Hong Kong Student Science Project Competition 2022

Template of Extended Abstract (Investigation Design Proposal)
(Word Limit: 1,000 words, Pages: 2 pages only)

Team Number: JDBC216
Project Title: Ocean Acidification - The 'Cleaning' of Water

Project Type: Investigation Design Proposal

To our best knowledge and after thorough literature research, as at 30/6/2022 , there are / are no* similar works. If there are, the reference links are as below:

The enhancement our project has made for the existing related products or research is summarized as below:

***Please delete if not applicable. HKSSPC values the originality of works. Students must conduct literature research thoroughly to ensure that their works are unique, and to list relevant reference materials to complement the research or invention.**

I. Background

Provide background information of project and/or state the problem to tackle
Provide highlights of the **literature review** with the support of pertinent and reliable references
Provide an overview of work and mention the **research gap that the project is trying to fill**

Global warming has been under the spotlight for decades - yet it remains a deep-rooted, complex, and on-going problem. The problem is ever serious, and experts warn that the "deadly trio" to the marine environment – ocean acidification, increased ocean temperature, and persistent oxygen loss – will result in irreversible damage if no significant improvements have been made.

Since the late 18th century, human activities such as burning fossil fuels have dramatically increased greenhouse gas concentrations in the Earth's atmosphere. In particular, the concentration of carbon dioxide in the atmosphere has increased from about 390 parts per million (ppm) to about 413 ppm over the past 10 years, as measured by the Mauna Loa Observatory[1]. However, this does not reflect the total increase in carbon emissions because almost half of it is absorbed by the oceans in the form of carbonic acid. In fact, according to some statistics*, over the past 200 years, the world's oceans have absorbed more than 150 billion metric tons of carbon dioxide emitted from human activities. Ocean carbon dioxide concentrations are now higher than at any time during the past 800,000 years, and the current rate of increase is likely unprecedented.

A significant producer of the aforementioned carbon dioxide is the fishing industry. When an organism dies and decomposes in the ocean, it usually sinks, bringing the carbon structures within it down to the bottom of the ocean. At the ocean bed, the broken down carbon structures then remain there and are stored for millennia until they eventually rise to Earth's surface again in the form of coal, crude oil, gas, as well as other fossil fuels. Through the process of the carbon cycle, the carbon in the organisms is effectively stored and recycled, and

[1] Stein, T. (2021, June 7). *Carbon dioxide peaks near 420 parts per million at Mauna Loa Observatory*. Welcome to NOAA Research. Retrieved June 30, 2022, from https://research.noaa.gov/article/ArtMID/587/ArticleID/2764/Coronavirus-response-barely-slows-rising-carbon-dioxide

would not be turned into carbon dioxide once they make contact with air. Yet, when a fish is caught and is brought away from the ocean, most of this carbon is instead released into the atmosphere as carbon dioxide, which would dissolve into the ocean and be turned into carbonic acid. In fact, researchers estimate that because of this overlooked phenomenon, carbon emissions from the fishing industry are 15 percent more than burning fossil fuels alone. The gigantic amount of carbon that originally will be sequestered and stored in the ocean in a harmless form for thousands or even millions of years is instead turned into a greenhouse gas, further worsening the problem of ocean acidification and global warming, in addition to affecting the ocean's ability to absorb future carbon dioxide emissions.

As carbon dioxide dissolves in seawater, it forms carbonic acid, which decreases the pH value of the seawater and causes ocean acidification. Pollutants from factories such as sulphur may also react with seawater and form acidic substances. Estimates of future carbon dioxide levels, based on business-as-usual emission scenarios, indicate that by the end of this century the surface waters of the ocean could be nearly 150 percent more acidic, resulting in an extremely low pH that the oceans haven't experienced for more than 20 million years. In this proposal, we will look into one of the causes of ocean acidification - the fishing industry, as well as the possible relief measures for combating this worrisome situation.

Meanwhile, a large amount of improper waste disposal to seawater should not be neglected as well. For instance, a study shows that pollution from plastic waste dumped into the world's oceans is correlated with ocean acidification[2]. The discarded plastic bottles became sources of harmful bacteria and microorganisms once dumped into the ocean. The accumulating bacteria that spread on plastic and into the ocean are usually referred to as the 'plastisphere'.

In addition, improper land management and agriculture practices may also lead to ocean acidification. Modern farmers usually apply chemicals to their crops to enhance their growth or kill unwanted insects and bacteria. However, these harmful chemicals may be washed downstream from the river to the sea. For example, a common herbicide used by farmers worldwide named glyphosate is a phosphonic acid, which has a pH value close to 2. Once these harmful acidic chemicals arrive in the ocean, it increases the acidity of the surrounding water, leading to ocean acidification in general.

First of all, ocean acidification can negatively affect marine life, causing organisms' shells and skeletons made of calcium carbonate to dissolve in seawater. Therefore, animals that produce calcium carbonate structures such as oysters, clams, lobsters, shrimp, and coral reefs have to spend extra energy either repairing their damaged shells or thickening them to survive, which could greatly impact the animals' abilities to grow, reproduce and survive, very often that such a rapid rate of growing shells is slower than the rate of the shell being corroded by the acidic water, leaving the creature extremely vulnerable.

The acidified water may also cause some marine animals to lose their sense of smell. The animals were less active and were less likely to respond when they encountered the smell of a predator, as shown by a report from the University of Exeter[3]. As a result, more prey may die from predators easily. This may put the entire food chain on the verge of collapsing. If one species dies out, its predators will not survive because of the lack of food, and

[2] Hadley, S. (2021, January 13). *Ocean acidification linked to plastic pollution- study*. Earth.Org - Past | Present | Future. Retrieved June 30, 2022, from https://earth.org/ocean-acidification-linked-to-plastic-pollution/

[3] *University of Exeter*. Featured news - Acidic oceans cause fish to lose their sense of smell - University of Exeter. (2018, July 23). Retrieved June 30, 2022, from https://www.exeter.ac.uk/news/featurednews/title_672112_en.html

species at a lower level in the food chain will likely be extinct. This will cause an unbalance in the food chain, in the end, affecting humans ourselves.

Additionally, ocean acidification raised alarming concerns about the threat it poses to human health and wellbeing. In the ocean, algal species grow exceptionally fast under highly acidified waters, and many of them even produce more harmful toxins in such scenarios. Marine species may be contaminated by the toxins and lose their life-essential abilities such as hunting prey and detecting predators, thus, decreasing their chance of survival. This may threaten the food chain and food security, which could bring tremendous economic loss. Furthermore, when other organisms or even humans eat these contaminated species, it may cause serious health problems. It is believed that such changes affect seafood supplies and the ocean's ability to act as a buffer zone to store pollutants, including future carbon emissions.

II. Objective(s)

State the **aim(s)** of project

We plan to investigate factors affecting the rate of ocean acidification and ways to alleviate it. In particular, we will find out the contributing conditions for the rate of production of carbonic acid in the ocean in the fishing industry.

III. Hypothesis

Propose an explanation for a phenomenon and stating how the **hypothesis** can be **tested** by experiments

Our hypothesis is that the conditions of the environment where an organism decomposes will affect the amount of carbon dioxide released into the atmosphere and into the surrounding environment. For example, factors such as the pH value, the density, the sodium chloride concentration, the reactivity, and the chemical composition are all considered. It is predicted that the amount of carbon dioxide released increases with acidity, density, and sodium chloride concentration.

It is assumed that the only factor affecting the decomposition of the organism in this experiment is the conditions of the fluid that it is submerged in and that the effects of temperature, humidity, as well as other factors are negligible.

IV. Methodology

The experiment set-up consists of a beaker which is filled with 200mL of a solution, a dead carbon-based organism (shellfish, vertebrate fish (goldfish), algae), and a gas chromatograph machine. The solution used in the experiment will be changed depending on the factor that is being investigated.

In each set of experiments, the independent variable is the condition that is tested while the dependent variables are the amounts of each type of gas generated during the decomposition of the organism. The volume of liquid used, the duration of each experiment run, as well as all other variables will be kept constant and controlled throughout each experiment run.

The first step of the experiment is to measure out 200mL of the liquid and transfer it into the beaker. The next step is submerging the dead organism in the liquid in the beaker and tightly sealing it with plastic wrap or an air-tight cover. A measurement of the amount of different gases in the beaker will be recorded using the gas chromatograph at this stage. The dead organism will be left in the beaker to decompose for another 30 days, during which carbon dioxide, as well as other gases, will be released. After 30 days, the amount of different gases will be measured again and compared with the previous measurement. The amount of each gas released in the process of decomposition of the organism can then be determined through subtracting the original concentration of each gas from the final concentration.

To test the effect of an acidic or alkaline environment on the amount of carbon dioxide produced, solutions of varying pH values (arranged in ascending order of pH: concentrated sulphuric acid, hydrochloric acid, ethanoic acid, citric acid, distilled water, sodium carbonate solution, ammonia solution, and sodium hypochlorite solution) are used in each experiment run.

To test the effect of sodium chloride concentration, mixtures of distilled water and sodium chloride of varying concentrations (0%, 25%, 50%, 75%) are used in each experiment run.

Another setup will be completed, with the organism decomposing under normal atmospheric conditions in the beaker instead. This setup can simulate the decomposition of fish that is left above water and in exposure to air for a long period of time.

To eliminate random errors in the experiment, the experiment will be repeated multiple times multiple times and the average value of every measurement will be taken. Graphs will be plotted for each set of experiment result data and a least-squares regression line will be plotted such that the exact correlation between each factor and the amount of carbon dioxide released can be shown in detail.

V. Expected Results and Impact of research

The results section is divided into 3 parts, one for each of the three organisms, namely goldfish, algae and clams.

1. Goldfish

   It is expected that the dead goldfish will be decomposed by acidic seawater.
   Carbon dioxide is produced and the goldfish is dissolved. In particular, the goldfish will dissolve the fastest in the liquid with the lowest pH, the highest salt concentration and the most carbon dioxide will be generated in those two set-ups.

   Algae

   The algae are dissolved in the acidic seawater. The algae turn from green to black and bubbles are formed. The set-ups with the lowest pH and the highest salt concentration will cause the algae to generate the most CO2.

2. Clams

   The size of the shells of the clams decreases as it is corroded by the acidic seawater. Carbon dioxide is produced during the chemical reaction. The clams dissolve the quickest in the set-up with the lowest pH and the most carbon dioxide will be generated in the set-up with the highest salt concentration.

$$\text{Carbon dioxide + water} \Rightarrow \text{carbonic acid}$$

$$\text{Calcium carbonate + carbonic acid} \Rightarrow \text{calcium hydrogencarbonate}$$

VI. Conclusion

There are some limitations to the experiment. As mentioned before, the model used for the experiment used controlled variables which are extremely difficult or near impossible to be kept at a constant throughout the entire 30-day duration of each experiment run, such as air temperature. Such may have had a negligible effect on the amount of carbon dioxide produced during each experiment run. These factors may also affect the rate of decomposition of the organism and how each organic compound in the organism is broken down. A more reliable measurement can be taken if there is a way to systematically maintain those controlled variables throughout the long duration of the experiment run. In addition, only a limited range of environmental conditions are considered due to limitations in equipment and the sheer scale and number of possible conditions of the ocean that may affect the amount of carbon dioxide produced.

All in all, the presence of acids has been demonstrated to be harmful to organic creatures and substances in the sea. If governments around the world do not take action to combat ocean acidification, the ecosystem of the ocean will be greatly affected and our lives will also be negatively impacted.

□ **Our project is developed based on our school's previous project and the enhancement is as below:**