Can Ecovative's Mushroom Material Serve as an Effective Substitute for Styrofoam?

Controlled Research Experiment:

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Abstract-

Using mycelium, which is the vegetative growth of fungus, as well as corn husk, Ecovative Design© has developed a biodegradable substance meant as an ecologically friendly substitute for styrofoam. Styrofoam has been proven to encompass a large portion of the widespread plastic litter throughout the northwestern Atlantic Ocean (Colton, Knapp, & Burns, *et al.* 1974). As all plastic, including styrofoam, photodegrades into carcinogenic microplastics that are ingested by marine animals (Andrady, *et al.* 2011), reducing the concentration of styrofoam being polluted into world's oceans, through the utilization of the mushroom material (M.M.), would begin to relieve the stress of a great ecological burden. One specific intended use of the mushroom material is as fishing buoys. This study determined the water quality effects of the M.M., as Ecovative© would be ineffective in its aim of benefiting the marine environment if the M.M. causes certain water quality parameters to exceed or fall below established tolerance levels. Specifically, this project's goal was to determine the M.M.'s effects on pH, temperature, salinity, and dissolved oxygen. Through monitoring two experimental water tanks with a M.M. buoy, and one control tank without any M.M., it was determined that Ecovative's M.M. has no effect on all of the water quality parameters mentioned above. Based on a two-tailed statistical t-test, there is a 95% chance that the M.M. has no effect on dissolved oxygen, salinity, temperature, and pH

Introduction-

Plastic debris in the marine environment has become an increasing threat to a vast amount of marine life. In beaches away from urbanized areas, a great majority of plastic litter is comprised of fishing litter (Derraik *et al.*, 2002). Discarded buoys are likely a contributor to this fishing litter problem. Using a revolutionary new creation consisting mainly of mycelium and corn husk, mycologists at Ecovative Design© have developed biodegradable floatation devices that are meant as an eco-friendly substitute to the harmful Styrofoam buoys that the world has become accustomed to. This project will test the water quality effects and of Ecovative Design's mushroom material.

If Ecovative Design's mushroom material is comprised mainly of corn husk and mycelium, then these biodegradable substances will have a fairly insignificant effect on temperature, pH, and dissolved oxygen. These parameters will likely stay constant, with respect to the control tank's data, throughout the whole experiment.

Background-

During the early 20th century, polymer chemistry became an increasingly growing commercial field due to the endless possibilities for the use of plastics, as well as the cost efficiency of creating such products. One of these many uses was creating plastic fishing buoys. In addition to plastic buoys commercial success, however, these products also had a negative effect on the marine environment, and therefore the global environment as a whole, that wasn't truly understood at the time. Now these negative environmental consequences are finally being understood and recognized by environmental scientists, and efforts are being made to reverse said effect. One of these efforts is being made by the company Ecovative Design who have developed an ecologically friendly substitute to styrofoam.

Locality:

Figure 1: All experimentation took place in Marine Biology Lab Greenroom on Governors Island

Materials-

Table 1. Table of material name, quantity and function.

Material	Quantity	Function
10 Gallon Tank	3	Contain Water and M.M.
YSI Monitor	1	Detect D.O., pH, Salinity, and Temperature
Mushroom Material	2	To Investigate Effect on Water Quality
Bucket	4	Obtaining Water Sample
Rope	4	Retrieving Bucket
Computer	1	Gather Background Info
Data Table	2	Organizing Collected Data
Metal Rack	1	Supporting 3 10 Gallon Tank

Procedures-

Figure 2: From top to bottom- experimental tank 1, experimental tank 2, control tank.

Precision Parameters

If the data for pH were not within .5 units, and temperature within .2° C., it was deemed imprecise and wasn't recorded.

Measuring Water Quality With a YSI Sensor:

1) Moisten the sponge in the cal/transport sleeve with a small amount of water and install it on the probe. The cal/transport sleeve ensures venting to the atmosphere. For dual support and Quatro cables, place a small amount of water (1/8th of an inch) in the cal/transport cup and screw it on the probe. Disengage a thread or two to ensure atmospheric venting. Make sure the DO and temperature sensors are not immersed in water.
2) Turn the instrument on. If using a polarographic sensor, wait ten minutes for the DO sensor to stabilize. Galvanic sensors do not require warm up time.
3) Press the cal button, highlight DO and press enter.
4) Place monitor into water without disturbing the foam.
5) Verify the barometric pressure and salinity displayed are accurate. Once DO and temperature are stable, highlight "accept calibration" and press enter.
6) Record Data of control and experimental tank.

Noting Results:

1) Observe water quality parameters being tested.
2) Record data on corresponding column on spreadsheet.

There will be one data chart containing both experimental tank data and control tank data, which will have the following parameters:

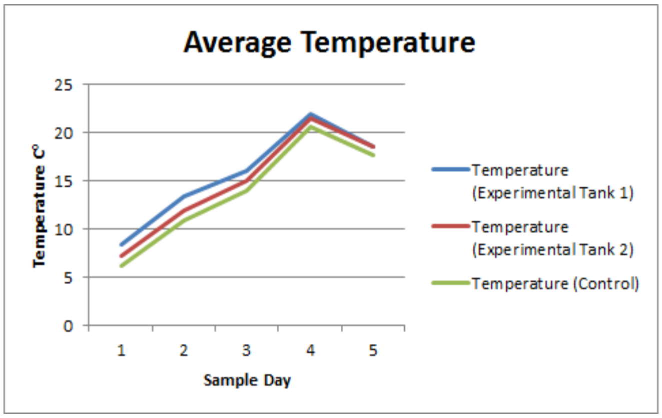
- Time
- Date
- Temperature (C)
- pH
- Dissolved Oxygen (Mg/L)
- Salinity (ppt)
- Notes/Qualitative

Safety and Ethics:

Heavy lifting is a major component of the beginning of the project.

Hazardous chemicals are required to neutralize waste water. These chemicals are harmful to the environment as well as irritate skin.

Results-



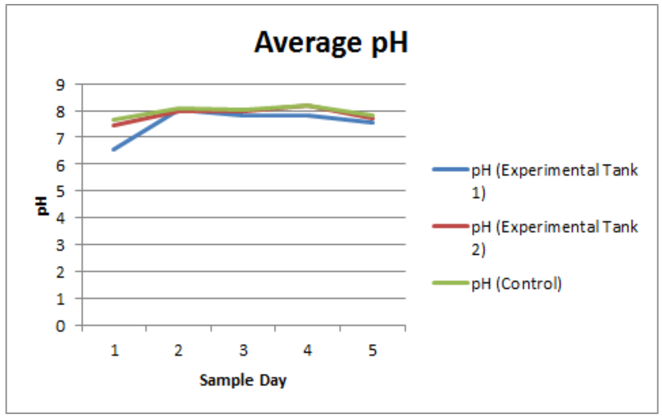
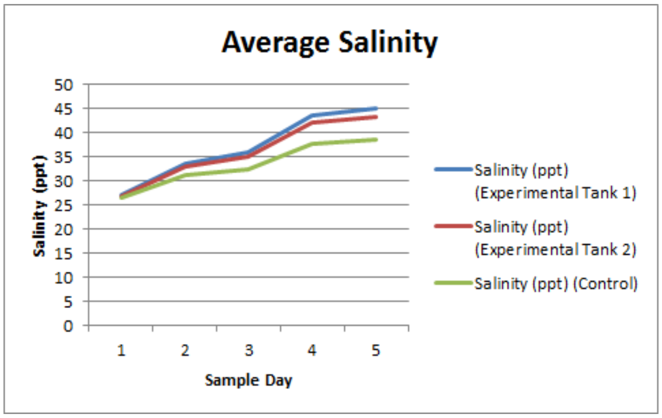


Figure 3 shows the temperature levels of all 3 tanks over 5 sampling days

Figure 4 shows the pH levels of all 3 tanks over 5 sampling days



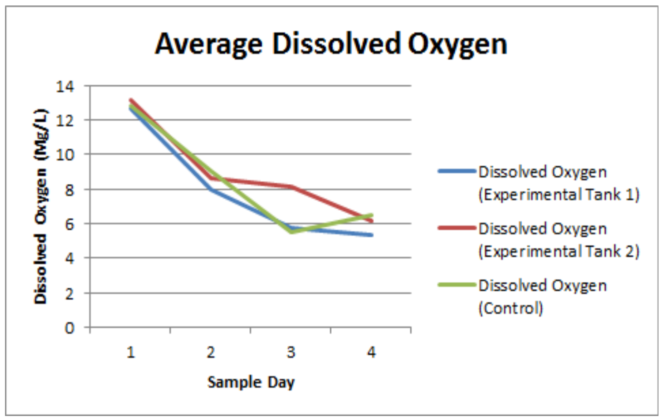


Figure 5 shows salinity levels of all three tanks over 5 sample days

Figure 6 shows dissolved oxygen levels of all three tanks over 5 sample days

Although the initial sample day for dissolved oxygen fell outside of the precision parameters and cannot be considered when analyzing and concluding data, the other three sampling days show a steady decrease in dissolved oxygen to the point where all the two experimental tanks are nearing a minimum tolerance level of 5 Mg/L. The control tank is also nearing this tolerance level.

Temperature increased at a similar rate between all three tanks, as shown in figure 2. On sample day 3 all tanks exceeded the maximum tolerance level of 20° C. As the control tank also reached this point, this was likely not a result of the presence of Ecovative's© mushroom material.

Salinity also increased at a similar rate between all three tanks. As the control tank increased correspondingly to the two experimental tanks, it is appreciable that M.M. and salinity have a neutral relationship. However, had this trial been prolonged, the M.M. in the two experimental tanks may have eroded to the point where they give off greater quantities of particulate matter, which would increase salinity.

The pH of all three tanks have roughly maintained thus far, typically staying within a range of 7.5 to 8. Due to a similar rate of change between all three tanks, it is evident that the M.M. and pH have a roughly neutral relationship. Still, further experimentation may prove to counter this claim or increase its magnitude of certainty.

Analysis-

The recorded experimental decrease in dissolved oxygen is likely result in seasonal changes in temperature. As water temperature increases, so does its ability to retain dissolved oxygen. Comparing dissolved oxygen as a function of temperature shows that as temperature rose from an average of 7.2° (C) on sample day 1 to 21.2° (C) on sample day 4, dissolved oxygen acted inversely by decreasing from 12.87 mg/L to 6.47 mg/L. This reinforces the idea that temperature variation results in variation of dissolved oxygen. Using the experimental and control data sets it was determined that the derived $t = 3.04$ exceeds the critical value of $t = +3.25$ at $p = .005$ when $df = 11$. Therefore, H_0 is rejected, and it is concluded, with 95% certainty, that these data sets are roughly the same. This suggests that the Ecovative Mushroom Material has an insignificant effect on the dissolved oxygen of a water body.

As implied in the paragraph above, variations in temperature are most probably due to seasonal changes. The Marine Biology Greenroom was chosen as the setting for this research, as it is not insulated and is therefore subject to temperature changes that are consistent with that of the New York Harbor and essentially the majority of water bodies on the eastern seaboard. This demonstrates that this fluctuation of temperature and consequently dissolved oxygen would occur in the natural environment, not just in a controlled experiment. Using the experimental and control data sets it was determined that the derived t = 3.04 exceeds the critical value of t = +2.896 at p = .01 when df = 8. Therefore, H_0 is rejected, and it is concluded, with 95% certainty, that the Ecovative Mushroom Material has an insignificant effect on the temperature of a water body.

Salinity increased throughout all 5 sampling days in all experimental and control tanks. This is also likely an indirect result of temperature. As temperature increased, the water levels in all three tanks subsided. When water level subsides, salinity tends to increase because the particulate matter starts to take up a larger portion of the overall volume of the water mixture. Using the experimental and control data sets it was determined that the derived t = 3.16 exceeds the critical value of t = +3.11 at p = .005 when df = 11. Therefore, H_0 is rejected, and it is concluded, with 95% certainty, that the Ecovative Mushroom Material has an insignificant effect on the salinity of a waterbody.

The pH of all 3 tanks were generally constant throughout all sampling days. This shows that the mushroom material buoys either did not contribute any substantial quantities acids or bases to the water or contributed a level of both acids and bases that caused them to cancel each other out and remain neutral.

Discussion:

Based on only the data from this study, Ecovative's mushroom material has no apparent effect on water quality. This speaks to the viability of Ecovative's mushroom material as a ecologically beneficial replacement to styrofoam. Styrofoam has a negative effect on water quality as a result of photodegradation, and as the M.M. has all of the commercial values of styrofoam, M.M. can function as an ecologically friendly substitute for styrofoam as it has a neutral effect on water quality.

Peer Reviewed Journal Articles:

Andrady, A. L. (2011). Microplastics in the marine environment. *Marine Pollution Bulletin*, *62*(8), 1596-1605.

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Dong, C. H., & Yao, Y. J. (2005). Nutritional requirements of mycelial growth of Cordyceps sinensis in submerged culture. *Journal of Applied Microbiology*,*99*(3), 483-492.

Leung, P. H., Zhang, Q. X., & Wu, J. Y. (2006). Mycelium cultivation, chemical composition and antitumour activity of a Tolypocladium sp. fungus isolated from wild Cordyceps sinensis. *Journal of applied microbiology*, *101*(2), 275-283.

Xiao, J. H., Chen, D. X., Liu, J. W., Liu, Z. L., Wan, W. H., Fang, N., ... & Liang, Z. Q. (2004). Optimization of submerged culture requirements for the production of mycelial growth and exopolysaccharide by Cordyceps jiangxiensis JXPJ 0109. *Journal of applied microbiology*, *96*(5), 1105-1116.

Limitations and Suggestions for Improvement-

Limitation 1: Aerators, although necessary to replicate the environment of the New York Harbor, will mask the effects of the M.M. on dissolved oxygen as they themselves are utilized to increase dissolved oxygen. On the first sampling day, D.O. was measured even though the aerators in all of the tanks hadn't been removed.

Suggestion 1: It is vital to anticipate this masking effect of aerators and to prevent this error from occurring by getting into the habit of removing said aerators in the first minutes of class. This will allow ample time for the D.O. levels to subside and eventually stop.

Limitation 2: As the volume of a water body decreases while all other properties remain the same, salinity will increase. Due to evaporation, the volume of water in all three tanks decreased over the course of the experiment, which likely caused an increase in salinity. This makes it difficult to attribute an increase in salinity directly to the M.M., as there are now multiple factors that could have lead to this.

Suggestion 2: Adding a controlled level of purified water to each tank would counter this limitation, although this could lead to a new limitation if the purified water and tank water differ in pH.

Limitation 3: During the course of spring break (a nine day period), all three tanks' aerators were unknowingly left out of the tanks. This may have negatively affected the tanks' ability to represent the constant churning of the New York Harbor.

Suggestion 3: Similarly to suggestion 1, getting into a habit of checking up on the tanks' aerators will decrease the chances of an occurrence like this.