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Learning from Malaysia, Oil Palm's Empty Bunches for Biological Adsorbent in Diesel Oil Spill Disasters

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Abstract: The oil spill disaster potentially occurrence is an inseparable part of oil, gas exploration and transportation activities that are national and international concern. Oil palm's empty bunches are a non-toxic material that is cheap, renewable, and widely found in Indonesia as one of the world's palm oil producing countries and can be used to deal with oil spill. Research that has been conducted in Malaysia has found that the fiber of oil palm's empty bunches has good adsorption in diesel oil spills. Literature review and compares the conditions between Malaysia and Indonesia. This paper aims to provide a comparison of the utilization and use of oil palm's empty bunches for the benefit of handling oil spills in the waters. In conclusion, Malaysia is more advanced in conducting research and utilizing oil palm's for adsorbent to spills that can also be done in Indonesia.

Keywords: diesel spills, oil palm's empty bunches, adsorbent

INTRODUCTION

Hydrocarbon characteristics as well as the environment can cause differences in the nature and direction of oil spills carried by water currents and wind, then scattered oil spills can evaporate or form stains on the surface of the waters, dispersing and accumulating in the form of deposits (Chen et al., 2019). So that the handling of hydrocarbon spills is not only focused on the effectiveness of handling techniques, but also on several factors such as the type of oil spilled, the number of spills, the location of the spill, weather, and sea water conditions (Silva et al., 2022). Oil spill pollution and their derivative products can be carried out using physical, chemical, and biology (Silva et al., 2022) The choice to use oil spill handling methods depends on several factors, including the type and amount of oil spills, climatic conditions, and the surrounding environment (Doshi et al., 2018) Oil spill handling methods can also be distinguished according to oil spill recovery and degradation.

Several remediation methods can be used to remove oil contaminants from the environment, namely: physical, chemical, and biological methods. Physical and chemical methods are not very profitable methods because they are relatively more expensive and the results are not very good for removing contaminants (Anastopoulos et al., 2016) In addition to physical and chemical remediation methods, bioremediation methods can be used as one of the remediation processes (Silva et al., 2022). Bioremediation is the process of contaminants that are biologically removed from contaminated spill sites (Puasa et al., 2022) In contrast to physical and chemical remediation, bioremediation promises more environmentally friendly and cost-effective treatments, including the use of adsorbent (Geng et al., 2019)

Physical countermeasures are the mitigation of hydrocarbon or oil spills using mechanical equipment, another technique that is commonly used is in situ burning, but this method is not ecologically a popular action (Negreiros et al., 2022) Localization of spills using oil booms and pumpers is carried out by moving hydrocarbon spills with limiting buoys, which are then transferred with a pump to a receiving facility. Commonly used physical methods are: (a) Boom : is a physical barrier that aims to collect oil spills and prevent them from spreading further (Sayed et al., 2021); (b) Skimmer: serves to move oil spills from localized surfaces using an oil boom with an installation that allows to suck up as many oil spills as possible, can be installed independently (stand-alone) or installed and coupled on ships (Đordević et al., 2022); (c) Sorbent or absorbent: is an insoluble product to take oil spills on the surface of the water by absorbing the oil spill (Vocciante et al., 2022); (d) In situ Burning: is a method of handling oil spills that is quite easy and simple, namely by burning oil spills on the surface of the water (Faksness et al., 2022) But there are several things that are of concern in the use of this method, namely attention to unplanned secondary fires, damage to marine life and vegetation such as mangrove forests, health problems due to smoke from burning oil on the surface of the water, and air pollution (Hammouda et al., 2021).

A tree, Elaeis guineensis, produces the most commonly used vegetable oil in the world today, palm oil. Indonesia, Malaysia, Thailand, Colombia, and Nigeria are the five top oil palm producers Oil palm's empty bunches of palm fruit are waste generated from the palm oil industry, this is also a significant issue in managing and reducing waste of empty bunches of palm fruit (Ong et al., 2020). Several studies and experiments have been conducted to improve the sustainability of the palm oil industry by utilizing empty bunches of palm fruit into various other products (Yun et al., 2020) combustion, and the processing of empty bunch fibers of palm fruit for natural adsorbent materials, including adsorbents that can be used in handling oil spill disasters. Even Malaysia has conducted research and experiments to use empty bunches of palm fruit as an ingredient to produce bioethanol (Derman et al., 2022). Each processing of 1 ton of fresh fruit bunches, will produce oil palm's empty bunches as much as 23% of fresh fruit bunches or about 230 kg of empty bunches of palm fruit (Kamal, 2018). Along with the spirit of going green and the interest in cost efficiency economically, a desire arises to use cheaper natural materials, especially from plantation waste as organic adsorbents or organic adsorbers for oil (Zamparas et al., 2019) The utilization of natural adsorbent material technology to clean up oil spills provides a significant possibility for high efficiency in efforts to eliminate contaminants from the surface of seawater without secondary pollution being generated (May et al., 2019) and (Zamparas et al., 2019). The use of plantation and agricultural waste as biosorbents has a good opportunity for the future because of its efficient disposal and low cost (Abdullah & Sulaiman, 2013). This is the novelty of this literature review and comparison by using biological absorbent from oil palm industry waste for oil spill cleaning.

Natural sorbent materials can be biodegradabled or degraded, abundant supplies because Indonesia is a large oil palm plantation country, and relatively low prices because they are products of the palm oil production process, so it is an added value and advantage compared to synthetic adsorbent materials, and this also provides advantages in reducing the waste of the palm oil production process more optimally (Zamparas et al., 2019).

Palm fibers and chemically treated palm fibers were used as adsorbents for oil spill treatment, the adsorption capacity of the fibers was found to increase with time, thickness of oil film, temperature, and particle size while it decreases with mass of adsorbent (Khalid et al., 2021).

This study aims to examine the opportunity to use oil palm's empty bunches as the basic material for biological natural adsorbent fiber materials to clean up diesel oil spills in Indonesia. This research is important because it provides a new reference for diesel oil spill adsorbing materials from natural raw materials that are abundant in Indonesia as an alternative to synthetic adsorbent materials that are currently used in handling oil spills in oil , gas industry, and adding value to waste empty bunches of palm fruit. This research is to answer the question of how to use empty

bunches of palm fruit as raw material for oil spill adsorbents in Indonesia by learning from research on the same in Malaysia.

METHOD

This research aims to explore the potential use of empty bunches of palm fruit as an effective biological adsorbent for oil spills, particularly in Indonesia. The approach involves conducting a comparative study of the use of these bunches in Malaysia and Indonesia through a literature review of scientific journals. The research employs a qualitative method, using the collected data and information from the literature review to draw conclusions.

Indonesia is a major producer of palm oil, leading to a large amount of empty bunches as a waste product. At the same time, Indonesia is also a significant producer of oil and gas, which means there is a risk of oil spills occurring during both production and transportation processes. Malaysia, as one of the world's leading producers of palm oil, has conducted numerous studies on the use of empty bunches of palm fruit as a biological adsorbent for various purposes, including oil spill remediation.

This research aims to build upon this knowledge and determine whether empty bunches of palm fruit could be used as a biological adsorbent for oil spills in Indonesia. By analyzing the available literature and drawing upon the experiences of Malaysia, the research aims to provide insight into the feasibility and potential benefits of using empty bunches of palm fruit as a biological adsorbent in Indonesia.

According to Abdulrazik et al. (2022), Malaysia has extensively studied and utilized empty bunches of palm fruit as a biological adsorbent for various purposes, including oil spill remediation. Their research has shown that these bunches can be effectively used to adsorb diesel oil spills. This information, along with additional data and insights obtained through a literature review, can be used to determine the feasibility and potential benefits of using empty bunches of palm fruit as a biological adsorbent in Indonesia.

The main articles used as literature review in this study described in Table 1.

Table 1. Literature review references

Article	Journal	Year	Authors
Application of Oil Palm Empty Fruit Bunch as Adsorbent: A Review	Transactions on Science and Technology	2019	(May et al., 2019)
Oil Palm's Empty Fruit Bunch as a Sorbent Material in Filter System for Oil-Spill Clean Up	Plants	2022	(Puasa et al., 2022)

RESULTS AND DISCUSSION

The palm oil industry has been an important part of socio-economic development in Malaysia since 1960 as one of the world's largest palm oil producers and exporters which statistically has shown the role of the palm oil industry to contribute 12% of Malaysia's total exports, equivalent to RM 80.4 billion or around USD 18.26 billion (Abdulrazik et al., 2022). The previous study was conducted in Malaysia using waste empty bunches of palm fruit collected from the local palm oil industry in the Manjung Perak area, Malaysia and seawater obtained from Port Klang with a salinity of 15.99 ppt and pH 7.5 – 8.1 as well as diesel fuel (Dynamic diesel fuel Euro 5) purchased from Petronas UPM Serdang, Selangor and stored at room temperature for testing (Puasa et al., 2022). These three basic components are part of the composition of diesel/diesel oil-absorbing natural materials, diesel fuel, and seawater where oil spills in the waters, will then be

used as samples for testing and laboratory analysis to measure the absorbtion capacity and efficiency of oil and seawater adsorbtion (Puasa et al., 2022).

In addition, samples from oil palm's empty fruit bunches are separated into three parts, namely the stalk, the bunch spots and the intact part, rinsed with distilled water until clean, then dried in the sun until it reaches a constant weight, then heated in the oven in the laboratory for 20 minutes at a temperature of 170 degrees Celsius, then the sample is allowed to cool at room temperature by making a triple experimental sample, which will later be studied based on the high efficiency of low efficiency of the water adsorbed, including characterization analysis and morphological analysis using the Scanning Electron Microscope (SEM), One Factor at a Time (OFAT), Response Surface Methodology (RSM), Placket-Burman Design, and Central Composite Design methods. (CCD). The selection of the part of EFB to be used in the subsequent parts of the study was based on the high efficiency of oil and low efficiency of water absorbed. From the result, the optimum part of EFB to absorb oil was analysed for characterization and morphological analysis (Puasa et al., 2022).

The results of laboratory tests to determine the optimal part of the empty bunches of palm fruit that best showed high efficiency in adsorbing oil and low efficiency of absorbed water showed that the fiber from the treated part of the stalk had the highest absorption efficiency of 33% ($p < 0.0001$) and the highest adsorbed water efficiency of 1% ($p < 0.0001$). Because the fiber obtained shows the high efficiency of the oil adsorbed with the low efficiency of the adsorbed water, the fibers from that part of the stalk were chosen for further study, as described in Figure 1 (Puasa et al., 2022)

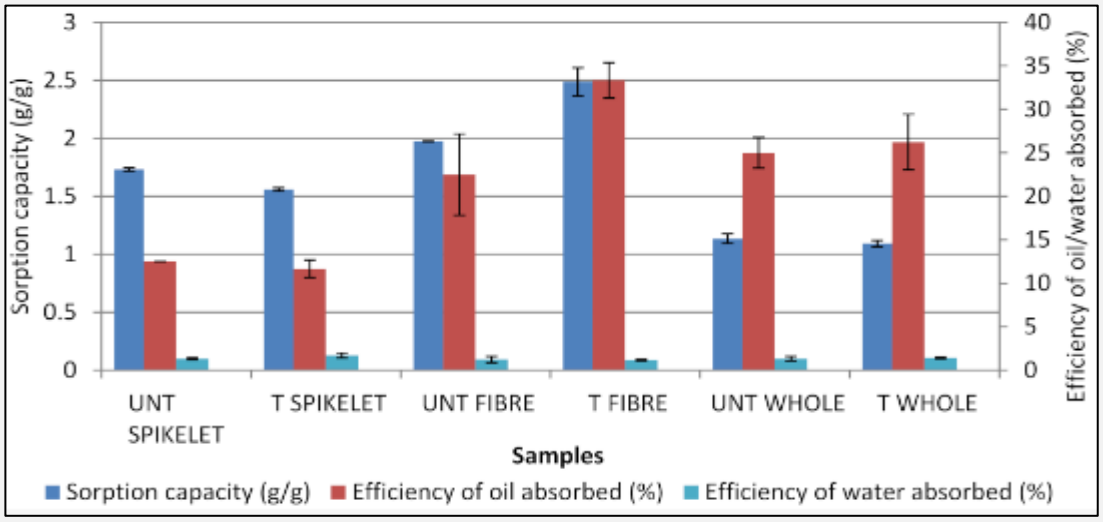

Figure 1. Absorption Efficiency of Empty bunches of palm fruit (Puasa et al., 2022)

The efficiency of the fibers of the empty bunch stalk of the palm fruit to adsorb more oil is because the natural fiber sizei of this part of the stalk is larger in diameter, but has a lower strength than the empty bunch spot part (spikelet), this is because the g acid content of alacturonic in the spikelet is lower than in the stalk part, which correlates with the lower (Nafu et al., 2015) Fourier Transform Infrared (FTIR) Spectroscopy Analysis for empty bunches of palm fruit that are heated (Treated = T) up to 170 degrees Celsius and that are not heated at (Untreated – UNT) as shown in Figure 2 (Puasa et al., 2022).

FTIR analysis of empty bunches of oil palm's fruit bunches unheated at 170 degrees Celsius as illustrated in Figure 3, showed a stretching of the OH group that showed a broad peak that contributed to cellulose reduction, thus also reducing the amount of hydroxyl, hemicellulose, and cellulose when empty bunches of palm fruit were exposed to heat (Puasa et al., 2022). The FTIR

spectrum for oil palm's empty bunches that do not go through heating up to 170 degrees Celsius then moistened with oil is illustrated in Figure 4, showing that the fibers of oil palm's empty bunches that get a warming treatment can adsorb more diesel oil compared to those that do not get heating (Puasa et al., 2022).

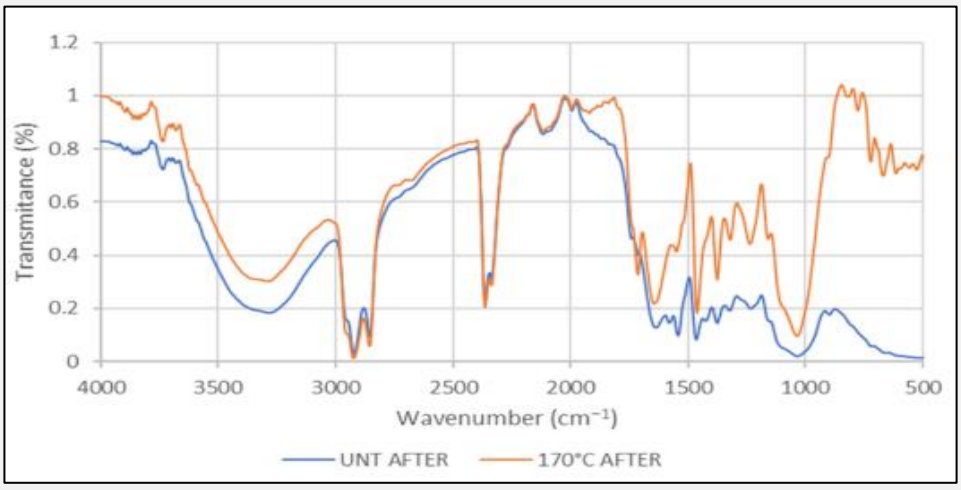

Figure 2. Infrared Spektrum (IR) results empty bunches of palm fruit before moistening with oil (Puasa et al., 2022)

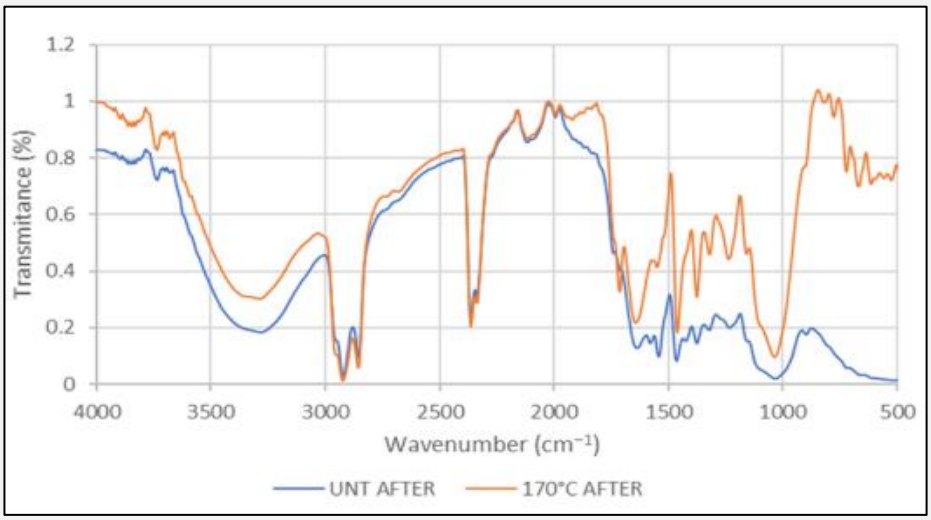

Figure 3. The results of infrared Spektrum (IR) empty bunches of palm fruit after warming up after being moistened with oil (Puasa et al., 2022)

Temperature and time significantly affect the efficiency of oil absorption, water absorption, as well as absorption capacitance. Optimization of oil adsorbed using one factor at the time (OFAT) results that the empty bunch fibers of palm fruit obtained have a higher absorption ability compared to those that do not get treatment (heating), a large amount of oil is adsorbed and the amount of water adsorbed shows lower results, as described in Figure 4 (Puasa et al., 2022).

Figure 5 shows an illustration of the effect of heating time on the fibers of empty bunches of processed palm fruit (Puasa et al., 2022). At different heating times, it shows the result that the highest adsorbed oil efficiency at a heating time of 20 minutes, then a heating time of 170 degrees Celsius and 20 minutes is the highest efficiency of oil adsorbed as well as low water absorption.

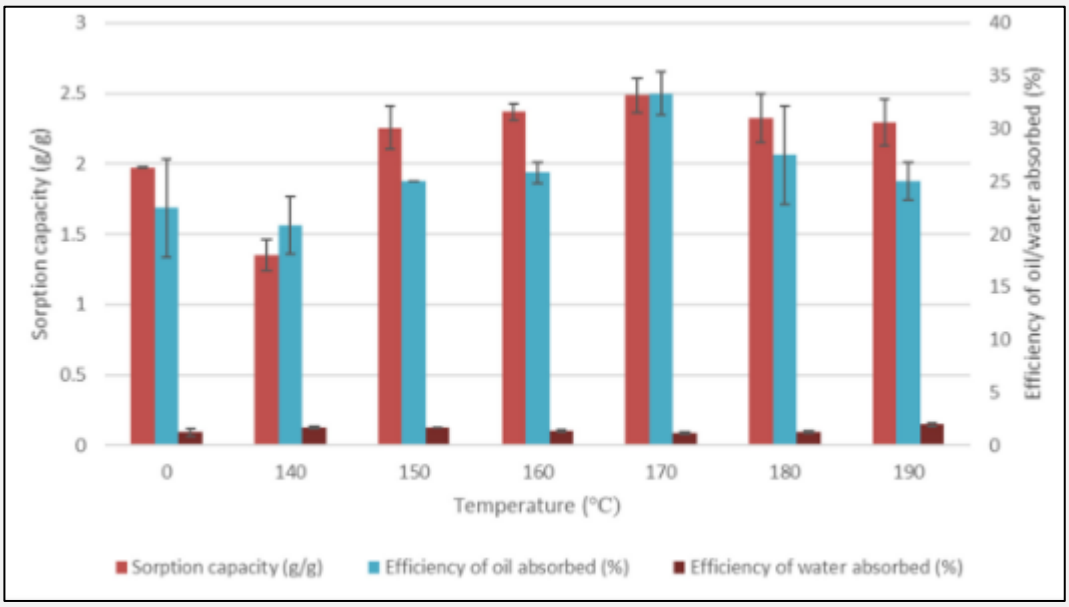

Figure 4. The impact of temperature on empty bunches of palm fruit on absorption (Puasa et al., 2022)

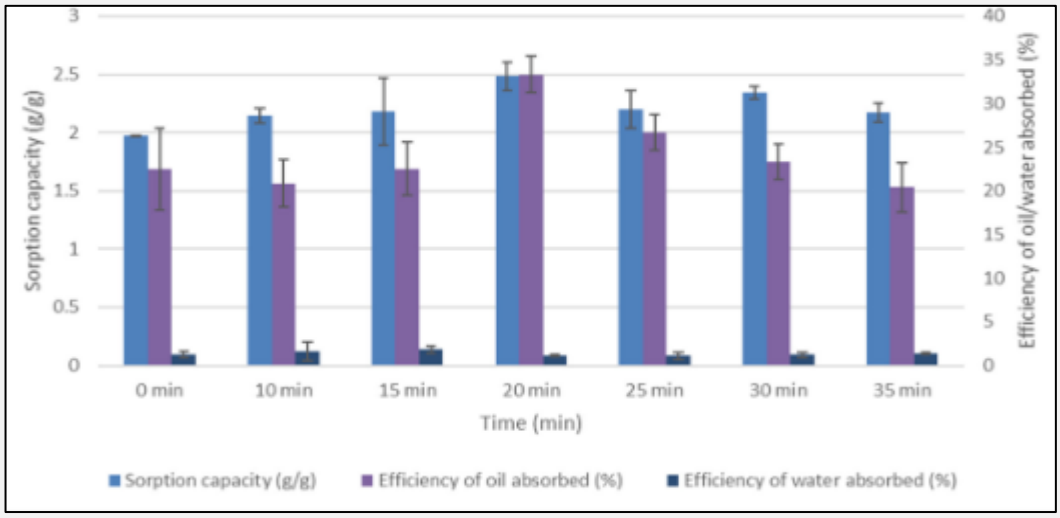

Figure 5. Effect of time on EFB-treated fibers. The data obtained are the average efficiency of the adsorbed oil (%), the efficiency of the water adsorbed (%), and the absorption capacity (g/g) (Puasa et al., 2022)

Fiber surface modification by means of thermal treatment is useful for reducing polar components, which can achieve good adhesion in the fiber matrix and improve the fiber matrix interface (Ahmad et al., 2019) It is proven that the efficiency of palm fruit empty bunch fibers in adsorbing oil increases to 170 degrees Celsius, fiber surface modification using thermal treatment results in reducing water absorption, supporting more significant fiber interactions (Puasa et al., 2022). The concentration of oil significantly affects the efficiency of the oil and the water adsorbed. Figure 6 shows that an increase in diesel concentration affects the absolute polar absorbed up to a concentration of 10%, and oil concentrations above 10% do not cause a further increase in diesel adsorption (Puasa et al., 2022).

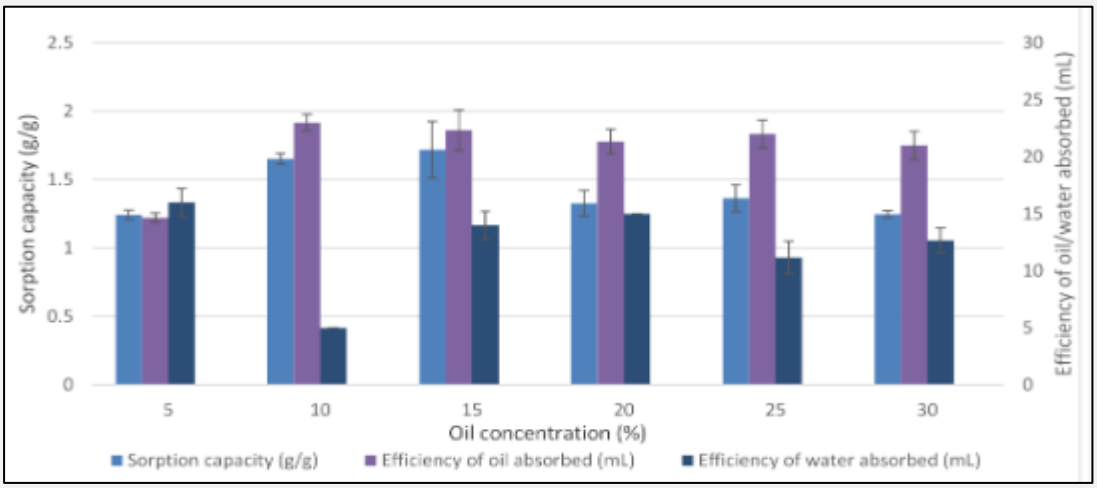

Figure 6. Effect of oil concentration on EFB-treated fiber. The data obtained are the average efficiency of the adsorbed oil (%), the efficiency of the water adsorbed (%), and the absorption capacity (g/g) at temperature (Puasa et al., 2022)

Comparative study to other scientific literature by May et al,.(2019) mentioning that another challenge for the utilization of oil palm's empty fruit bunches is the high processing cost to transform EFB into value added products instead of direct utilization. The application of oil palm's empty fruit bunches as a raw material for biofuel, paper production, briquette and activated carbon requires a few stages of treatment where heat, chemical, water and time is consumed at a large scale. In addition, secondary wastes maybe generated along the process of modification which eventually possesses secondary pollution if released into the environment prior to any treatment (May et al., 2019).

Another study by Khalid et al. (2021) mentioned that isolation and characterization of magnetic oil palm's empty fruit bunches cellulose nanofiber composite as bio-sorbent also able to be use for heavy metals removal application in the aquatic environment, with research conducted in Malaysia. Abdulrazik et al. (2022) in his scientific article entitled "Multi-Product Productions from Malaysian Oil Palm Empty Fruit Bunch (EFB): Selection for Optimal Process and Transportation Mode" described the various uses of biomass palm's oil empty fruit bunches. This explains that Malaysia has been earlier and more advanced in research and utilization of palm oil plantation waste, namely oil palm's empty fruit bunches for various uses related to biological sustainability.

Then, what about in Indonesia? Several studies have been conducted in Indonesia regarding the use of palm oil's empty fruit bunches several times, but there has been no detailed research regarding its use in adsorbent materials for cleaning up oil spills (data searched by the author on the Google Scholar website). A search on the Scopus website found only 3 articles published between 2020 and 2022 with the keywords oil AND palm AND empty AND fruit AND bunches AND adsorbent AND Indonesia as shown in Figure 7.

In Figure 8 below, show the subject areas of research conducted in 2020 – 2022, shows a little research and writing of scientific articles conducted regarding the use of oil palm's empty fruit bunches for biological oil spill absorbent materials. Three Indonesian scientific articles discussing the benefits of empty palm fruit bunches oil during 2020 – 2022 are shown in Table 2.

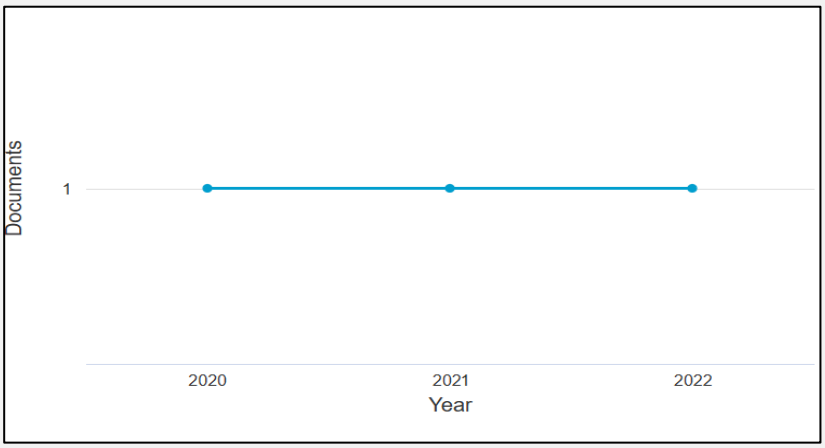

Figure 7. Oil palm's empty fruit bunches application in Indonesia 2020 - 2022
Source : Scopus, data downloaded on December 10, 2022

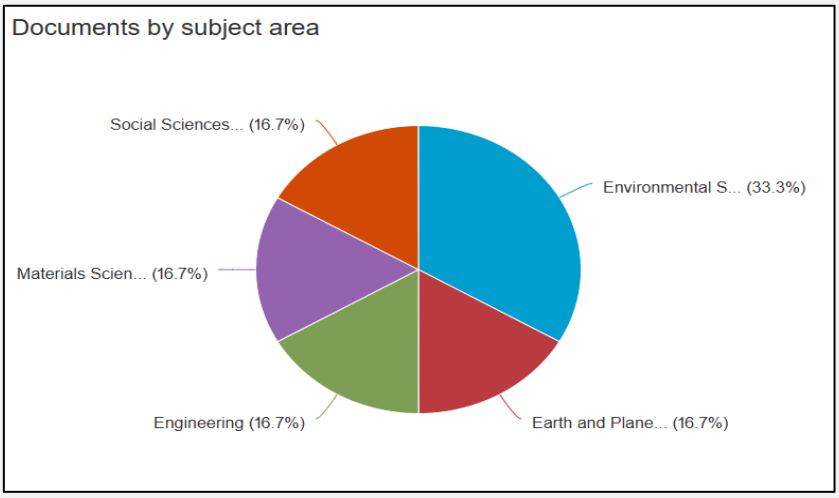

Figure 8. Subject area of research on 2020 - 2022 related to oil palm's empty fruit bunches use for adsorbent in Indonesia
Source: Scopus , data downloaded on December 10, 2022

Table 2. Articles published related oil palm's empty fruit bunches used , 2020 - 2022

Title	Journal Sources	Year	Authors
Preliminary study of molecular sieve materials to alleviate problems faced by tropical peatland	IOP Conference Series: Earth and Environmental Science	2022	(Santi et al., 2022)
Improvement of anionic and cationic dyes removal in aqueous solution by Indonesian agro-waste oil palm empty fruit bunches through sialylation approach	Groundwater for Sustainable Development	2021	(Saputra et al., 2021)
Product Distribution and Characteristic from Pyrolysis of Indonesia Palm Oil Residues	IOP Conference Series: Materials Science and Engineering	2020	(Cahyono et al., 2020)

CONCLUSION

The use of industrial waste in plantations and palm oil processing in Indonesia can actually be done by learning from Malaysia which has previously conducted research and experiments on the use of empty palm fruit bunches for various products and other products that are more efficient and environmentally friendly. This research found that Malaysia has first conducted research and utilized the products of the palm oil industry for various uses in various sectors, which in this study were used as adsorbent materials for diesel oil spills in water, as part of the method of handling diesel oil spills in the water.

Oil palm's empty bunches of palm fruit processed and analyzed based on laboratory tests of the methods and approaches previously outlined have been shown to provide good and efficient results in an effort to adsorb diesel oil spills, optimization of oil efficiency adsorbed through conventional OFAT and RSM statistical approaches resulting in 23 mL and 25.33 mL of adsorbed oil, respectively. In conclusion, the results obtained support statistical RSM as an effective tool for optimizing factors to increase adsorbed oils compared to conventional OFAT approaches. Further in-depth studies of empty bunches of palm fruit as an adsorbent material for oil pollution will further enhance the application of agricultural/plantation waste as a bioremediation tool in Indonesia.

Converting oil palm's fruit bunches into value-added adsorbents is a way to solve the disposal issue and substituting the conventional adsorbents. The utilization of oil palm's empty fruit bunches as an adsorbent has gained recognitions owing to its abundance, relatively low cost and rich in lignin, cellulose and hemicellulose. Nonetheless, modifications that are more environmentally friendly, able to produce adsorbents with excellent physicochemical properties and adsorption performance is yet to be explored and developed, especially for pilot scale to industrial applications. A great opportunity for Indonesia, especially academics and researchers to make more use of palm oil's empty fruit bunch for various benefits for applications in Indonesia, as one of the producing countries and the palm oil industry.

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