in the water due to various sensors assisting their movement. The robots will have cameras and will utilize machine learning [1] to recognize when sunset occurs in different regions based on the application of the robot. This is when they will be sent out to embark on their part of the mission. The robots will have lights as well so the cameras will have an illuminated plane to look at as they maneuver through the water. Machine learning [17] will once again be used to spot the difference between blue-green cyanobacteria and normal algae and only the blue-green cyanobacteria will be attacked [24]. Once cyanobacteria has been detected, scrubbers will be turned on to break the blooms apart. A vacuum will then be turned onto suction the remnants of the cyanobacteria. The vacuum will have a nanofilter at its tip so that all excess water gets filtered out and only the cyanobacteria is sucked in. After the filtration, the cyanobacteria will be sucked into an expandable bag of kevlar, which will be attached to the robots. As this process continues, the cyanobacteria will fill up the bag of kevlar and a trained employee can manually pick up this bag once it is fully filled. The robots will be coded to recognize when the bags are filled and then they will dock back up next to the aerator. The employee will transport this bag to the company that has employed us and the process of transesterification will take place at the site of the company. Transesterification is a process that breaks down algae so that oil is produced. The oil can be mixed with alcohol and sodium hydroxide which will create two layers and the fuel will be filtered and separated. Biofuel will becreated as a result of this [23]. Therefore, we are not only eradicating cyanobacteria but transforming it into biofuel by the means of an environmentally friendly process which is beneficial for the environment. Over the last 10 years, the cost of maintaining algal blooms was over 1 billion dollars. Therefore, in order to be cost effective, our solution should cost less than 1billion over the span of a decade. Our solution costs $14,370 per system, and there are approximately 6,000 harmful blooms every 10 years, meaning $14,370 times 6000 would only be $87 million per decade, which is $913 million less than the status quo, proving to be costeffective.

Possible real-life applications

Our solution is applicable to both large scale and small scale real life scenarios [12]. For example, if there was a large cyanobacterial bloom such as the one in Lake Erie in the year 2011, our solution would be able to solve this problem. A large-scale bloom like this would require more sets of aerators and robots, but the concept would be the same. Robots would use machine learning by the use of cameras [22] to detect the blue algae and vacuum it up into an expandable bag made of kevlar. The robots would also use scrubbers to remove cyanobacteria [20] that had accumulated in large amounts and then vacuum more after that. The aerators would keep on filtering oxygen throughout the parts of the lake that had been hit hardest by cyanobacteria. The abundance of oxygen will kill any remaining cyanobacteria and prevent a regrowth of cyanobacteria in the region. Lake Erie has continually been experiencing these blooms over the past two decades because there is no prevention of the regeneration of this bacteria. The oxygen aerator(s) would be the perfect way to efficiently reduce the chances of a cyanobacterial bloom from occurring again [13]. The cyanobacteria would then be turned into biofuel.

On a smaller scale, our solution would also be very efficient. We would obviously use a smaller number of our systems for a bloom that covers a smaller area. An oxygen aerator would be placed at the top of the body of water, producing a cyclical movement of oxygen which wouldculminate at the bottom of the water body. The robots would do the same job in a smaller scenario, as they would scrub off excess cyanobacteria and vacuum the bacteria up into an expandable bag made of kevlar. A human would manually pick up the bag and send it to the company that has hired us. The company then would turn this cyanobacteria into biofuel throughthe process of transesterification as algae would be broken down, oil would be released, and filtration would result in the creation of biofuel which would be beneficial to the environment.

Supplementary information

3D modeling of the aerator and robot on AutoDesk inventor

Figure 1

Figure 2

Kevlar sheets

Kevlar is a very strong material which is incredibly difficult and almost impossible to rip. Usually, bulletproof vests are made of this material, proving its strength. This will be used to case the cyanobacteria bags.

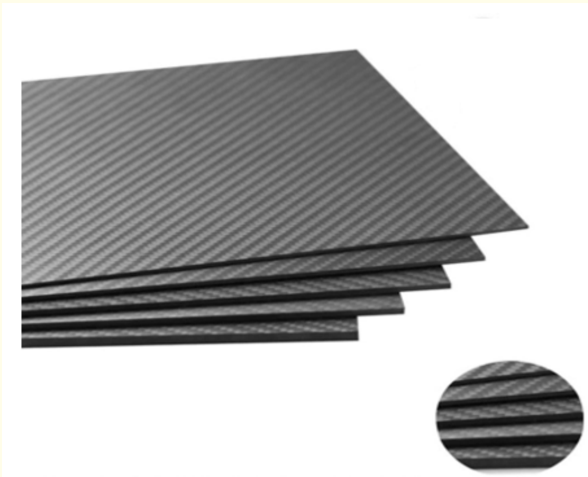

Figure 3

Supplementary information

cyanoDecision.cpp

This is a pseudo - code file we created to outline the major sensor of the Robo-Rator robot as it searches for Cyanobacteria in the surrounding area. This file specifically takes advantage of machine learning - based on computer vision as well as a fluorescence detector to determine the likelihood and percentage of Cyanobacteria in a surrounding radius of the robot. Based on these variables the robot will come to an automated conclusion when confident enough that there is cyanobacteria.

Figure 4

cyStorage.cpp

This is one of the several pseudo-code files we developed inorder to give a basic idea on how the system would functiontogether with its other parts to read information from the capacitive sensor in order to send information to the baggingmodule.

Figure 5

Supplementary information

Algae blooms cost chart on US communities [10]

Figure 6

Natural occurrence of cyanobacteria

Figure 7

Microscopic view of cyanobacteria [21]

Figure 8

Machine learning classification process

Figure 9

Supplementary information

Figure 10

Biodiesel process: [11]

Figure 11

Compound models of diesel and biodiesel (MolView Model) [4]

Figure 12

This is the atomic structure of regular diesel. This is thetype of fuel you would use in regular cars and trucks.

This is the atomic structure of biodiesel. It is similar to the structure of regular diesel, except it also contains the Ester functional group.

This similarity allows bio diesel to be used in normal engines, which makes it a better and more environmentally friendly source, as it is cleaner, and carbon neutral.

Conclusion

With technology advancing everyday, there is hope that one day, the type of technology ideated in our solution will be available for widespread use. Through the power of machine learning and artificial intelligence, robots will be able to detect cyanobacteria in bodies of water. This will help specifically eliminate cyanobacteria and no other forms of life in aquatic ecosystems. Instead of spending millions on cyanobacterial bloom relief, the solution will be significantly affordable, saving the money of the government and all those impacted by the outbreaks. Our solution is not perfect but we intend to continue to make improvements so that future generations will benefit from our work and live on a safer and more healthy planet. Through hard work and dedication, the technology will one day be made to turn cyanobacteria, something that was once toxic, into biodiesel, a safe energy alternative that does not emit CO_2. The future is very exciting and we hope to contribute to the effort of making the world a more environmentally conscious place through technology.

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