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ORIGINAL ARTICLE

Palm fibers and modified palm fibers adsorbents for different oils

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Abstract The cleanup of oil spill using natural adsorbents is considered as an eco-friendly and cost-effective way, emphasizing the importance of such natural and effective promising technique. Palm fibers, PFs, were used as natural sorbent material for oil spill removal. The present study examines the sorption efficiency and capacity of raw and modified fibers for three types of oil: diesel oil, crude oil and vegetable oil. The results revealed that the efficiency of fibers to remove different types of oil from artificial saline water was related to sorption time and the system conditions such as oil film thickness, particle size, sorbent dosage and temperature. The results showed high sorption efficiency and capacity of palm fibers for different kinds of oil. PFs were very proved to be promising fibers because of all advantages of agricultural wastes plus the high resistance of that fibers which appeared obviously in the present study.

1. Introduction

The hazards of oil spills to marine and freshwater environments have increased by the increase in production and transportation of crude oil all over the world. Oil spills have a worldwide concern due to its influence environmentally and economically [1,2]. Hazardous chemicals are released from oil spills such as polycyclic aromatic hydrocarbons which have harmful effect to aquatic and human lives and may require too much time for heeling [1,3].

The main oil spill response techniques include burning, skimming, use of dispersants and sorbent materials [4,5]. Among these techniques, adsorption is considered as a simple, applicable and low cost technique for oil spill treatment in comparison with other used techniques. The ideal sorbent material used for oil spill treatment should has the following characteristics: oleophilicity, enduring, reusable, biodegradable, has high uptake capacity and high selectivity of oil.

Natural sorbents, if used effectively, can be more efficient than synthetic products. In particular they are low cost and biodegradable materials so the use of them in oil spill treatment should be paid more attention [6]. Among the natural sorbents, straws and cotton were tested and proved to have high oil sorption capacity as well as their availability in nature. On the other hand, attention should be paid to other natural sorbents which may have the same efficiency as straw and cotton or may be more. Accordingly, it is important to study the applicability of using waste products available in abundant as natural sorbent for oil spill treatment. Instead of disposing

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them, they can be comparable with other methods in oil spill cleanup from different water surfaces [7].

Palm fibers (Phoenix dactylifera or date palm) is a flowering plant species in the palm family Arecaceae, cultivated for its edible sweet fruit [8]. The present study examined the efficiency and capacity of palm fibers for the removal of various oils from water. Three types of oil were used: Crude oil, diesel oil and Vegetable oil. To evaluate the potential use of Palm fibers, effect of sorption time, oil concentration, particle size, adsorbent dosage as well as the temperature of the crude oil were examined. To assess a possible mechanism of oil sorption on palm fibers, scanning electron microscopy (SEM) analysis and FTIR analysis were carried out on raw and modified palm fibers.

2. Materials and methods

2.1. Materials

The Palm Fibers, PFs, (Phoenix Dactylifera) were collected from date farms (local trees, Rashid farms, Egypt). Three types of oil were used: crude oil from petroleum plant station (Enppi Company, Enppi – Engineering for the petroleum and process industries), diesel oil collected from market (Misr super diesel) and vegetable oil collected from local market. An artificial saline water was used in the study.

2.2. Preparation of adsorbent

The palm red fibers were cut into small pieces to obtain suitably sized adsorbent for blending. The pieces were washed with water to remove any adhering substances and were oven-dried to a constant weight. Then, the pieces were ground and sieved in a standard set of sieves 2, 1.25, 1, 0.8 and 0. 5 mm, with the aid of Mechanical sieve-shaking device. PFs were divided into 2 portions; the first part was stored in a plastic bottle before using [1]. The second part was chemically treated by acid and alkali separately as follows: The PFs were soaked in NaOH (2% w/v) and H_2SO_4 (2% v/v) separately overnight in room temperature, then removed and oven-dried at 80 °C. Then it was stored in a dry place until its usage. Diesel oil was used for measuring adsorption capacity, efficiency and water uptake before and after acid and alkali treatment at adsorption time 60 min, using particle size of 2 mm.

2.3. Adsorption experiments

Certain amount of oil was poured into a 250-ml beaker containing 100 ml of artificial sea water at different oil film thicknesses (1.1, 2.3, 3.4 and 4.5 mm). 0.2 g of the fibrous material was gently and evenly placed onto a stainless steel net at oil/water interface for a certain period of time [0, 1, 5, 10, 15, 30, 60, 90, and 120 min]. The fibers (adsorbent) were moved upright by hanging the net over the cell and they were left to drain. The sample weight was determined and recorded. All tests were carried out at room temperature and all weighing used an analytical balance with accuracy (0.001 g) [1].

Sorption efficiency and capacity were calculated from the following relations:

$$\text{Sorption efficiency } (\%) = \frac{\text{mass of oil removed}}{\text{initial mass of oil}} \times 100 \quad (1)$$

$$\text{Sorption capacity } (\text{g/g}) = \frac{\text{mass of oil removed}}{\text{mass of adsorbent}} \quad (2)$$

3. Results and discussion

3.1. Properties of used oils

Different kinds of oils were tested in the application of sorbents, crude oil, diesel oil and vegetable oil which have significant effects on the efficiency of oil removal onto the used adsorbents. The physical properties of oils are presented in Table 1.

3.2. Adsorption experiments

Oil adsorption capacity, efficiency and hydrophobic–oleophilic characteristics of the agricultural product of Palm fibers, PFs, were thoroughly examined. Several factors have been varied to study their effect on oil adsorption for the three different oils using raw PFs and modified PFs. Effectiveness of removal depends on a variety of factors including the type of oil spilled, contact time, the thickness of the oil film, mass and particle size of palm fibers and temperature.

3.2.1. Effect of contact time

Fig. 1 shows the effect of adsorption times (1–120 min) on oil removal capacity for diesel, crude and vegetable oils using film thickness of 1.1 mm onto PFs. It was shown that the adsorption capacity was increased with increasing adsorption time until it reached a maximum of 24 g oil/g adsorbent for diesel oil, 22 g/g for crude oil and 16 g/g for vegetable oil. It can also be seen from figure that the rate of oil removal was very high in the beginning; then, it was gradually reduced and became steady. These results are in agreement with the previous studies, as they discussed effect of contact time on oil adsorption using activated recycled rubber, date palm powder, low grade raw cotton fibers, coconut, raw bagasse and barely straw, respectively [9–14].

3.2.2. Effect of oil film thickness

Fig. 2 shows the adsorption capacity of PFs as a function of film thickness (1.1–4.5 mm thickness) using 0.2 g of adsorbent at a constant time (60 min) for different types of oil, diesel, crude and vegetable oils. The figure indicates that the sorption capacity of PFs was enhanced by increasing the oil film thickness. These results are compatible with Hussein et al., as they have studied the effect of thickness on carbonized pith bagasse [15], where they discussed different factors affecting the adsorption of oil including oil film thickness, onto law grade raw cotton Fibers [16].

Table 1 Physical properties of different types of oils.

Parameters	Crude oil	Diesel oil	Vegetable oil
Viscosity (cp)	62	604	56
Density (g/cm^3)	85	93	83