BIOSORPTION OF OIL AND GREASE IN ARTIFICIAL WASTEWATER USING OYSTER SHELL (*Crassostrea malabonensis*)

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ABSTRACT

This study aims to explore the ability of oyster (*Crassostrea malabonensis*) shells as an adsorbent of oil and grease in wastewater. Numerous pollutants can harm our environment. Oil and grease are examples of a pollutant that can cause a serious problem to our environment. Effects of varying amounts of powdered oyster shell and a varying amount of contact time on the sorption capacity of powdered oyster shell on the biosorption using oyster shell were observed. The solutions were then analyzed using Gravimetry (n-Hexane Extraction) (SM 5520 B). The results were used to estimate the adsorbent sorption capacity. The results revealed that a high percentage of adsorption was obtained at a contact time of 24 hours (69.74%) and an adsorbent dosage of 30 grams (79.17%). Generally, the more adsorbent dosage and the longer the contact time, the higher the percentage adsorption of oil and grease.

Keywords: oyster shells, equilibrium test, oil and grease, adsorbent dosage, contact time

INTRODUCTION

Major oil spills have come to the attention of the public and media (Fingas, 2019). Oil pollution that is caused by routine ship operations is one of the most significant cases of marine pollution. For the past decade, around 24,000 tons of oil were spilled by tankers every year worldwide (Karakasi & Moutsatsou, 2010 as cited in Muhammad, et. al., 2015). Oil and grease contain fats, waxes, oils, and other related elements found in water, generally wastewater (Environmental Protection Agency (EPA), 1999). There are many factors to why there are present oil and grease in wastewater for example are restaurants, farmhouses, food processing industry, and slaughterhouses (Hamid et al., 2015).

The contamination of groundwater and the subsequent clean-up has been the biggest concern with oil and grease spills. With the number of instances, oil spills and pollution still pose an environmental problem in the world. Oil spill brings damage to marine life, contamination of water because spilled oil damages the shoreline, birds, and other wildlife that is dependent upon the affected water. The consequence of oil spills in bodies of water, both environmental and financial losses, the search for an environmentally sound remediation solution is needed. Accidents of spilling the oil usually happen while the oil undergoes the utilization process, resulting in loss of energy together with threats to the environment. There are several causes of oil spillage, such as the irresponsibility of humans, vandalizing, illegal disposal, or natural catastrophes like earthquakes and hurricanes. It also affected our economy's fisheries, agriculture, and tourism (Olufemi & Otolorin, 2017). A high concentration of oil and grease in the sewer system can lead to clogging because of the disposal of oil and grease inside the sewer system (Hamid et al., 2015). One of the reasons why marine animals die is because of oil spillage, through the depletion of dissolved oxygen in the water which is important for marine animals to survive (Chikwe and Oglobe, 2019).

The methods in many instances used to remove spilled oil involve booms, dispersants, skimmers, in situ burning, and so on. However, most of them need huge monetary input and their use is constrained because of cost factors that often reject the importance of air pollution control. In addition, most dispersants are frequently inflammable and bring health hazards to operators, potentially harming animal, and plant life (Olufemi & Otolorin, 2017). The clean-up operations on oil spills can also be a factor for more damage to fragile coastal marsh and environment. The adsorption process can treat oil and grease spillage by using appropriate adsorbents. Adsorption means the process of chemical or physical separation, demanding the activity and presence of adsorbent and adsorbate in a given liquid system. Adsorption indicates physiochemical processes wherein adsorbents such as bentonite, zeolite, alumina, animal shells, activated carbon, and activated charcoal get rid of adsorbates from any liquid system by physically attracting onto its surface through the use of intermolecular forces (Chikwe & Ogbole, 2019). Oil can be absorbed from the sea surface through the use of appropriate sorbent materials. There is an important capacity in sorbents for the recovery of oil from the sea surface, the least dangerous risks on ecosystems, and a low price. Adsorption or absorption mechanisms are two of the ways on how sorbents recover from an oil spill. Adsorption is the process of distributing adsorbates over the surface of the adsorbent. Meanwhile, absorption deals with the distribution of the absorbate throughout the absorbent's body. If added to an oil spill, sorbents can change the oil from liquid to semisolid phase. The oil can be easily recovered by getting rid of the sorbent structure. Sorbent's hydrophobicity or oleophilicity is one of the major disadvantages of sorbent properties that influences the effectiveness of oil sorption in the presence of water (Nwadiogbu et. al., 2016).

The process of wastewater treatment uses biosorption to remove organic and inorganic pollutants, heavy metals, micropollutants, and priority substances (Derco & Vrana, 2018). Biosorption is usually used to remove heavy metals in water. Using natural sorbents in cleaning up an oil spill with eco-friendly and cost-effective materials is likely to yield good results, and further attention should be given to this aspect. Natural sorbents are effective and eco-friendly sorbents in cleaning up the oil spill. The use of oyster (Crassostrea malabonensis) shells as a cost-effective, alternative, and non-toxic adsorbent not only lessen the impact to the environment but also adds economic and utility worth to it as a waste. Accordingly, reusing waste oyster shells as an adsorbent for wastewater remediation does not only give a new way of modifying the environment but also give worth to waste, therefore it contributes to the improvement of the oyster meat trade (Xu et al., 2018). The recycling of shell waste offers many advantages and has potential application in various fields; however, oyster shell waste has potential in wastewater treatment (Ramakrishna et. al. 2018).

Oysters are a type of bivalve mollusk that grows in brisk water. It is commonly found in the coastal area wherein then fresh water and brine water meet. Like in many other living organisms, oysters need a specific environmental condition to survive, but in general, oysters can be found in most of the places around the earth. It also has been the usual food near the coastal area around the world. Since the demand for oysters has increased, aquaculture technologies were developed to supply more. The aquaculture is improving economically, but on the other hand, the environmental part remains problematic. Over-cultivation without thinking of the consequences will affect the stability of the coastal environment. Also, the disposal of the waste shell from the oyster is one of the problems. Moreover, the methods in recycling the waste oyster shell are not properly developed and the oyster shells are dumped as food waste. Wrong management of the shells gives the tendency to contaminate the farming area, which would result in affecting the products that the farmers made and constantly affect the means of support of the community (Chilakala et al.,2019). Some oyster shells are used to condition the soil and to provide feeds for the chicken, while other oyster shells are abandoned in the field and produce a nasty fishy smell for a long period. Thus, new applications on making use of the waste oyster shell are anticipated to contribute to raising recycling awareness within the society (Asaoka et al., 2009). They are left in a huge pile on the side of the sea in the form of seaside dumping and shore landfills because of the trouble in guarding landfill sites or lacking support for the economy in recycling (Huh et al., 2016).

When a marine shell is heated at a high temperature, the calcium carbonate in the shell turns into calcium oxide. Then the following treatment with water turns the calcium oxide into calcium hydrate, Ca(OH)2, which is a major exothermic reaction. In the condition of oil spills, it is known that when the calcium hydrate product is mixed into an oil-contaminated body of water, the product will bind with the oil, forcing the oil to detach from the water with calcium hydrate product, resulting in a clean and uncontaminated water layer (Filbert, 2007).

The study is aimed to determine the adsorption potential of oyster shells in the removal of oil and grease in wastewater. Specifically, it would determine the effects of adsorbent dosage on oil and grease adsorption and the effect of contact time on oil and grease on the equilibrium loading. Determining the effects of adsorbent dosage and contact time will aid in the determination of the oyster shells' biosorption potential. The study intends to help the coast guards to solve the problem of oil spills in an eco-friendly and cost-effective way. This study would help identify potential biosorbent that can be used to remove pollutants in water. The study will benefit the local industry because the study gives value to the waste oyster shells.

In this study, the oyster shell will be tested as an adsorbent of oil and grease in wastewater. The wastewater that will be used is artificially made with distilled water and oil and grease. This study will be focusing on oil and grease only; moreover, other water pollutants will not be covered. Other factors that affect biosorption such as temperature will not be included in this study.

METHODOLOGY

Speciation of Oyster (Crassostrea malabonensis)

The oyster shells were specified in the Bureau of Fisheries and Aquatic Resources in Capitol Drive, Balanga City, Bataan.

Preparation of the Biosorbent

The oyster shells were purchased at the Public Market of Orani, Bataan. The shells were properly washed with distilled water to remove the residual musculature and sun-dried for 72 hours. Afterward, the dried shells were crushed using mortar and pestle and passed through a sieve to obtain fine particles.

Artificial Wastewater

The artificial wastewater was made by mixing oil grease with distilled water to produce a solution stock solution. Additional distilled water was added to adjust its concentration.

Equilibrium Test

A sequence of equilibrium test was performed in a room with a temperature of 30 degrees Celsius (Mariano, 2010).

To determine the equilibrium, an adsorption test was carried out by adding powdered oyster shell to the 6 solutions of oil & grease and varied amount of powdered oyster shell added and length of adsorption time. The samples were subjected to constant stirring for 24 hours. After waiting for the designated contact time, a decantation process was done to separate the mixture. The solutions were being brought to the CRL Environmental Laboratory for analysis. The test method used was Gravimetry (n-Hexane Extraction) (SM 5520 B). Effects of varying amounts of powdered oyster shell and a varying amount of time on the sorption capacity of powdered oyster shell on the biosorption using oyster shell were observed. The results were used to estimate the adsorbent sorption capacity. The equation was used to determine the efficiency of the test (Mariano, 2010 as cited in Lampitoc et. al., 2015).

$$\%adsorption = \left(\frac{C_i - C_{eq}}{C_i}\right) \times 100$$

Where:

Ci = initial concentration of the adsorbate, (mg/L)

Ceq = final concentration of the adsorbate, (mg/L)

RESULTS AND DISCUSSION

The Bureau of Fisheries and Aquatic Resources specified the oyster as the Crassostrea malabonensis. For the performance study, two parameters were used to determine the ability of oyster shell powder as an adsorbent. The two parameters were contact time and adsorbent dosage.

Effect of Contact Time

The performance of the powdered oyster shell to absorb the oil and grease at the assigned time was studied. The study of contact time was to find the desirable time for the highest oil removal for the performance study experiment. Table 1 shows the result of the equilibrium test at a varying contact time and constant adsorbate dosage of 10 grams. The initial concentration was found to be 889 ppm.

Table 1. Results of Varying Contact Time

Contact Time (hours)	Final Concentration (mg/L)	Percentage Adsorption (%)
12	539	39.37
18	422	52.53
24	269	69.74

The results showed that the highest percentage removal occurred where the oyster shell powder was in contact for 24 hours as shown in figure 1. More so, it was found out that as the contact time increases, the percentage of oil and grease removal also increases. The percentage removal of oil and grease ranged from 39 percent to 70 percent with a varying contact time. In 2018, Hale et al. stated that the various types of bacteria living around oyster reefs could have evolved to help oysters rid themselves of oil and oil-related chemicals. These bacteria could biodegrade oil or eat and break down oil.

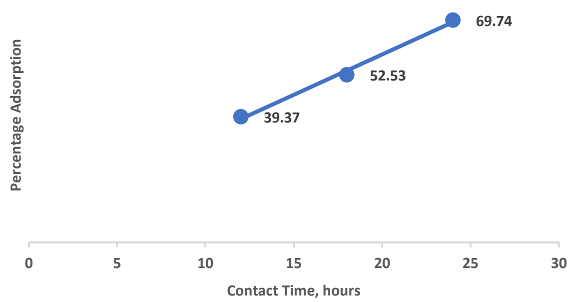

Figure 1. Effect of contact time on the percentage of oil and grease removal

Effect of Adsorbent Dosage

The adsorbent dosage study was studied to determine the advisable dosage for the highest of oil and grease removal. The varying adsorbent dosage was put into a 24-hour contact time. Table 2 shows the result of the equilibrium test at varying adsorbate dosage and constant contact time of 24 hours. Notably, the increment of the percentage removal is around approximately 6-7 percent per increment of 10 grams of adsorbate dosage.

Table 2. Results of Varying Adsorbent Dosage

Adsorbent Dosage (grams)	Final Concentration (mg/L)	Percentage Adsorption (%)
10	300	66.25
20	248	72.10
30	185	79.19

The results showed that the percentage removal shows changes with the increase of adsorbent dosage. Figure 2 showed that at 30 grams of oyster shell powder, 79.19 percent of the oil and grease were removed from the solution. In addition, it was found out that there was a direct relationship between the adsorbate dosage and percentage removal. The percentage removal ranged from 66 percent to 79 percent.

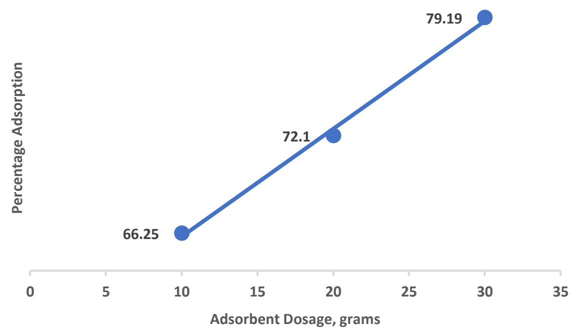

Figure 1. Effect of Adsorbent Dosage on the percentage of oil and grease removal

When the oyster shell powder was poured into the artificial wastewater, it was observed that the oil and grease slowly turned into a semisolid phase. The more adsorbent dosage and the longer the contact time, the larger oil and grease content will turn into a semisolid phase. Due to gravity, the semisolid phase of oil and grease fell to the bottom of the container (Karakasi & Moutsatsou, 2010). The findings were consistent with the study of Hamid et. al. in 2015 where oyster shells were used as an adsorbent.

CONCLUSION

The effect of contact time and the effect of adsorbent dosage were determined. As a conclusion from this research study, it shows that oyster shell powder can act as an adsorbent material in removing oil and grease from wastewater. The sample with 30 grams of adsorbent and 24 hours of contact time resulted in the highest percentage removal of 79.19 percent of the oil and grease.

It is suggested that for further studies, experiment on another water pollutant to determine the highest adsorption efficiency of the oyster shell powder. It is also recommended that for future studies, the effect of varying temperature, initial concentration, and varying pH could also be studied.

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