

AN EXPERIMENTAL STUDY OF SIX DIFFERENT TYPES OF THE NATURAL FIBRES AS AN OIL SPILL ABSORPTION

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ABSTRACT

Marine pollution arises due to the harmful substances that arrive at the ecosystems because of human errors, technical errors, and natural errors. Once it happened, it triggered impacts on the environment, natural cycle, fishery industry, human life, marine life, economic and social. This study, directed by an on-site experimental to analyze the most oil absorption from six different types of natural fiber such as *Fine Wood Dust, Coarse Sawdust, Coir, Kapok, Cattail, And Baggage*. The experiment was steered in a fishing village at Kampung Nelayan Batu 1 located in Lumut, Perak. The objectives of this study are to rank the best oil absorption from six different types of natural fiber and to identify the absorption time and the quantity of absorbed oil from the six different types of natural fiber in absorbing the spilled oil created by the fishing boats. The result displays that Cattail is the most natural fiber in absorbing spilled oil from the water surface, followed by Kapok, Fine Wood Dust, Coir, Bagasse, and Coarse sawdust, respectively. The on-site experiment showed that a 100-gram cattail is desirable to absorb 50 milliliters of spilled oil within less than 6 hours. The experiment was manually performed and observed.

Keywords: oil absorption, natural fiber, marine pollution, fishing boat, water surface

INTRODUCTION

The fishery subdivision is an important sub-sector and shows a substantial role in the national economy. It demonstrates the fishery industry grows and influences the marine fish landing and aquaculture productions yearly (Fisheries, 2011). However, the growth in aqua production leads to an increase in marine pollution. The waste polluted oil produced by the fisheries vessels encompasses the significant source of hydrocarbon. Once this hydrocarbon inflowing into the receiving aquatic environment initiated destructive to the environment and generate negative effect to the marine ecosystem, environmental, economic and tourism (Shi, Wang, Luo, & Zhang, 2019). Commonly, pollution is identified as contamination to the ecosystem which brought by a threat impact to the organism in the ecosystem, altering the growth rate, the breeding of plant or animal species and disrupting the human amenities, comfort, and health (Osofsky, Weems, Hansel & King, 2016), (Doshi, Repo, Heiskanen, Srviö, & Sillanpää, 2017). Once the oil spill happened, it provides negative effects and harm to our marine environment and causes loss. It origins severe long-term environmental and social-economic impacts on marine ecosystems and the subsistence of coastal communities. Once the oil spill transpired, it delivers negative effects and harm to our marine environment and causes loss. It causes severe long-term environmental and social-economic influences on marine ecosystems and the sustenance of coastal communities (Doshi, Repo, Heiskanen, Srviö, & Sillanpää, (2017).

Marine contamination arises as external elements go into the water and could trigger marine life to perish and human health is interrupted and influencing ecosystems on the sea and land (Sakthipriya, Doble & Sangwai, 2015). Releasing the oil from the ship must adhere to the law set by the authorities and the legal framework for the elimination of oil in the sea. Consequences the causes of the oil spill disasters are from waterway accidents, the oil rig, and the acts of wanton vandalism which usually affected so seriously the environment, marine creatures, plants, life of other animals, and human in a long time (Hoang, Pham & Nguyen, 2018). Once the polluted oil has entered the sea, it has some contents of the oxygenated oil spill and oil slick such as aromatic contents, acids, alcohols and could cause the pollution of water in a long time. Several developing techniques and useful methods were used to recover the oil spill such as mechanical recovery or burning, especially using bioremediation, solidifies, or dispersants (Berna, et al., 2012). However, the selected methods were based on the type of oil spills, the number of oil spills, conditions of weather, and the environment. The variation, transformation, alteration process of spilled oil into the sea which caused an interaction to the seawater under the natural conditions is shown in Figure 1 (Boopathy, 2000).

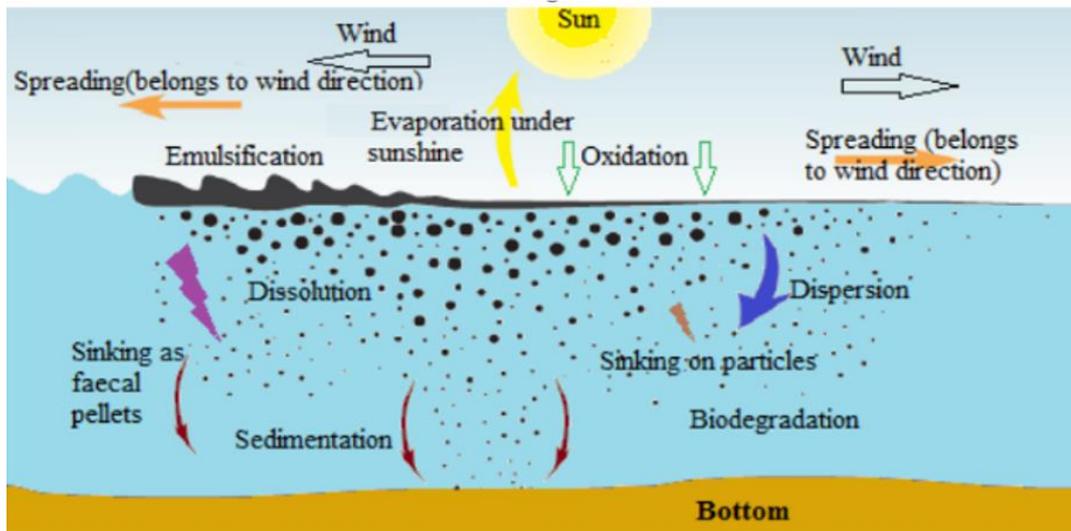


Figure 1. The variation, transformation, alteration process of oil after spilled into the sea (Boopathy, 2000)

One of the methods to control the oil spill is by developing the oil absorbent. It is utilized to remove the spilled oil from the surface water area. The nature of raw materials can be grouped into three classes such as natural organics, inorganic minerals, and synthetics. Natural organic material is becoming increasingly important as an alternative to synthetic materials. It is environmentally responsive, cost-effective, and simple to gather and dispose of after use (Wahi, et. al., 2013). This study focuses on using six different types of natural materials as an oil absorption substance. This is an effort to protect the oil pollution at the surface of the fishing water at Kampung Nelayan Batu 1, Lumut Perak. The objectives of this research is to rank the best oil absorption from six different types of natural fiber and identify the absorption time and the quantity of absorbed oil from the six different types of natural fiber. The six types of natural fiber used in this study are Fine Wood Dust, Coarse Sawdust, Coir, Kapok, Bagasse, and Cattail as shown in Figure 2.



Figure 2. the six types of natural fiber

LITERATURE REVIEW

Natural Organic Sorbents

Natural organic solvents containing cattail, straw, sawdust, rice sacks, bagasse, cotton, wool, kenaf, milkwood, kapok, silk-floss fiber, and populus seed fiber obtain escalating interest for their high biodegradability (Likon, et al, 2013). It has been remarked that straw, sawdust, rice husks, and coconut husk suffer drawbacks in terms of high-water uptake and comparatively low oil absorbency (Ali, El-Harbawi, Jabal, Yin, 2012). While cotton, milkwood, silk-floss fiber, cattail, kapok fiber, and populus seed fiber be able to absorb substantially additional oil than synthetic organic ingredients (Singh et al., 2013), natural organic materials are cheap, abundant, and eco-friendly, and attractive to use (Singh et al., 2013). Sawdust is considered as a comparatively influential raw material amongst all kinds of adsorbents as it is low-cost, eco-friendly, and low-density (Zang, Liu, Zhang, Gao & Wang, 2015).

The natural fiber

The natural fiber is originated from plant, animal, or mineral sources. The common example includes cotton, linen, jute, flax, ramie, sisal, and hemp, and this fiber is obtained from the fruits, seeds, leaves, stem, and skin plants. The seed fiber is collected from seeds such as cotton, cattail, kapok. The leaf fiber is accumulated from leaves, such as sisal and agave. The bast fiber or skin fiber is accumulated from the skin or near the stem, such as jute, kenaf, hemp, ramie, rattan, soybean, vine, and banana fiber. The fruit fiber is accumulated from the fruits of the plant such as coconut and coir fiber and stalk fiber is collected from the stalks of the plant such as straws of wheat, rice, barley, and other crops containing bamboo, grass, and tree wood. The natural fiber can be used as a element of complex raw material as the orientation of fiber impacts the properties. The natural fiber can be matted into sheets to make products such as paper, felt, or fabric and can be used as an oil absorption at the surface water area (Sakthipriya, Doble, & Sangwai, 2015).and (Ya, 2013). Besides, inorganic mineral materials and organic synthetic fibers also have been used for oil absorption (Lin, et al., 2012), (Moura & Lago, 2009) and (Wang, Zheng & Wang, 2013).

Definitions of Cattail

Cattail is a natural solvent that can be applied to clean up the spilled oil on the surface of the water either in the sea, lake, and river. The sorbent is widely used due to its low cost and the ability to remove high amounts of spilled oil (Wahi et., al., 2013).

Table 1. The definition of eattail

Authors	Definition
Cui, Xu & Liu (2014)	Cattail fiber was from fruits of cattail plants and when the cattail plant increased mature the sheaths of the cattail plant would spontaneously crack, and the cattail fiber would blow away like a flying wedding.
Singh et al., (2013)	Cotton, milkwood, silk-floss fiber, cattail, kapok fiber, and populus seed fiber can absorb substantially additional oil than synthetic organic materials.
Cao, Dong, Xu & Wang, (2018)	Cattail fiber has the potential to be efficient sorbents.
Dong et al., (2016)	Blended sorbent fiber assemblies the strengths of each sorbet utilized. For example; Cattail-Kapok hybrids have high oil sorption capabilities due to kapok fiber while maintaining high selectivity due to cattail fiber.
Mitich, (2000)	Cattail fiber is found in the Cattail plant, a wetland species found mostly in the Northern Hemisphere.

The other usefulness of eattail

Cattail has been used for various uses such as cleaning wastewater at sewage treatment, thermal for thermal insulation, pillow, cattail fiber paper, composite panel. Cattail was potentially used for making insulation boards and cattail has a potential cellulosic material for production compound boards of contrasting concentrations that be able to be utilized in construction, packaging, and lightweight composites (Correa et al., 2015). It is believed cattail particleboards could be used in the same applications that wood-based on low-end furniture, door cores, shield sheets, and other internal construction developments. Besides, the cattail was suitable for biofuel development because the cattail has good densification properties high energy density, and high-quality fiber.

Cattail is one of the common plants, but cattail has many uses as it is used for making pillows at a low price (Grosshans, 2014).

METHODOLOGY

The initial experimental process

The process of the methodology for the in-house experiment applying 500ml water, 10ml motor oil, and 100g of the different types of natural fiber. The initial experimental process is as follows:

- Use the same size of the container.
- Insert with the 500ml of water into a container.
- Insert with the 20ml amount of oil into 500ml of water.
- Insert with the 100gram of different types of natural fiber in the container which has been poured with water and oil.
- Stir the water.
- Record the result after 24 hours.

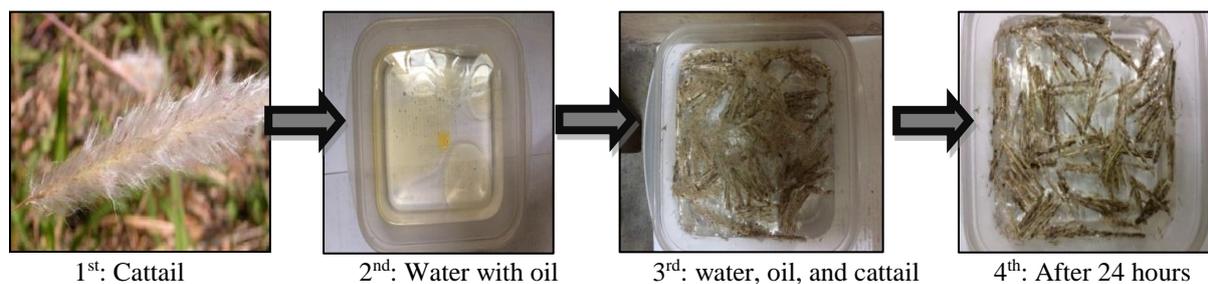


Figure 3. The oil absorption test process for cattail

In-House Experimental Analysis

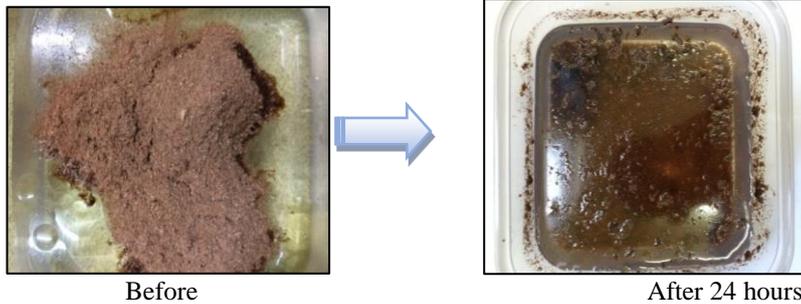
The in-house experimental analysis was conducted to identify the absorption from the six types of natural fiber. The time was taken every 6 hours for 24 hours in a day. The taken time was recorded every 6 hours, 12 hours, 18 hours until 24 hours. The in-house experiment applied the natural fiber of 100 grams, the motor oil of 50ml, and the water quantity of 500 ml. The in-house experiment was conducted using freshwater and seawater. It was conducted to justify the reliability and validity of the absorption rate within 24 hours.

Table 2. The result of the oil absorption experiment

				Fine wood dust	Coarse sawdust	Coir	Kapok	Bagasse	Cattail
Water	Quantity (ml)	Motor oil (ml)	Amount of natural fiber (g)	Condition after 24 hours to contain oil form on the water surface					
Freshwater	500	20	100	Yes	Yes	No	Yes	No	Yes
Seawater	500	20	100	Yes	Yes	No	Yes	No	Yes

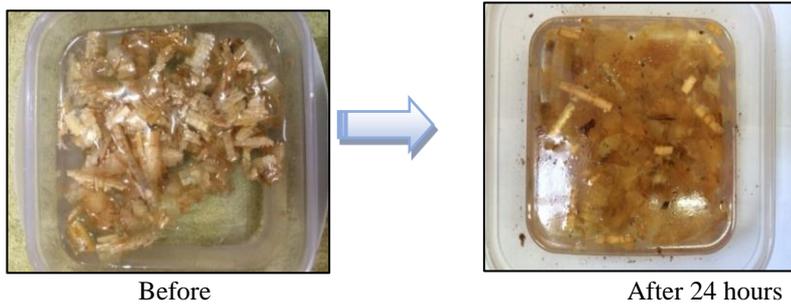
Table 2 shows that the fine wood dust, coarse sawdust, kapok, and cattail have absorbed the motor oil. However, the coir and bagasse have not absorbed the motor oil. The detailed results are as follows:

1) Fine Wood Dust



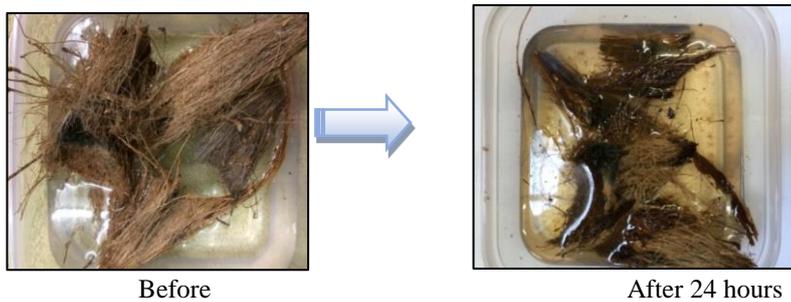
After 24 hours, fine wood dust did not absorb oil. Before 24 hours, the fine wood dust was floating on the water surface and, after 24 hours the fine wood dust sinks into the water. The fine wood dust was less absorbing oil on the surface of the water.

2) Coarse Sawdust



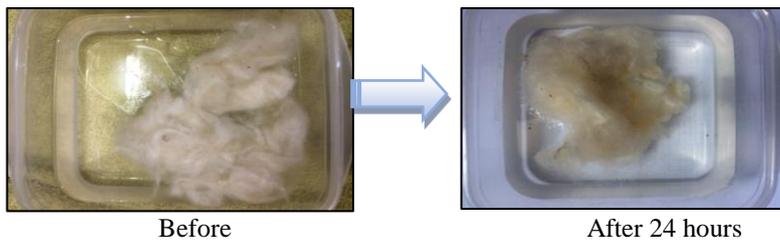
After 24 hours, the coarse sawdust did not absorb the oil. After 24 hours, the coarse sawdust was sinking into the water.

3) Coir



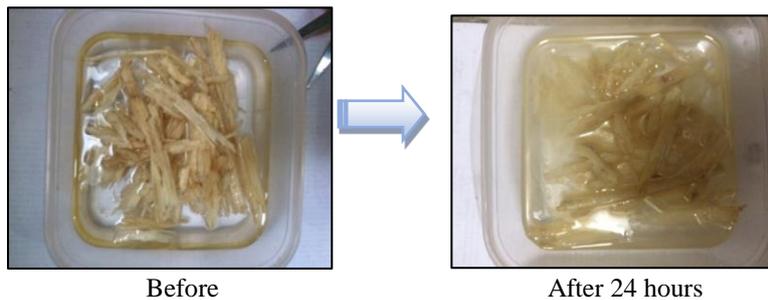
After 24 hours, the coir has absorbed little quantity of oil and, the color of the water has changed from white to yellow color.

4) Kapok



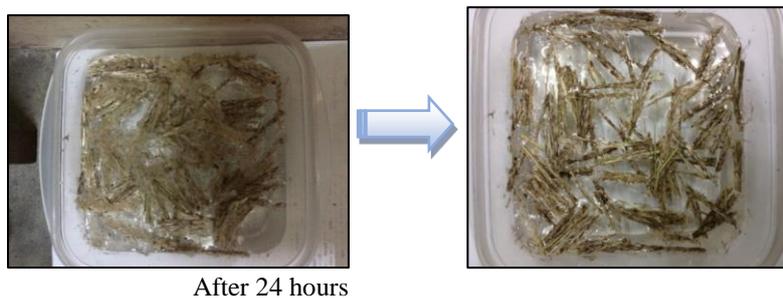
After 24 hours, the kapok was a good material that has absorbed the oil on the surface of the water. The kapok also did not sink in water and still floating as before the 24-hour experiment.

5) Bagasse



After 24 hours, the bagasse did not absorb the oil on the surface of the water and the bagasse also sinks in water after 24 hours experiment.

6) Cattail



After 24 hours, the cattail was good and effective to quickly absorb the oil on the surface of the water.

The On-site Experiment

There are 27 fisherman boats/vessels at Kampung Nelayan Batu 1, Lumut, Perak which have formed approximately 0.05 liters spilled oil per vessel/per day. The total amount of spilled oil from the fisherman boat is approximately 1.35 liters per day. The on-site experiment was conducted in 24 hours and every 6 hours the absorption result has been recorded. The on-site experiment showed that a 100-gram cattail is desirable to absorb 50 milliliters of spilled oil within less than 6 hours. The experiment was manually performed and observed.

Cattail fiber derives from the fruits of the cattail plant which is an exceedingly ordinary plant increasing up near lakes. Single cattail fiber is brittle and short and primarily utilized as stuffing for heat preservation and life protectors. Owing to the hydrophobic characteristic and low cost, cattail fiber was ever investigated as a biomass sorbent for the oil sorption function (Cui, Xu, G & Liu, 2014). The exclusive bamboo-shaped structure of the cattail fiber delivers an open space with a huge surface area was liable for the oil sorption (Hua, 2017).



Figure 4. The on-site experiment at the Kampung Nelayan Batu 1, Lumut, Perak

The following images show the on-site experiment at the kampung Nelayan Batu 1, Lumut, Perak for six natural fibers.

1) Cattail



Before



During



After

2) Kapok



Before



During



After

3) Fine Wood Dust



Before



During



After

4) Coir



Before



During



After

5) Bagasse



Before

During

After

6) Coarse Sawdust



Before

During

After

From the on-site experiment, it shows that the cattail is good and effective in oil absorption. The cattail requires 10 minutes to absorb the oil spills. The on-site experiment faced a challenge as the oil spill was easily being spread to the other area due to the currents flow of coastal water. After the cattail has absorbed the oil, it did not give a negative impact and creates pollution to the water and the environment because the cattail is an environmentally friendly and natural material (Wahi et al., 2013). The kapok has absorbed the oil spill, but it took a longer time than the cattail. Meanwhile, the fine wood dust, coarse sawdust, coir, and bagasse did not absorb the oil spill. The fine wood dust and coarse sawdust were difficult to dispose of after absorbing the oil spill because they were easily being spread to another area.

FINDING AND DISCUSSION

Table 3. Types of natural fiber and quantities of oil absorbed (in ml)

Types	Weight (gram)	Motor oil (ml)	Quantities of oil absorbed (ml)
Fine wood dust (3)	100g	50ml	14ml
Coarse Sawdust (6)	100g	50ml	4ml
Coir (4)	100g	50ml	12ml
Kapok (2)	100g	50ml	50ml
Baggase (5)	100g	50ml	8ml
Cattail (1)	100g	50ml	50ml

Table 3 shows cattail and kapok have absorbed more oil than fine wood dust, coarse sawdust, coir, and bagasse. The weight of each type of natural sorbent is equal to 100 grams with 50 ml of motor oil. The experiment is observed and recorded every 6 hours for 24 hours. Cattail is the best natural fiber in absorbing oil by 50ml, kapok is absorbing 50ml, followed by fine wood dust absorbing 14ml oil but it sunk in the water floor. Coir absorbing the oil by 12ml, bagasse absorbing 8ml of oil, and course sawdust only absorb 4ml of spilled oil.

Table 4. Hours and quantities of absorbing oil

Time (in hours)	Quantities of absorbing oil (in ml)					
	Fine wood dust	Coarse sawdust	Coir	Kapok	Bagasse	Cattail
6 hours	5ml	2ml	4ml	30ml	2ml	50ml
12 hours	10ml	4ml	8ml	40ml	4ml	0ml
18 hours	14ml	4ml	12ml	50ml	8ml	0ml
24 hours	14ml	4ml	12ml	0ml	8ml	0ml

Table 4 shows the cattail is good and the most effective in spilled oil absorption. The cattail requires 10 minutes to absorb the spilled oil. This actual experiment has a limitation of difficulty to control the spilled oil as the spilled oil easily and spread faster in the other area due to the currents flow of water. Kapok shows as the second higher absorption, but it takes more time as compare to cattail. Meanwhile, the fine wood dust, coarse sawdust, coir, and bagasse did not absorb spilled oil. The fine wood dust and coarse sawdust were difficult to dispose of because this natural fiber was easy to spread to another area. The strategy and effort for clean-up activity depend upon various surrounding factors such as water temperature, proximity to the shoreline, spill volume, soil type and density, waves, weather, and currents. Meanwhile, the variation, transformation process of oil, the interaction between oil and seawater under natural conditions such as the wave, wind and sunshine. The formation of slick oil after spilling oil depended on many different factors such as weather, speed of spreading on the water surface, drifting in the seawater, evaporation into the air, biodegradation, and emulsions between water and oil that effect dramatically the change of viscosity, density, the force of interfacial tension.

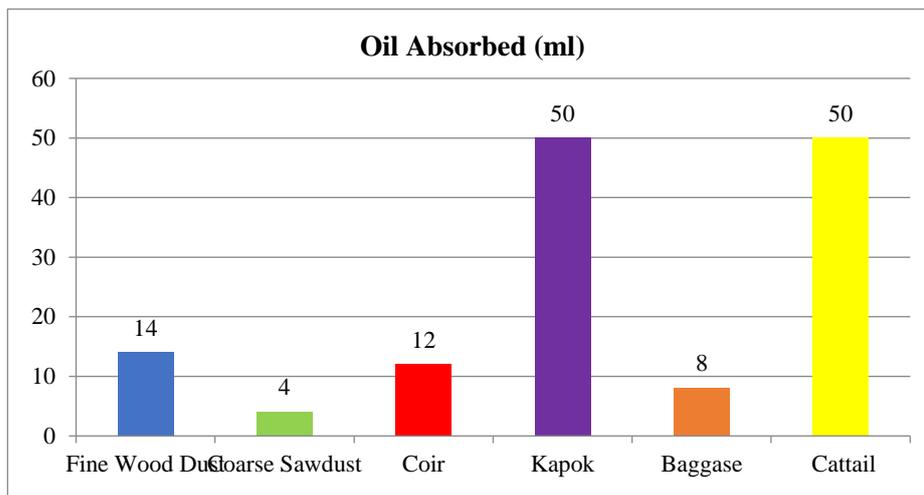


Figure 5. The quantities of the absorbed oil

Figure 5 explains the absorption rate by indicating a cattail is the best natural fiber every 6 hours for 24 hours experiment as compared to the other types of natural fiber.

Table 5. Ranking of the highest oil absorption

No	Ranking of highest oil absorption
1	Cattail
2	Kapok
3	Fine Wood Dust
4	Coir
5	Bagasse
6	Coarse Sawdust

Table 5 shows the ranking of the highest oil absorption respectively. The ranking of the highest oil absorption is cattail, kapok, fine wood dust, coir, bagasse, and coarse sawdust respectively.

CONCLUSION

From the six different types of fiber experimental, it is found cattail is the most efficient and faster in absorbing spilled oil on the spilled oil-water surface. The natural fiber is good and effective in absorbing oil spills. It proved that the cattail is the most suitable natural fiber in absorbing the spilled oil on the surface water area. The results obtained from the in-house experiment and at the actual place are the same which indicated that the cattail is the best natural fiber and cattail does not give any negative impact on the marine environment as cattail is environmentally friendly. The natural fiber is easy to get and use and cheap as compared to another method to clean up the spilled oil. Cattail has more advantages in oil absorbency between other natural fiber and cattail also has advantages in buoyancy. The buoyancy of natural fiber is very important to avoid the natural fiber sunk in the water floor after the natural fiber absorbed the spilled oil.

RECOMMENDATION

Based on the findings of this study, several recommendations can be drawn to provide a possible solution and suggestion as follows. A quick response, the right decision, and the best resource application are very crucial in combating the oil spill incidents. Any delay in responding could contribute to catastrophic damage especially to the marine ecosystem. Once the oil spill occurred and without proper remediation, mitigation, and clean-up activities, the spilled oil continues to persist in the surroundings.

As the study was conducted at the Kampung Nelayan Batu 1 in Lumut, Perak, thus it is recommended that the Kampung Nelayan Batu 1 villager should aware and prepare not to release the spilled oil from their fishing boats. The villagers should lodge a report of oil spill cases to the government and related authorities such as the Marine Department and Department of Environment. It is recommended to apply cattail in absorbing the spilled oil as cattail is efficient in absorbing the spilled oil, ecologically pleasant, and cost-efficient (Wahi et al., 2013). This natural fiber is cheaper and free as compared to the other oil sorbent such as oil boom and skimmer methods to remove and clean up the oil spill. Generally, the cost of the oil sorbent boom is RM315.00 with 76mm diameter and 1.2-meter length.

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