Effects Of Oil Spills On Underwater Plant Life

Background

Most motor oils are made from a denser petroleum hydrocarbon base stock derived from crude oil, with added ingredients to enhance particular properties (Pennzoil, 2019). Oil spillages are a disastrous occurrence in the environment and have a negative effect on both animals and plants. According to the United Sates Environmental Protection Agency, 750 million litres of oil are disposed of improperly every year (Rogers, 2018). Although the impact that oil spills have on animals is spoken about in the media, the damage to underwater plant life takes a tremendous toll as well. Spilled oil floats on the surface of the water due to the difference in density, blocking the fundamental component, sunlight from reaching the plants within the body of water (Rogers, 2018). Spilled oil may also coat the leaves of plants, where the majority of photosynthesis occurs, which therefore reduces or blocks out sunlight. Without sunlight, plants deprive the energy needed to undertake photosynthesis (Rogers, 2018).

Long term effects from oil spills can also cause a buildup of mousse over the surface of the water, which can then turn into tar. The breadth of the tar has the potential to absorb excess solar radiation and increase the waters temperature, causing photosynthesis to decrease (Rogers, 2018). The residue from the oil can also block the plants ability to absorb carbon dioxide, which is another fundamental principle in photosynthesis (Rogers, 2018). In the Mexican gulf, a major disaster called “Deepwater Horizon” involving an oil spill from a BP drilling rig which exploded in April 2010, leaking over 750,000,000 litres of oil into the ocean. Nine years later and researchers are still investigating the horrendous impacts that is has had on underwater marine life including plants (Hickey, 2018).

Photosynthesis is the procedure when cells synthesize organic compounds (e.g. glucose) from inorganic molecules (CO_2 and H_2O) in the presence of sunlight (Cornell, 2016). Photosynthesis needs a photosynthetic pigment (chlorophyll) and only occurs in specific organisms including plants and particular bacteria. The photosynthesis equation is $6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$. Photosynthesis uses solar radiation to convert water and carbon dioxide into necessary nutrients that nourish plant life. Therefore, plants and algae need dependable access to water, carbon dioxide and sunlight to perform this essential process. DCPIP solution can be used when measuring photosynthesis (Cornell, 2016). DCPIP has a higher affinity for electrons and the photosynthetic electron transport chain can reduce DCPIP as a replacement for NADP+. Reduced DCPIP is colourless, the loss of colour is caused from the reducing agent created by the light-dependent reactions.

Light dependent reactions utilise photosynthetic pigments to turn light energy into chemical energy in particularly, ATP and NADPH. (Cornell, 2016). These reactions take place in the discs inside the chloroplast called thylakoids and are composed of three main steps; excitation of photosystems in light energy, the production of ATP via an electron transport chain and reduction of NADP+ (NADPH) and the photolysis of water (Cornell, 2016). Chlorophyll in photosystems I and II absorb light, which activates the release of high energy electrons.

In Photosystem II the excited electrons are transported between carrier molecules in an electron transport chain. (Cornell, 2016). The translocation of H+ ions in the electron transport chain, from the stroma to inside the thylakoid, creates a proton gradient. The protons are then sent back to the stroma via ATP synthase, which utilises their path way to synthesise ATP (Cornell, 2016). In Photosystem I, the excited electrons are used to reduce NADP+ to form NADPH. The electrons that become misplaced from Photosystem I are returned by the de-energised electrons from Photosystem II (Cornell, 2016). In photosystem II, the electrons that were lost are then replaced subsequent to the photolysis of water. The products of the light dependent reactions are then later utilised in the light independent reactions (Cornell, 2016).

Personal engagement

I decided to choose this topic as I have a passion for the environment and the impact that our society has upon it today, as it will ultimately shape our future. Oil spills are unfortunately a common occurrence in the ocean with the Great Barrier Reef and the East Coast of Australia taking a toll. In 2009, it was estimated that 270 tonnes of fuel oil was leaked from the cargo ship, Pacific Adventurer polluting Morton Island, Bribie Island and the Sunshine Coast in Queensland (McCormick, 2018). In 2010, another ship carrying coal called the Shen Neng 1, spilled around 3 tonnes of oil near the reef, which may have led to detrimental effects on marine life (McCormick, 2018). I am looking forward to conducting this experiment to see the impacts of oil spillages in the ocean on underwater plant life as well as the effects of oil spills on the rate of photosynthesis.

Safety

Before the experiment took place, a detailed risk assessment was completed using riskassess.com.au, which included all hazardous chemicals as well as the procedures to undertake in terms of prevention from hazards occurring. It was then submitted and approved by the teacher and laboratory staff.

Personal safety- A lab coat, safety goggles and gloves were worn at all times during the experiment, when handling the DCPIP solution, phosphate buffer solution and isolation medium to prevent any spillages and from harming the skin. Extra caution was taken when handling the scissors to cut the stems of the E. canadensis to ensure no harm occurred.

Environmental issues - Research on the E. canadensis plant took place to ensure that there was plenty of the species in the environment. All chemicals that were used including DCPIP, potassium chloride, sucrose and phosphate buffer were not classified as hazardous chemicals therefore they were poured down the sink in the laboratory and washed down with plenty of water. The motor oil that was used was placed in a waste container and taken to the nearest used oil facility for recycling. This was to ensure that no damage to the environment would occur.

Ethical considerations - No animals were used in this experiment so ethical considerations regarding animals did not need to be used. All IB ethical guidelines were carried out during the experiment. All materials that were ordered were used sufficiently and there were no excess materials left over. The motor oil that was ordered, came in its original container, which left an access, however this was placed in storage for later use.

Explanation

The photo to the left shows a bird's eye view of the plants in condition 1 (control), condition 2 and condition 3 after 1 day of being underneath the lamps. As seen in the control condition there is no buildup of mousse of the surface as there was no motor oil added, the plants are healthy and green. Whereas in condition 2 and 3 there is a buildup of mousse on the surface, blocking the light from accessing the plant, the plants are still seen to be somewhat green however there is brown on some of the leaves.

The second photo shows trial 2, condition 3 (5cm3 of motor oil), after two days under the lamps. As seen in the photo a thick layer of oil (buildup of mousse) is covering the E. canadensis, blocking the light from accessing the plant, therefore slowing the process of photosynthesis. It can also be seen that the leaves of the plant are brown which means that the plant is dying, possibly from the lack of sunlight.

Evaluation

The experimental hypothesis, "An increase in the volume of motor oil added to the water will decrease the rate of photosynthesis (time it takes to decolourise the DCPIP solution) of E. Canadensis", was supported by the results due to the positive correlation between the volume of motor oil added to the water, and the rate of photosynthesis. This was hypothesized as when oil is left on the surface of water it builds a thick layer of mousse, blocking the sunlight from reaching the plant. Sunlight is a fundamental element in the process of photosynthesis, therefore a lack of sunlight would slow the process down or even completely stop it from occurring altogether. The reliability of the data was satisfactory as there was a clear trend and all conditions gave sufficient data. The trend line displayed a significant increase from the control condition to the second condition (0cm3) and then a slight increase from the second experimental condition to the fifth experimental condition (15cm3). The error bars for each condition were relatively small, the control condition and the first and second experimental condition had the largest error bars, which signified some error. In experimental conditions three, four and five the error bars were smaller, indicating little error and minimal impact on the reliability of the results. The t-test values were derived from comparing the control condition to the other experimental conditions in the experiment. The control condition and the first experimental condition were compared together and gave the t- test value of -9.77562, which was well below the critical t-value meaning that there was significant statistical difference in the results. All of the t-test values gave significant statistical difference as the t-test value was well below the critical t-value of 1.860. Therefore, it could be concluded that the results confirmed the hypothesis due to the volume of oil increasing and the rate of photosynthesis decreasing.

Sunlight plays a huge role in the process of photosynthesis, as the energy from the light converts carbon dioxide and water into carbohydrates such as glucose, to provide the plant with nutrients (Cornell, 2016). Therefore, when plants have limited access to sunlight, the conversion is slowed down, which leads to the plant gradually dying from a lack of nutrients (Cornell, 2016). This can therefore relate back to the results, as the increase in volume of oil on the surface of the water, blocked the sunlight from accessing the Elodea plant, the thick layer of mousse may have also increased the waters temperature due to absorbing excess solar radiation, which could have potentially led to a decreased rate of photosynthesis. As a consequence, the time it took to decolourise the DCPIP solution was much longer than when there was no oil on the surface of the water (control condition). From the graph, it can be seen that there is an increase in time from the control condition to the fifth experimental condition. In condition five the time it took to decolorize the DCPIP solution was an average of 56.56 seconds whereas in the control it was 35.80 seconds, demonstrating a decreased rate of photosynthesis in the fifth experimental condition. As a result, this can link to the bigger picture of the damage that oil spillages have on the ocean and the growth of underwater plant life.

There was a number of limitations that may have affected the data. One of the main limitations when completing the experiment was the time it took to get through one condition, as the method of measuring the rate of photosynthesis using the DCPIP solution needed to be completed at the same time. This lead to the plants being left in the laboratory for more than two days in conditions one and two, due to the lack of time. From the graph, it can be seen that the increase in the time was most significant from the control condition to experimental condition one and then from experimental condition one to experimental condition two. This significant increase may have been caused from the plants being left for more than two days and therefore the build-up of the oil, on the surface of the water would have thickened and blocked the sunlight more so, than the control condition and experimental conditions three, four and five as they were measured after two days. This could have been prevented by completing one condition at a time instead of three at a time, which would allow for more time to prepare the solutions for the centrifuge.

Another limitation included the small portion of the chloroplast pellet that was produced after the solution had been centrifuged. This may have been due to the size of the leaves of the Elodea plant, as they were very small, it may have not given sufficient data compared to if the chloroplast pellet was larger. This could be improved by testing a different fresh water plant with bigger leaves, such as Echinodorus cordifolius (Radican Sword) which would provide a larger pellet of chloroplast. The final limitation to the method was not keeping the centrifuge tubes cold and not placing them in an ice water salt bath. It was expected that the solution in the centrifuge tubes containing the pellet of chloroplast and the isolation medium would be centrifuged straight away, the need for an ice-water bath seemed unnecessary, however because there was not enough time to centrifuge experimental condition two on the same day they had to be left in the refrigerator over-night. This may have affected the data as keeping the centrifuge tubes cold when they are not being used was necessary to preserve enzyme activity. Enzymes are proteins and become denatured when the temperature is increased, therefore to prevent the denaturing of enzymes they need to be stored in cold conditions usually below -20 Cº. As the conditions of storage were not cold enough that rate of photosynthesis may have been decreased. It can be seen on the graph that condition two had the largest difference from where the trend-line suggests the mean time should have been, this may have been due to the decrease in photosynthetic rate, from the denaturation of the enzymes. To prevent this from happening, the centrifuge tubes could be cooled by placing them in a refrigerator. Additionally, once the centrifuge tubes held the solution with the chloroplast pellet, it would be ideal to place them in an ice-water salt bath to prevent the denaturation of enzymes.

These three improvements would allow for more accurate, reliable and consistent results when it comes to measuring the effect of different volumes of oil on rate of photosynthesis and decrease the room for error. For future recommendations of experiments, different methods of measuring the rate of photosynthesis including the production of oxygen, the uptake of CO_2 or measuring the increase in dry mass could be used. The production of oxygen could be conducted by observing the bubbles evolving from pondweed or by utilizing ‘Audus apparatus’ to measure the amount gas produced over a certain period of time (Gardam, 2013). Recommendations for extension of this investigation would include having a variety of different underwater plants to test on, including plants that are found in the ocean and not in a pond, lake or river. A plant that would provide more accurate results, which is found in the ocean would be Macrocystis pyrifera, known as giant kelp. This plant would provide more accurate results due to the increased surface area of the leaves, it would produce a larger pellet of chloroplast to test. Having a variety of plants that live in the ocean would increase the reliability of results as there would be a larger sample of data. The findings could have the potential to be generalized and therefore the significance of the impacts to the ocean could be identified

Conclusion

In conclusion, the results demonstrated, that as the volume of motor oil added to the beaker of water containing the E. Canadensis increased, the rate of photosynthesis measured using a DCPIP solution (time it took to decolourise the DCPIP) decreased. These results have the potential to spread awareness and provides insight to society about the detrimental effects of oil spills on the ocean and underwater plant life. If more research was carried out on the effects of oil spillages on underwater plant life, it would extend knowledge to the wider population and the possibility of additional safety measures in regard to limiting future oil spillages may be established.

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