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Removal of Spill Oil from Aqueous Medium by Natural and Industrial Waste Polymer

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Abstract

Oil is a significant source of energy in the modern world. Transferring the oil from the production companies by ships or vehicles across the world according to its demeaned. The opportunity of the oil spillage in the oceans or seas accidentally or intentionally action. It is reported that the optimum sorbents to remove oil spills are prepared from the assembly. The structure of sorbents, material, and physical characteristics of oil are the factors that affect the retention performance of the sorbents and the sorption of the oil. The major problem for the sustainable environment is the disposal of utilizing sorbents. Biodegradable materials that naturally exists shows excessive potential as compared to artificial materials. Polymers that have hydrophobicity and oleophilic properties can absorb oil at an extraordinary rate. In this study, sawdust, wool, high-density polyethylene (HDPE), and polyvinyl chloride (PVC) are used to test the amount of oil sorption. It demonstrates that the influence of weight for materials' sorbent enhancing the value of capacity of oil sorption. It also shows that the higher amount of oil uptake and high capacities of oil sorption in sawdust as compared to other materials, then, PVC, HDPE, bark, and caprice come respectively. However, the amount of oil uptake and capacities of oil sorption are less obtained in wool.

Disciplinary: Chemical & Petrochemical Techniques Engineering, Sea Ecology and Environmental Management, Waste Management.

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1 Introduction

The spillage of crude oil considers as one of the key causes of pollution in rivers, underground waters, oceans, or seas which are the sources of the water that can be polluted by-products of petroleum and oil. Quickly action needs to be done in order to reduce the economic and environmental influences of the spillage of oil and petroleum products over the sources of the water (Annunciado et al., 2005).

Generally, the hazard of spillage is where production, transportation, storing and using of oil and petroleum. An odor and unfavorable taste are the properties of spilled oil and that will lead to many damages to the economy and environment (Zahed *et al.,* 2005). From several industries, the contamination of petroleum and oil is also another source of pollution of the water. The most influenced by such incidents is the atmosphere of the seawater. Therefore, a crucial demand to develop the material or process that can collect and also separate the polluted oily organic and oil from the sources of the water (Broje et al., 2006, and Kujawinski et al., 2011).

Eventually, poisonous components coming from the spilled oil go into the chains of the food and as a result, it will impact our healthiness. It is important to quickly remove the spilled oil that causes various ecological problems (Hussein et al., 2009). Furthermore, this oil spillage can affect the plants and animals either from the oil itself or from the cleanup process. To recover the plants and animals much rapidly, these mentioned two types of influences are necessary to be investigated.

Living things can be harmed by oil spillage because it has chemical-toxic components. Such spillage could influence organisms, both by ingestion, which is considered as an internal exposure, and by irritation of the eye and skin which is considered as an external exposure. Also, spilled oil can suffocate several small kinds of invertebrates or fish. Reducing the ability to keep the temperature of the mammal's and a bird's body is also caused by spilling oil on fur and feathers (Conserve-Energy-Future, 2020).

There are two mechanisms which are adsorption and absorption can describe the sorption process. The penetration of the oil into the pore areas of the material can be occurred by the absorbents. In contrast, the attraction of the oil spillage into their surfaces, without penetration into such materials, can be occurred by the adsorbents Adsorption which is a promising and economical technique is utilized to reduce the problems of ecological oil spillage and to eliminate this pollution (Karan et al., 2011).

The sorbents of oil could be categorized into three types which are: (i) natural organic-vegetable such as, the fiber of the wood, feathers, sawdust, kenaf, ground-corncobs, hay, and other products of carbon-based, (ii) organic-synthetic such as products of polyurethane and polypropylene, and (iii) inorganic mineral products such as perlite, silica, diatomite, sand, zeolites, sorbent clay, volcanic ash, and wool.

The aim of using wool, leaf of Conocarpus plant, the bark of the plant, Polyvinyl chloride (PVC), and High-density polyethylene (HDPE) as an eco-friendly sorbent of spillage of oil or wasted oil which they have low thermal conductivity, cost-effective, squeezable, high capacity for absorption spillage of oil, and flexible can assist, support, and improve the efforts to face the environmental problems in everywhere in the modern world.

2 Materials and Methods

2.1 Materials

The crude oil obtained from the Basra Oil Company, Basra, Iraq, is used as pollutants. Conocarpus leaf is taken from the waste of trees, PVC obtained from polymers waste, wool obtained from animal remains, HDPE obtained from waste of polymers, and bark of plant obtained from waste of trees are utilized as oil sorbents. They were dehydrated, crushed, and lastly screened into 2 mm mesh size.

2.2 Oil Spillage Test Procedure

The oil spillage is prepared by adding 50 ml of water in a beaker and then adding 1 g of crude oil into the water with stirring for 5 min to allow the crude oil to become homogenous on the surface of the water.

Sawdust was added to the oil spillage about 0.25 g with stirring for 5 min to allow the mixture to become homogenous on the surface at different temperatures (25, 35, 45, and 55°C). After two hours, the mixture was picked up and put on a filter paper to remove the excess crude oil before weighing it on a balance. Oil absorbency (g/g) was calculated by the weight ratio between the absorbed oil and the original dried materials. The same procedure of clean-up of oil spillage using different materials (wool, leaf of Conocarpus plant, the bark of the plant, PVC, and HDPE (ASTM-1141, 2003: ASTM-D95, 1999; Anvaripour *et al.*, 2013).

2.3 Oil Sorption Calculation

The general sorption mechanisms include absorption technique. The oil absorption tests were conducted following the standard method [American Society for Testing and Materials (ASTM) [F726-06] by using crude oil (Yuan *et al.*, 2012). The oil uptake (g) and the oil sorption capacities Q for sorbent materials are obtained from

$$Oil\ uptake\ = m_0 - m_s \quad (1),$$

$$Q\ = \frac{m_0 - m_s}{m_s} \quad (2),$$

where m_o is the total mass of wet sorbent after the oil drained for 10 s, and m_s is the mass of wet sorbent before sorption. The wet sorbent was sorbent taken out using a nipper and then weighted. Each sample with the same sorption time was independently measured three times, and the average values were calculated. All of the oil sorption measurements were conducted at 25°C (Rotar et al., 2014).

The amount of total net of sorption is the change between the weights of the drained sorbent and the initial sorbent. The usage sorption of oil was established by withdrawing the content of water from the amount of total net of sorption.

The efficiency of oil recovery (R) is considered as a measurement of the sorbents' oleophilic and hydrophobicity,

$$R = \frac{M_0}{M_t} \times 100 \quad (3),$$

where M_0 is the sorption of net oil, and M_t is a quantity of sorption for the total net (Ahmad et al., 2005).

3 Result and Discussion

The sorbent of oil plays a significant role in several areas, for example, environmental remediation, separation of oil/water, cleanup of oil spills. It is significant to shed light on choosing the oil sorbent that should depend on the little water pickup, perfect reusability, and capacity of oil sorption.

Three kinds of material sorbents are synthetic inorganic, synthetic inorganic, and natural organic. The aim of using sorbents is significant due to their effects to remove the oil spillage by changing the liquid (oil spillage) to the phase of semi-solid. Nowadays, commercially using absorbent of hydrophobic such as silica aerogels in the cleaning process. In the present study, the modified waste wool, leaf of Conocarpus plant, the bark of the plant, sawdust, PVC, and HDPE are utilized as the materials of hydrophobic absorbent floats on the surface of contaminated water with oil spillage.

The process of cleaning oil spillage is known as an evolving and complex technology. Therefore, there is no recommendation for all the oil spillage. There are different factors which are oil type, the conditions of soil and subsoil, the conditions of the prevailing weather, and the contaminated surface affect the behavior of oil spillage. Therefore, selecting a suitable cleaning technique must pay attention to these parameters. Three or more techniques are used together in order to obtain an influence cleaning methods (Mitul, 2004: Chatterjee et al., 2002).

3.1 Effect of the Weight of Sorbent Materials on Spill Uptake

The effect of increasing weight is studied by using a different weight of sorbent materials (0.25, 0.50, 0.75, and 1.00 g) for two hours at 25°C for wool, the leaf of Conocarpus plant, the bark of the plant, sawdust, PVC, and HDPE. This study is conducted at the same procedure as shown in Figure 1.

It displays that the sawdust takes the capacity of maximum sorption which is approximately 4.98 g oil/g Sawdust. Then, PVC, and HDPE take a medium average capacity of sorption 3.936-3.66 g oil/g PVC, HDPE correspondingly. Afterward, caprice and bark take the capacity of sorption 3.12-2.89 g oil/g caprice and bark correspondingly. The minimum capacity of oil sorption goes to the wool approximately 2.24 g oil/ g bark. A higher capacity of oil as competed to the other sorbents because of its lower density and higher porosity. Also, it reveals that the greatest amount of oil is adsorbed on the initial stage which is in a few minutes of the process. Then, a little amount of oil is adsorbed [10]. Sawdust is designated as the key sorbent because of its higher capacity for oil sorption. Also, the influences of the size of the particle on the capacity of sorbent absorption were calculated in this study (Figure 1).

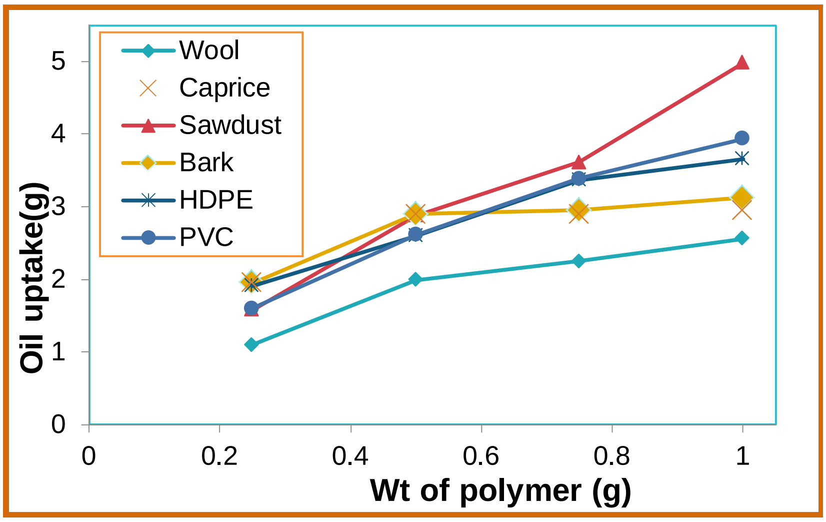

Figure 1: The effect of increasing the weight of sorbent materials on spill 2hr uptake at 25°C.

3.2 Effect of the Weight of Sorbent Materials on Oil Uptake Value

The oil uptake value (Q) is calculated by using Equation (2). The Q values of sorbent materials decrease with an increase in the weight of sorbent materials as shown in Figure 2. When reaching optimum Q values as shown in Table 2, the Q values have a linear relation with the increase in the weight of sorbent material.

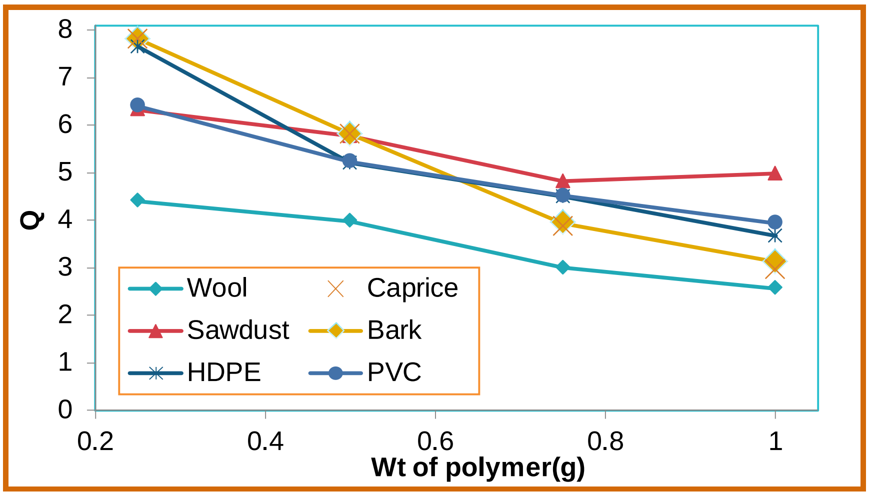

Figure 2: The effect of increasing the weight of sorbent materials on Q at constant time 25°C

Many Investigators have studied the consequence of altered characteristics of oil and also altered the kind of sorbents influencing the capacity of sorption. These studies established that altered the ratio of weight to the oil of materials plays a significant part in establishing the sorption of oil. Mainly, the important parameters in the sorption of oil are the materials' surface area and the particles' pore size. The oil flow rate is increased into the capillary network in case of high pore size. (Yuan and Chung, 2012).

Generally, oil that has the highest viscosity can easily be absorbed by the polymer's particle at a higher frequency or on the surface because of its greater initial ratio. Oil can feed via the network of the capillary to the inferior of the particles of materials when it has a high viscosity, specific gravity, and molecular weight (Yuan and Chung, 2012).

The capillary diffusion of oil inside the tiny pores of particles is highly influenced by the oil viscosity and this fact is confirmed by Darcy's law. The capacity of sorption reduces due to obstructing the pores layer when the viscosity of the oil is high. Many studies are conducted to show the influence of altered materials and the microstructure of them on the sorption of oil and Researchers analyzed the effect of different materials and their microstructure on oil sorption and the properties of retention.

Yoneda (2015) is stated that materials display great oleophilic and hydrophobicity. Conversely, since the materials of oil eliminating are simply contaminated or fouled by adhesion of high oil because they have the characteristic of oleophilic nature, the reusing of such materials is restricted via the capacity of absorption or degraded separation (Yoneda, 2015).

3.3 Effect of temperature of sorbent materials on the spill uptake

The effect of increasing weight is investigated using different weights of sorbent materials (0.25, 0.50, 0.75, and 1 g) at two hours and different temperatures (25, 35, 45, and 55°C). The oil uptake values of sorbent materials decrease with increasing temperature as shown in Figure 3-8.

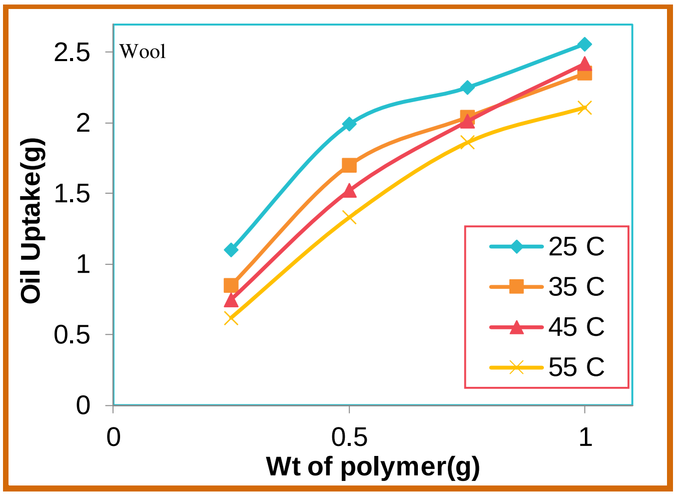

Figure 3: The effect of temperature on the oil uptake of the sorption wool.

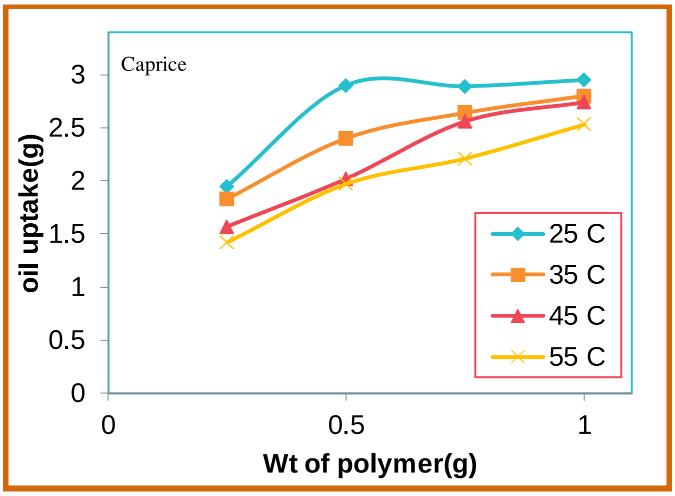

Figure 4: The effect of temperature on the oil uptake of the sorption caprice.

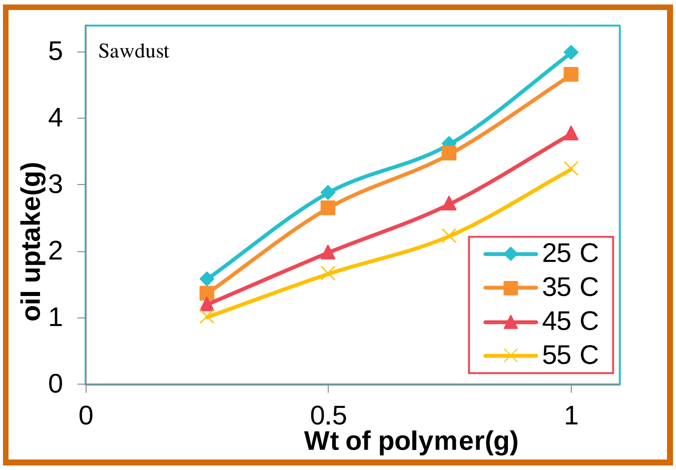

Figure 5: The effect of temperature on the oil uptake of the sorption Sawdust.

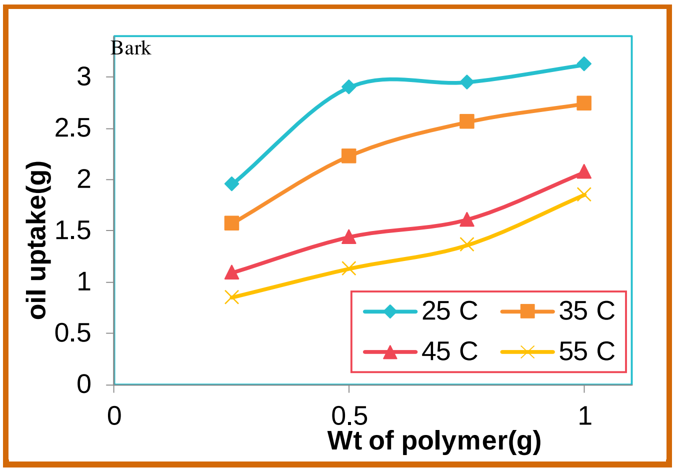

Figure 6: The effect of temperature on the oil uptake of the sorption Bark.

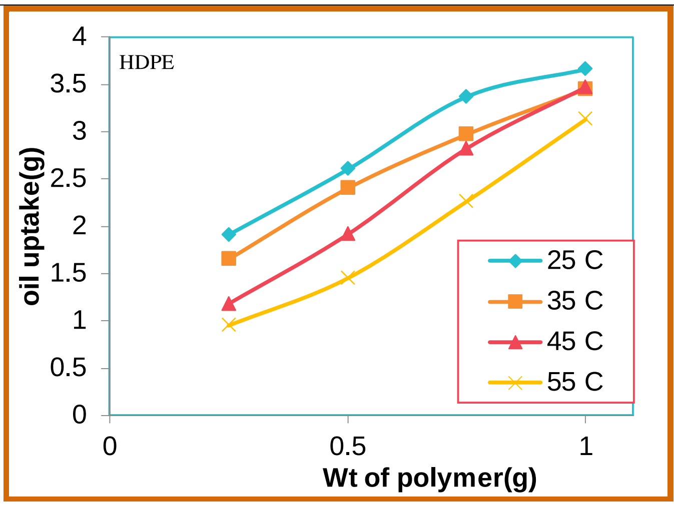

Figure 7: The effect of temperature on the oil uptake of the sorption HDPE

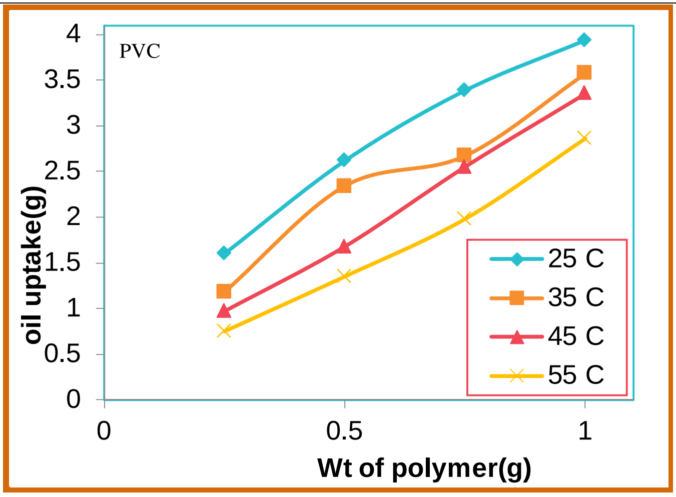

Figure 8: The effect of temperature on the oil uptake of the sorption PVC.

3.4 Effect of Temperature on the Sorbent Materials, Particularly on Q

The Q values of sorbent materials decrease with the increases of the temperature as shown in Figures 9-14. When reaching optimum Q values as shown in Table 1, the Q values have a linear relationship with an increase in the weight of sorbent material.

It is significant to mention the influence of temperature on the efficiency of dispersants. It is stated that enhancing the dispersant viscosity and oil viscosity due to enhancing the temperature of lower water. When the viscosity of oil becomes high because of the weather or the temperature of lower water, the required energy in order to mix the oil and dispersant enhance (Clayton et al. 1993). Usually, enhancing the temperature of higher water leads to enhance the dispersants' solubility in water. Indeed, the temperature of higher water will influence the temperature of oil spillage. Therefore, according to the aforementioned information, enhancing the temperature will lead to reducing the viscosity of oil and as a result the dispersion.

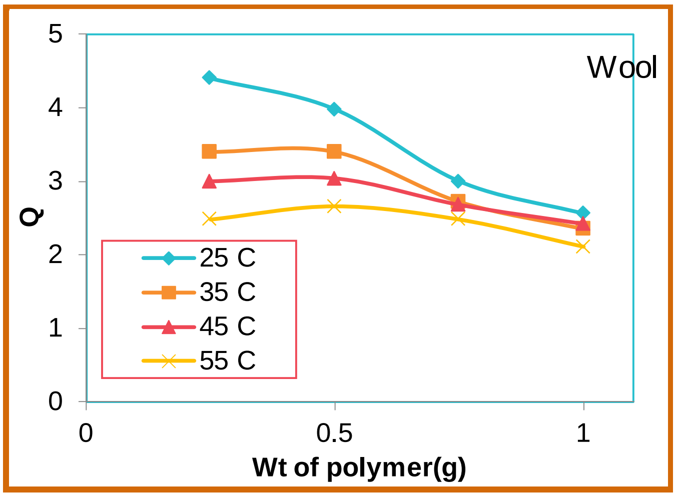

Figure 9: The effect of temperature on the Q of sorption Wool.

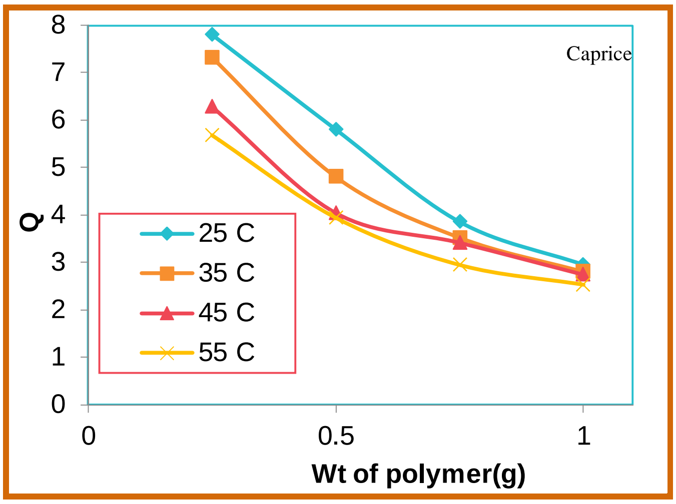

Figure 10: The effect of temperature on the Q of sorption Caprice.

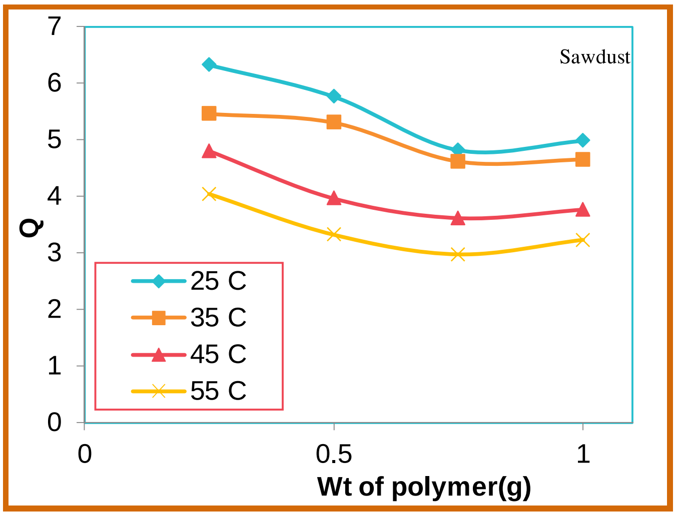

Figure 11: The effect of temperature on the Q of sorption Sawdust.

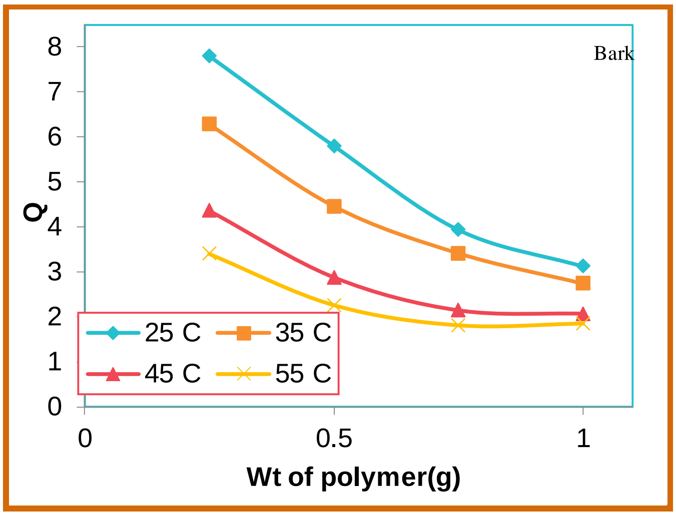

Figure 12: The effect of temperature on the Q of sorption Bark.

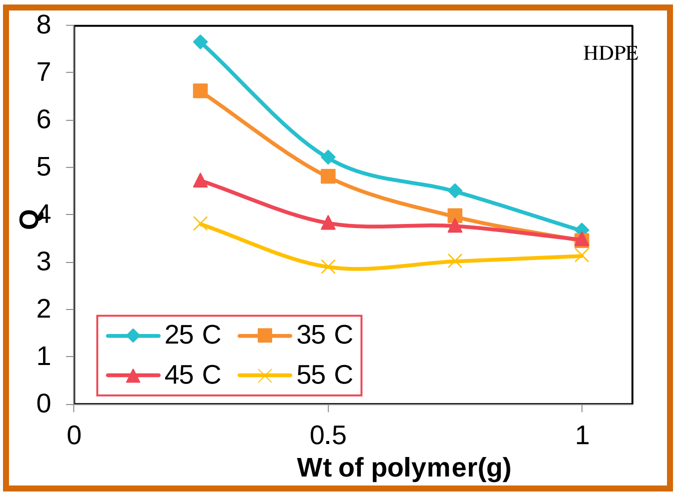

Figure 13: The effect of temperature on the Q of sorption HDPE.

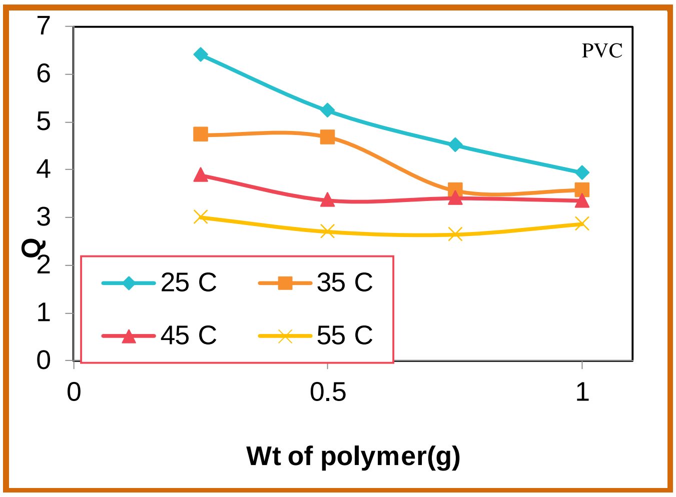

Figure 14: The effect of temperature on the Q of sorption PVC.

3.5 Oil Recovery Efficiency

The efficiency of oil recovery (R) is considered as a measurement of the sorbents' oleophilic and hydrophobicity (Table 1).

Table 1: Efficiency of Oil Recovery for Wool, Caprice, Sawdust. Bark, PVC, and HDPE.

Temp.	Wt. of polymer(g)	The efficiency of Oil Recovery (R)					
		Wool	Caprice	Sawdust	Bark	HDPE	PVC
25 °C	0.25	81.48	88.64	86.34	88.64	88.43	86.49
	0.5	79.92	85.29	85.21	85.29	88.43	83.95
	0.75	75.00	79.40	82.80	79.73	88.43	81.86
	1.00	71.91	74.68	83.28	75.73	88.43	79.74
35 °C	0.25	77.27	87.98	84.51	86.26	86.84	82.53
	0.5	77.27	82.76	84.13	81.68	82.76	82.39
	0.75	73.12	75.81	82.19	77.34	79.84	78.07
	1	70.15	69.23	82.30	73.26	77.53	78.12
45 °C	0.25	75.00	86.26	82.76	81.34	88.43	79.51
	0.5	75.25	80.16	79.84	74.23	88.43	77.04
	0.75	72.83	77.34	78.32	68.22	88.43	77.27
	1	70.76	73.26	79.01	67.45	88.43	77.01
55 °C	0.25	71.26	85.03	80.16	77.27	88.43	75.00
	0.5	72.68	79.76	76.85	69.34	74.36	72.97
	0.75	71.26	72.22	74.83	64.45	75.10	72.53
	1	67.85	71.67	76.36	64.95	75.79	74.09

4 Conclusion

In this study, it is found the relationship between temperature and the amount of oil absorbed and the relationship between the weight and the quantity of oil absorbed is related in which we observe that the higher the weight the greater the amount of absorption.

This research compared the capacity of oil absorption, that Sawdust can absorb oil higher than PVC, HDPE, bark, caprice, and wool in the dry system. Afterward, sawdust was utilized to eliminate a layer of crude oil spread over synthetic water. For the dry system, it is concluded that the maximum capacity of adsorption of Sawdust was about 4.98-gram crude oil/gram sorbent. Sawdust can be effectively applied to eliminate crude oil in the pollution of a layer of crude oil from the environmental marine.

5 Availability of Data and Material

Data can be made available by contacting the corresponding authors.

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