Petroleum Hydrocarbons Adsorption from Aqueous Solution by Raw Sugarcane Bagasse

R. Behnood, B. Anvaripour, N. Jaafarzade Haghighi Fard, M. Farasati

Abstract- One of the major sources of water pollution is oil spills or oily waste waters and removing this pollution is a global concern. Oil spills may be due to the release of crude oil or its products from pipes, tankers, ships, offshore platforms. In general wherever oil is produced, transported, stored and used there will be the risk of a spillage. Nowadays natural sorbents are applied as single solution for oil spills since this technique is effective, rapid and cost saving for cleaning these pollutions and reduce environmental effects. In this paper, raw sugarcane bagasse in different particle sizes was used for the sorption of layer of crude oil from surface of sea water. FTIR analysis of raw bagasse was performed. Effect of time and particle size for dry system and crude oil layer system was evaluated. The results showed that maximum adsorption capacity of raw sugarcane bagasse for dry system and crude oil layer system was about 8 g and 6.6 g crude oil per g sorbent, respectively.
Keywords—Oil spills, natural sorbents, sugarcane bagasse, adsorption

I. INTRODUCTION

Water is the main living part of all creatures and has covered 70% of the earth and is being polluted with many activities of human including urban, agricultural and industrial. Water protection must be one of the major topics in our life because we depend on water.

Considering water pollution, shocking statistical data should not be neglected. According to declaration of World Health Organization, about one billion people in the world do not have access to clean drinking water. Every year, about 800 million people are suffering from many kinds of diseases resulting from drinking polluted water [1].

Therefore, water pollution problem is very important and appropriate planning and necessary activities should be prepared to avoid and reduce this pollution. One of the main sources of water contamination is oil spills or oily waste waters. Oils and petroleum products polluted all sources of water such as seas, oceans, rivers or underground waters. Currently oil spills are a chief problem in the oceans and seas as a result of their environmental and economical influence [2].

Oil spills may be due to discharge of crude oil or its derived products such as gasoline, diesel or machine oil from tankers, ships, offshore platforms, or heavier fuels used by large ships, or accidents in pipe lines or production process, as well as spills of other oily waste waters such as produced water, and ballast water.

In recent years, a number of natural biodegradable sorbents have been found as one of the most cost-effective and capable means for the oil spill cleanup and a number of works have been studied for utilizing these materials in the removal of oil spill, e.g., barley straw [3], rice husk ash [4], peat-based sorbents [5], fatty acid grafted sawdust [6], carbonized bagasse [7] and acetylated bagasse [8] which can be excellent sorbents [9], [10].

In this study the raw sugarcane bagasse was selected as a natural organic sorbent. This sorbent was used in different particle sizes and the effect of contact time and existence of water was studied.

Oil sorption properties of raw bagasse for different oil products in literature are summarized in table 1.

Table 1. Oil sorption properties of raw bagasse

Sorbent	Type of pollution	Q_{max} (g/g_s)	Particles size (mm)
Raw sugarcane bagasse	Gas oil [10]	10	0.8-1
	7-day weathered oil [10]	12	0.8-1
	Gasoline [11]	12	<0.297
	N-heptane [11]	3	<0.297
	Motor oil [12]	6.5	

II. EXPERIMENTAL PROCEDURE

A. Sorbent and oil properties

Crude oil had a specific gravity of 0.86 at 15°C was obtained from Abadan's oil refinery, Iran. Raw sugarcane bagasse was obtained from Karoun Agro-Industry factory, Shooshtar, Iran. The prepared bagasse after being transferred to the laboratory was washed for several times with tap water and then dried in open air under sunshine. This bagasse was crushed with a vegetable crusher to smaller sizes.

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R. Behnood, Safety and Protection Engineering Department, Petroleum University of Technology, Abadan, Iran
B. Anvaripour, Safety and Protection Engineering Department, Petroleum University of Technology, Abadan, Iran
N. Jaafarzade Haghighi Fard, Health Department, Jondishapour University of Medical Sciences, Ahvaz, iran, and Nano Technology research center, Jondishapour University of Medical Sciences, Ahvaz, Iran
M. Farasati, Water Engineering Department, Razi University, Kermanshah, Iran

Then the crushed bagasse was sieved with different mesh sizes: 8, 18, 20, 30, 60, 100, and 200.

These sieved sorbents was washed again with distillate water and was dried in oven at 60°C for 10 hours, then used as sorbent for crude oil layer. Table 2 shows test methods for sorbents properties.

Table2. Test methods for sorbent properties

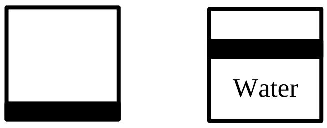
Properties	Value	Test method
Sorbents water Soluble	4.93%	ASTM D5029-98
Sorbents moisture	6.91%	ASTM D2867-99
Particle density	Data in Table 3	ASTM D854-02
Bulk density	Data in Table 3	ASTM D2854-96

B. Adsorption experiments

The tests used in this study to determine the sorption capacity were done in a batch system, according to:

1. ASTM F726-99 for sorption experiments
2. ASTM D1141-98 to produce saline water

Sorption experiments were done for dry system (figure 1.A) and oil layer system (figure 1.B).



A) Only crude oil B) Crude oil layer

Figure 1. Sorption experiments

For dry system 50 ml of crude oil was first put in 250 ml beaker and then 1 g of sorbent was added to crude oil. These tests were performed in static system, without stirring.

For crude oil layer sorption, 100 ml of artificial sea water was put in 250 ml beaker. Crude oil was added to form an oil layer with a specified thickness. Then, sorbent was spread over the surface.

After certain sorption time, sorbent was removed with a net that was hanged over the beaker for 5 min to provide the falling down of crude oil that was not adsorbed.

The remaining oil was separated from the water and its weight was recorded. Each experiment was performed twice and the sorption capacity was calculated using "(1)":

$$\text{Oil sorption capacity} = \frac{\text{weight of adsorbed oil}}{\text{weight of sorbent}} \quad (1)$$

III. RESULTS AND DISCUSSION

Figure 2 shows particles which pass through sieves with different mesh sizes.

Figure 2. Raw bagasse with different particles size

Table 3 gives the result of bulk density and true density for different sorbents.

Table 3. Sorbents density

Sorbent name Raw bagsse	Bulk density (g/cm^3)	Particle density (g/cm^3)
Mesh number 10	0.174	0.65
Mesh number 18	0.141	0.68
Mesh number 20	0.108	0.68
Mesh number 30	0.101	0.71
Mesh number 60	0.093	1.06
Mesh number 100 Microsize	0.083	1.18

Identification of the important bands exhibited in FTIR diagram is according to previous studies of banana trunk fibers [13] and sugarcane bagasse [11].

In figure 3 the strong signal at about 3412 cm^{-1} is due to the stretching vibrations of hydroxyl groups present in cellulose, hemicellulose, and lignin of sugarcane bagasse. The medium signal, between 1500 cm^{-1} and 1750 cm^{-1}, is due to carboxylic groups, present in lignin and hemi-cellulose. The bands at 2920.26 cm^{-1} and 2850 cm^{-1} corresponds to asymmetric C–H and symmetric C–H stretching of CH_2-groups respectively. The band at 1248.38 cm^{-1} corresponds to C–O stretching in hemicellulose.

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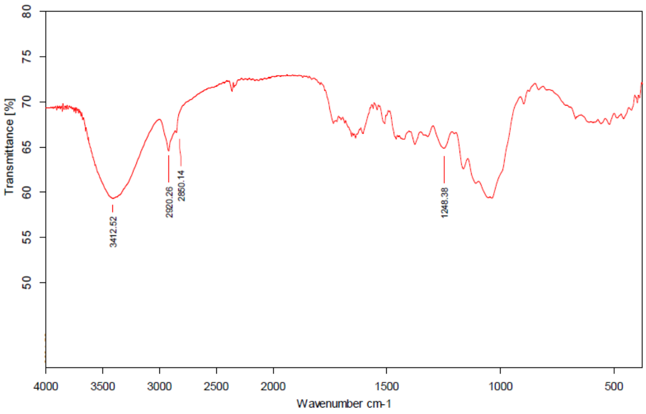

Figure 3. Raw sugarcane bagasse FTIR

Figure 4 shows the results of sorption times 2-30 min on crude oil sorption in dry system for sorbents with different particle size.

It is obvious from figure 4 that sorption capacity of bagasse with different particle size has increased with time. The maximum sorption capacity has reached after about 5 minutes, which shows that oil gets is being trapped very fast.

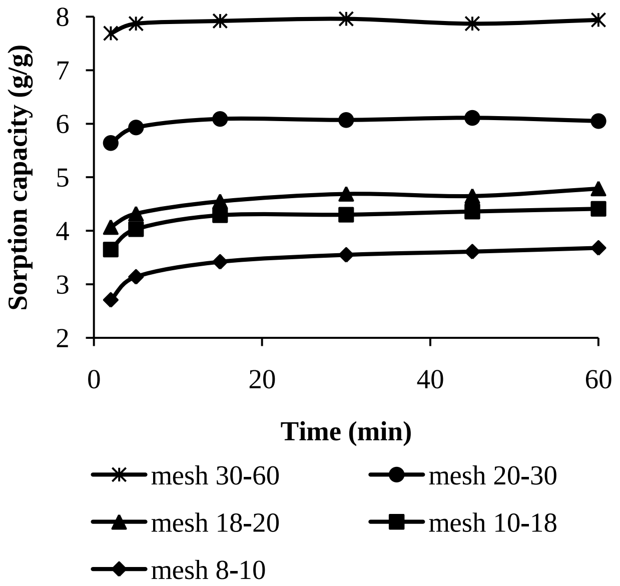

Figure 4. Time effect for dry system

Figure 5 illustrates the effect of bagasse particles size on oil sorption capacity. It shows that decreasing the average particle size increases its oil sorption capacity, where an optimum is obtained at an average particle size of 0.2 mm. However, decreasing further the average particle size decreases the oil sorption capacity.

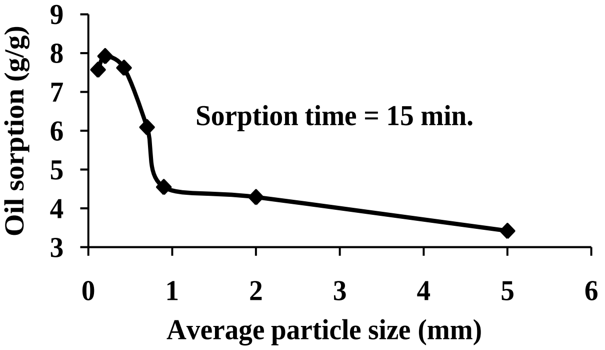

Figure 5. Effect of particles size

Decrease in bagasse particle size in the range of smaller sizes will have higher effect. This can be due to fibrous form of the sorbent that causes the particles with different fiber lengths and equal diameter pass through the sieve. This causes formation of heterogeneous and non-uniform particles in large sieves and the number of larger particle size in unit of mass is low due to higher bulk density. So that sorption amount of crude oil in bagasse pile is lower. For particles of smaller than 1 mm, the effect of decreasing size is higher because particles are more homogenous in these sizes and the number of particles increases more considerably.

Figure 6 shows the effect of particles size and sorption time for a crude oil layer at the surface of artificial sea water. Seven grams of crude oil was added to 150 ml water that formed a layer about 2.4 mm thickness and then 1 g sorbent was spread over the surface. The efficiency of crude oil removal is shown in figure 7.

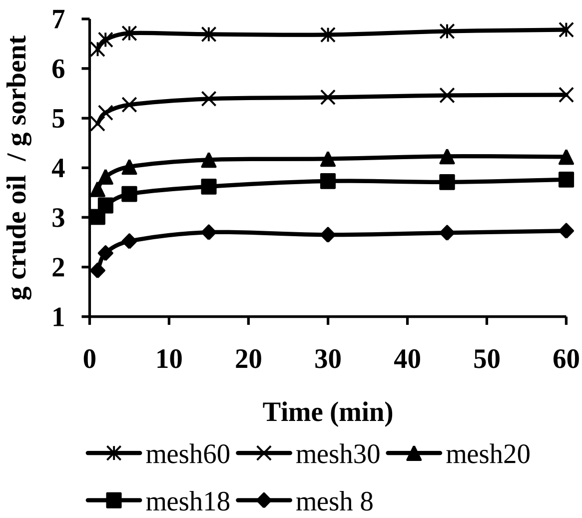

Figure 6. Effect of sorption time

Considering figure 6, the maximum sorption capacity has reached after about 5 min.

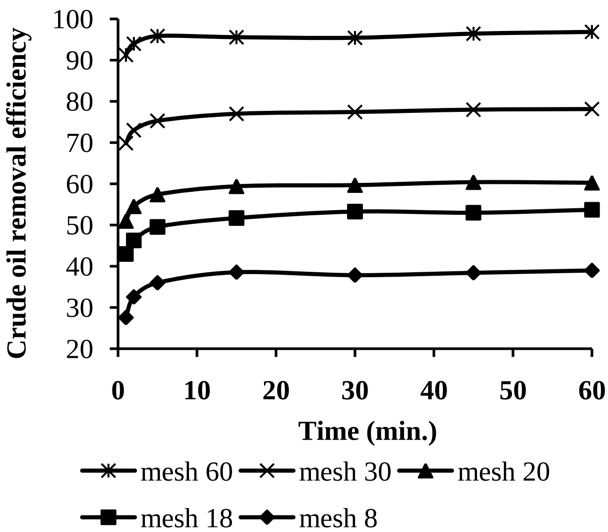

Figure 6. Crude oil removal efficiency

As seen from the above figure, the raw bagasse mesh size 60 has the sorption ability of 96% for the crude oil layer at the saline water surface.

IV. CONCLUSIONS

This research examined the efficiency of using raw sugarcane bagasse of different particle sizes to remove crude oil by measuring its adsorption capacity in dry system and crude oil layer system. The sorbent showed a rapid oil sorption and a good sorption capacity of approximately 7 g oil/g sorbent. The following conclusions were found from this work:

1. The bagasse can be applied to effectively remove crude oil in crude oil layer pollution from marine environments.
2. Maximum adsorption capacity of raw bagasse for dry system was obtained about 8 g for raw bagasse mesh number 60.
3. Particle size effect was evaluated and it was shown that the sorption capacity improved with decreasing particle size, due to increasing surface area.
4. Maximum adsorption capacity of raw bagasse for crude oil layer was about 6.6 g crude oil per g sorbent. Optimal sorption time was observed at about 5 minutes.

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AUTHORS PROFILE

Reza Behnood
Educations: Amirkabir University of Technology, Iran, BSc in Chemical Engineering 2011.Petroleum University of Technology, Abadan, Iran, MSc in Chemical Engineering (HSE) 2013.
Acce ant removal from water and modification of sorbents, 6th national conference pted conference papers:
1. Comparative study for Methyl Tert - Butyl Ether (MTBE) removal from water, ICWEE 2011.
2. Natural sorbents for oily pollut on world environmental day, Tehran University, Iran, 2012.
3. Experimental investigation of some natural plants as oil spill sorbents. The first international conference of oil, gas, petrochemical and power plant, Tehran, Iran, 2012.

Bagher Anvaripour
He received his PhD in Chemical Engineering from Birmingham (UK), MSc in Hydrocarbon Reservoir Engineering from Abadan Institute of Technology (Iran) and BSc in Chemical Engineering from Abadan Institute of Technology (Iran). He is currently associate professor and head of Safety and Inspection Department at Petroleum University of Technology, Abadan, Iran.

Nematollah Jaafarzadeh Haghighi Fard
Educations:
Shaheed Beheshti University, Tehran – Iran, BSc in Chemistry 1979. Tehran University of medical sciences MSPh in environmental health engineering 1991.Tehran university of medical sciences, Tehran – Iran, PhD in environmental health engineering 1999.
Books:
1. Surface water drainage in low-income community (Translated), 1999, Ahvaz Jondishapour medical sciences university, Ahvaz Iran.
2. UASB for wastewater teatment , 2002, Dezab, Ahvaz, Iran .
3. Marine polution (Translated) , 2006 , Khaniran , Tehran , Iran .
4. Waste water engineering solving problems (Translated), 2007, Khaniran, Tehran, Iran .
5. Chemistry for environmental engineers (Translated) 2007, Andishe rafi, Tehran, Iran.
6. Hand book of Environmental engineering calculation, 2vols (Translated) 2007, Andishe rafi, Tehran, Iran.
7. Integrated solid waste management (Translated), 2007, Khaniran, Tehran, Iran.
8. English on Environmental Sciences, 2007, Khaniran, Tehran, Iran.
Work experiences:
*Official expert of chemical industries, ministry of industry, Sari, Iran, 1980 – 1981.
*Official expert of medical drugs, ministry of health and medical education, Iranshahr – Iran, 1981 – 1982.
*Official expert & research coordinator, Fars department of environmental protection, Shiraz – Iran, 1982 –1988.
*Lecturer at faculty of health, Ahvaz Joondishapour medical sciences university, Ahvaz–Iran, 1991 – till now.
*Lecturer at Ahvaz research & advanced educational center, Islamic Azad University, Ahvaz – Iran, 1994 – 1999.
*Scientific advisor at bureau of environmental protection departments of Khoozestan, Fars, Bushehr & Kohkiloyeh proviances, Iran – 1992 - 2004.
*EIA & Water quality supervisor and consultant in Dezab,s and sazab,s consultant engineers . Ahvaz – Iran 1996 – 2003and 1944-2005.
*Scientific consultant at EIA and water quality in KWPA research committee, Ahvaz – Iran, 1999 till now.
*Scientific member in NSIOC research committee, Ahvaz – Iran, 2002 till now.
*And 51 journal papers, 21 scientific presentations, 52 research work, and supervise 31 theses.