Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation Design Proposal)
(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: SDBC084

Project Title: 網開一面/ Investigation of using cellulose-containing biodegradable materials as fishing nets

Project Type: Investigation Design Proposal

***To our best knowledge, there are / ~~are no~~ * similar works in the field*; (if there are,) related research links are as below:**

1. https://phys.org/news/2021-05-bio-based-biodegradable-nets-solution-ghost.html
2. https://www.frontiersin.org/articles/10.3389/fphar.2016.00185/full#:~:text=The%20two%20main%20mechanisms%20that,release%20occurs%20in%20two%20phases

The enhancement our project proposed / the difference with related research are:

Both designs are biodegradable fishing nets and serve the purpose of decomposing abandoned fishing nets. However, our design makes use of enzyme and cellulose containing material instead of micro-algae.

Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.

I. Background

Fishing nets made of non-degradable materials may continue to catch and kill marine organisms for a long period of time after they are lost or abandoned. It is estimated that there are 4.4 kilometers of ghost nets per square kilometer of fishing grounds and 92.8 fish caught per hundred square meters of ghost net. The ghost nets kill species of seabirds, sea turtles, marine mammals and elasmobranchs, some of which are endangered, threatened or protected. Fishing nets made up of plastics will break down into microplastics which contaminate the sea. The plastic debris causes the death of more than 100,000 sea mammals and seabirds each year. It takes approximately 600-800 years on average for ghost fishing nets to naturally decompose.

Our group has found out that there is one project which is similar to our investigation. The project SEALIVE develops bio-based fishing nets from green alternatives such as micro-algae, so that fishing net production is more sustainable, and could greatly reduce the time for decomposition of biodegradable nets to limit the potential of formation of ghost nets. Both designs are biodegradable fishing nets and serve the purpose of decomposing abandoned fishing nets. However, our design makes use of enzyme and cellulose containing material instead of micro-algae, searching for another alternative for making fishing nets.

II. Objective(s)

The aim of this project is to reduce ghost fishing by developing a non-polluting and biodegradable fishing net as an alternative. Death of marine animals and contamination of seawater due to improperly disposed or abandoned non-degradable fishing nets can be reduced to achieve sustainability in life below water, the 14th sustainable development goal.

III. Hypothesis

The size of our fishing net made of lignocellulosic material can be reduced after 2-6 months in water by polymer encapsulated enzymes. Through experiment, the material used for encapsulation, design of the fishing net, and concentration and type of cellulase used in the fishing net can be determined.

IV. Methodology

Our group aims to investigate the strength and durability of our design to guarantee efficient usage of our fishing net for at least 2 to 6 months through 3 dimensions: the fishing net, the polymer capsule and the encapsulated enzyme.

In terms of the fishing net, we plan to do a tensile strength test to compare the strength of different lignocellulosic materials, including coconut husk and rice husk.

In terms of the polymer capsule, to control the rate of decomposition of lignocellulosic material, we plan to control the time of release of enzymes from polymer capsule to lignocellulosic material after the fishing net is released to the water. We will investigate the rate of enzyme release in water caused by the gradual degradation of biodegradable polymer capsules made of different materials. A control set up of enzymes directly incorporated in the fishing net will be tested. The degradation time of PLA, PGA and PLGA microspheres will be tested. The material that can degrade in water within 2-6 months is the most desirable. When the encapsulate material is degraded after months in water, enzymes inside the capsule can be released to be in contact with and break down lignocellulosic material.

In terms of the encapsulated enzyme, the activity of different types of cellulase will be investigated. A control set up of lignocellulosic material without any enzyme will be tested. Seawater has a high pH of around 7-8. The time taken for cellulase, i.e. beta-glucosidase and endoglucanase to break down lignocellulosic material of the same surface area and length under water of high pH will be investigated.

V. Expected Results and Impact of research

First, for the tensile strength test of different materials of fishing nets, it is expected that coconut husk should have the highest maximum tensile strength of about 327 MPa when compared to rice husk of 135 MPa, which is similar to that of conventional fishnet. Therefore, coconut husk should be a better natural material for making the fishing net.

Secondly, PLGA is the most suitable material to encapsulate the enzyme. The rate of degradation of PLGA varies from several weeks to months, depending on the ratio of the amount of PGA to PLA, molecular size and hydrophilicity of PLGA. Complete degradation of PLA takes around 3-5 years, it takes a long time for the fishing net to degrade, PLA cannot reduce ghost fishing effectively compared with PLGA. While PGA degrades in 2-4 weeks, which is not long enough to be used in fishing nets.

Thirdly, in order to make the fishing net last for a longer time, it is predicted that using enzymes at a lower concentration would most lengthen the time of degradation of the cellulose fishing net.

At last, to ensure that the type of enzyme chosen could work better even under high pH to facilitate degradation of fishing nets in marine environments, the type of cellulase which takes the least time in breaking down all cellulose is more desirable. Therefore, beta-glucosidase is the most suitable cellulase to break down lignocellulosic material in water of high pH. Optimum pH of beta-glucosidase is 6.5 while the optimum pH of endoglucanase is 5.5. Therefore, the activity of beta-glucosidase is higher than endoglucanase in a higher pH similar to that of seawater. Therefore, beta-glucosidase is the most suitable cellulase for the fishing net.

Our group has noticed that non-biodegradable abandoned fishing nets have led to severe occurrences of ghost fishing and marine pollution. With our investigation of a biodegradable fishnet, we hope to reduce pollution of

sea water and disruption to marine life. With the use of plant-based materials and the aid of enzymes and biodegradable polymer capsules, the decomposition processes of the fishing net could be sped up to 6 months, greatly reducing the risk of ghost fishing caused by discarded fishnets that degrade only after hundreds of years. Furthermore, the products formed from decomposition of fishing nets and polymer capsules are non-polluting, non-toxic and harmless to marine life. We hope to provide a green alternative of fishing nets which causes less harm to marine organisms.

VI. If your team will compete for the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. *(Word limit: 300 words)*

Our investigation of biodegradable fishing nets is related to the 14th sustainable development goal, "Life under water". Our design can achieve sustainability in life under water by reducing death of marine animals due to abandoned fishing nets in the sea. Our design makes use of non-toxic material, such as plant based fiber and granulated sand. The design will not create any toxic substances unlike conventional fishing nets which use polymers. Harm to marine animals is reduced with less toxic substances. Moreover, our fishing nets will be decomposed by enzymes if they are left abandoned in the water for a long time. Size of fishing nets will be reduced with time. Therefore, less marine animals will be tangled by the abandoned fishing net in the sea, deaths of marine animals are reduced. Biodiversity of marine animals can be conserved, achieving the goal of sustainable life under the sea.

VII. If your team will compete for the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award. *(Word limit: 300 words)*

VIII. Conclusion

We are confident that through conducting tests, our investigation of the best-suited design can be more all-rounded while limitations are reduced to better achieve the sustainable development goals.