# *WATER OIL CONTAMINATION CONTROL USING NEW DEVELOPED ENVIRONMENTALLY FRIENDLY MATERIAL FROM THE SUGARCANE INDUSTRY WASTES*

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## ABSTRACT

As it is known Egypt is one of the countries having oldest sugarcane industry, which goes back to the year 710 AD. Cane plantations are the main agricultural product in five governorates in Upper Egypt (El-Menia, Sohag, Qena, Luxor, and Aswan), producing not less than 16 million tons a year. Eight factories (Abou-Korkas, Gena, Nagaa-Hamadi, Deshna, Kous, Armant, Edfuo, and Komombo), located in such upper Egypt governorates generate huge amount of wastes during the manufacturing stage, the so-called Bagasse which is the fibrous, and cellulosic materials remaining after the era of the sugarcane and the juice extraction, presents about 30% of such wastes. The amount of bagasse generated yearly through the manufacturing stage of the above-mentioned eight factories is approximately about 2.8 million tons, getting-rid safely of such huge amount presents a serious environmental problem. Storage of that material openly in the so hot climate in Upper Egypt may cause self-ignition under air temperature reaches 50 degrees centigrade in summer, due to the remained residual content of sugar. At the same time, preparing places for safe storage for such amount is very expensive with respect to the valueless of it. So the best way for getting rid of bagasse is converting it into an added value environmentally friendly material, especially till now the utilization of it is so limited. Since oil pollution became a serious concern, the issue of environmental cleaning arises. With the structure of sugarcane bagasse, which contains fiber and high content of carbon, it can be an adsorbent to adsorb the oil contamination from the water. The present study is a trial to introduce a new material for the purification of water systems to score two goals at once, the first one is getting rid of that harmful waste safely, the second goal is converting it to a commercially valuable material for cleaning, and purifying water from oil spills, and petroleum pollution. Introduced the new material proved very good performance, and higher efficiency than other similar materials available in the local market, in both closed and open systems. The introduced modified material can absorb 10 times its weight of oil while doesn't absorb any water.

**Keywords:** Environment, Water resources, Agricultural wastes, Oil pollution control, Sugarcane bagasse

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## 1 INTRODUCTION

Oil pollution, occurs usually in water areas such as sea, rivers, canals, lakes, and other waterways, has become a serious problem in Egypt. (Last August 2015, a serious oil spilled from an electric power plant to the river Nile at Assiut governorate has occurred causing a big environmental problem). The problem of removing traces of oil from water, such as that in ship ballast tanks and irrigation and drainage canals, possesses technical and economic challenges (Global ballast water management program, 2002). At the same time, owing to the intensive petroleum activities in the Middle East, and Arab region and gulf, oil pollution in the sea is continuously increasing and also crude petroleum oil becoming the prime factor of oil spilling, Fig.1 (HARC, 2014). So it became essential to produce some cheep and effective materials for protecting the intakes of water treatment plants, lakes, tourist resorts, and beaches. Because of the high expensive cost of using the commercial materials available in the local market, thinking of producing a new friendly, environmentally material from some local agricultural wastes hoping to score two goals at the same time, getting-rid safely of such harmful wastes, and converting it into an added valuable material, for cleaning and purifying water from oil spills.

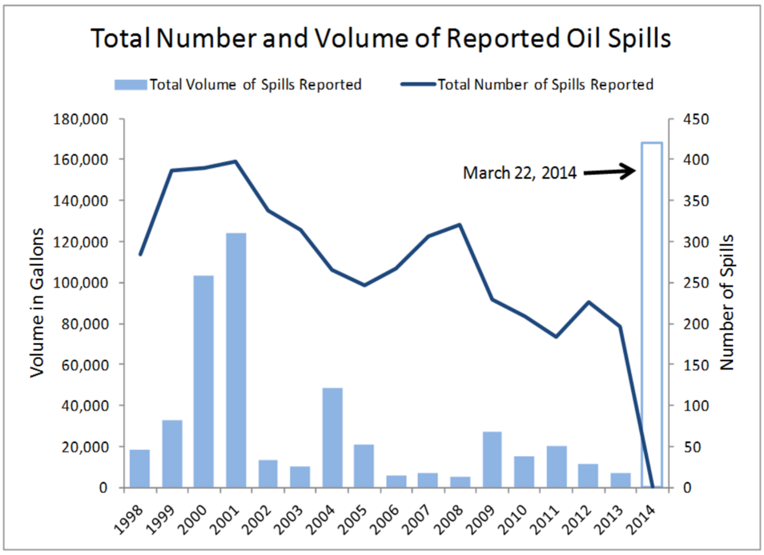


**Figure 1. Total number and volume of reported oil spills (http://maps.harc.edu/oilspill/)**

Since Cane plantations in Egypt are concentrated in Upper Egypt, with a total amount of cane cultivated of about 16 million tons a year, eight big factories in Sugarcane industry were located (in Abou Korkas, Georgia, Nag Hamadi, Deshna, Cows, Armant, Edfu, and Komombo). These factories of sugarcane production generate the huge amount of wastes such as bagasse, the usage of that organic waste has not been widely implemented in Egypt yet. It is known that bagasse is an outstanding fibrous organic material having a good content of carbon, so this work will investigate the possibility of using it as a purification material for getting rid of any oil spills in water which may impose serious damage on the environment. Our article today, reviews the state of the art oil spill control techniques from both chemical and engineering concepts using the available local wastes (bagasse).

Through a collaborative effort between Assiut University in Egypt, and Tuskegee University in the USA, to develop an oil absorbing material from sugarcane waste (bagasse). The main goal was to modify bagasse by chemical and engineering manipulations to produce an economically competitive oil absorbing material.

The chemical manipulations involve grafting fatty acids to bagasse. Spectroscopic, thermal, and elemental analyzes were used to characterize grafted bagasse, including a determination of the nature of the bonding between the fatty acid and cellulose (California association of port authorities' reports, 2002). Surface characterization showed a greater surface area for grafted bagasse in comparison with commercial material.

The engineering manipulations include varying the particle size of the grafted bagasse and studying the effect of particle size on the oil absorbing capability of the" Purification elements" prepared from these materials. Variously designed closed systems and open channels were used for the oil absorption studies. Performance related parameters, such as the purification index, as measured by the turbidity of the oil/water mix, and the pressure drop across the purification elements were studied.

Comparative studies showed that the grafted bagasse compares well to the commercially available purification materials. Preliminary economic analyzes of the developed bagasse reveal its economic advantage over the commercial materials.

## 2 STATE OF THE PROBLEM

In spite of the availability of great amounts of agricultural wastes in Egypt, most of them are environmentally harmful, the utilization of such wastes still under the needed suitable standard. At the same time, many serious environmental problems are existing, and increase without an efficient tool to overcome quickly, and cheaply.

In August 2015, serious oil spilled occurred upstream Assiut potable water treatment plant on the western bank of the river Nile threatening the safety of the drinking water, and the water treatment plant in that Area was closed few days, and the people suffered from bringing water from other sources. In addition to the other harmful impact to the aquaculture and fish, plants, birds as well.

The problem lasted for more than a week. If there was a stack of prepared absorbent material available in the nearby area ready for the use as a floating booms around the intakes of the water treatment plants to absorb, and protect them by preventing the oil contaminations to reach the intakes.

As sugarcane bagasse is one of the wastes has a high content of carbon, and its structure contains a huge amount of fiber, we tried to make use of it as an absorbent to absorb oil contaminations from water environment, after some chemical and engineering treatments.

## 3 OBJECTIVES OF THE WORK

The main objectives of this work is to introduce a new environmentally friendly material, through converting bagasse as a harmful agricultural waste into an effective oil absorbent material. So many goals can be scored at the same time:

- Getting-rid safely of the huge amount of sugarcane manufacturing wastes.
- Introducing an added value new, cheap, and effective material for solving the problem of oil-contaminated water.
- Introducing simple and inexpensive technology as a way for opening many small projects which contribute to decreasing the size of the problem of unemployment youth in Upper Egypt

## 4 EXPERIMENTAL WORK

### 4.1 Bagasse, and Bagasse Preparation

Bagasse which shown in Photo 1, it is one of a big amount of agricultural organic waste has not yet been fully utilized in Egypt. It has high adsorption capacity due to the existence of activated carbon in the composition of the agricultural by-product. In this work, bagasse is used because it is inexpensive raw material. Where one ton of refined sugar generates two tons of bagasse. Bagasse contains about 50% cellulose, about 25% hemicelluloses, and about 25% linen (Global ballast water management program, 2002). Also, bagasse is famous of highly activated carbon content which makes it a good adsorbent. The following photo shows the fresh sugarcane bagasse.

Figure 1. Sugarcane bagasse

Raw bagasse is autoclaved using a two percent aqueous sodium hydroxide solution in order to remove "wax", lignin, and silicates. The resulting material is bleached and then dried to a constant weight.

## 4.2 Grafting Fatty Acids to Bagasse

Prepared bagasse, in excess, is mixed for two hours with stearic acid, basic compounds, and water. The obtained mixture is dried in a vacuum at 60-degree centigrade for 20 hours. This procedure resembles a patented procedure (Cease, 1988).

## 4.3 Grafting Fatty Acids to Cellulose

Two approaches were pressed. Commercial cellulose (Sigma) was treated with stearic acid and zinc oxide under basic aqueous conditions, in an exact manner that the prepared bags were treated.

The first material is called secondary bonding grafted cellulose. The second approach, the cellulose was reacted under nitrogen with acid chlorides using a 1:3 mole ratio of cellulose to acid chloride. The acid chloride (Aldrich) contained 60 percent stearoyl chloride and 40 percent palmitoyl chloride. The product was filtered, washed with ethanol, and then dried at approximately 100 degrees centigrade for 24 hours under vacuum. This second material is called primary bonding grafted cellulose.

## 4.4 Evaluation of grafted bagasse

The evaluation of the grafted bagasse was carried out through two systems:

### 4.1.4 The closed system

Where a pump was used for circulating oily water through a column containing grafted bagasse, grafted waste newspaper prepared exactly as grafted bagasse (just for comparitive purposes), or commercial oil absorbing material available in the local market. This set-up simulates equipment used in removing oil from the ballast tanks, Fig. 2.

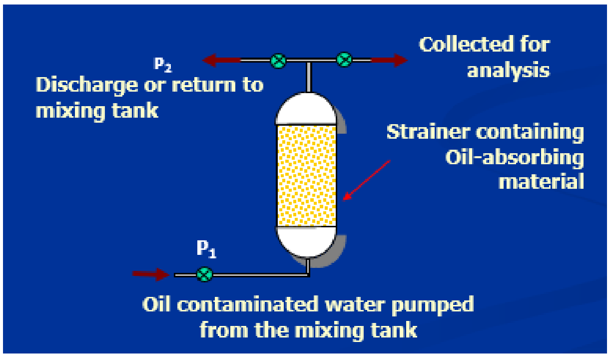


**Figure 2. Closed system purification**

### 4.2.4 The open channel

Where the oil absorbing material was contained in a rectangular bag (purification element); the bag is placed in an open channel with water containing traces of oil and flowing at a controlled rate. This experimental set-up simulates flow in rivers, lakes, and irrigation canals, Fig. 3


**Figure 3. Open system purification**

## 4.5 Oil Absorption Analyses

A turbidity meter was used to compare relative amounts of oil in the water mixtures after they had passed or flowed through an oil absorbing material.

# 5 RESULTS AND DISCUSSION

## 5.1 Characterization of Material

Infrared spectroscopy and thermal analysis were used to compare the materials. Fig. 4 shows the different nature of the bonding in the secondary bonding and primary bonding grafted cellulose. The carbonyl absorption at approximately1550 cm-1 represents that of a carboxylate anion while the carbonyl absorption at 1741 cm-1 is that of an ester. These absorptions occur, respectively, in the secondary and primary cellulose materials. The carbonyl region of the IR spectrum of the grafted bagasse resembles that of the secondary bonding grafted cellulose. Hence, the fatty acid in the grafted bagasse is not directly bonded to the cellulose of bagasse. This would imply that forced conditions of water flow or the pH change could remove the fatty acid from the material.

Thermal analysis of the materials indicates that a new material has been prepared in the case of the secondary or primary cellulose materials. The thermograms of cellulose are clearly different than those of the grafted material. Since the grafted bagasse, thermal analysis is not a useful method for analyzing the product. Both bagasse and grafted bagasse give very similar thermograms.

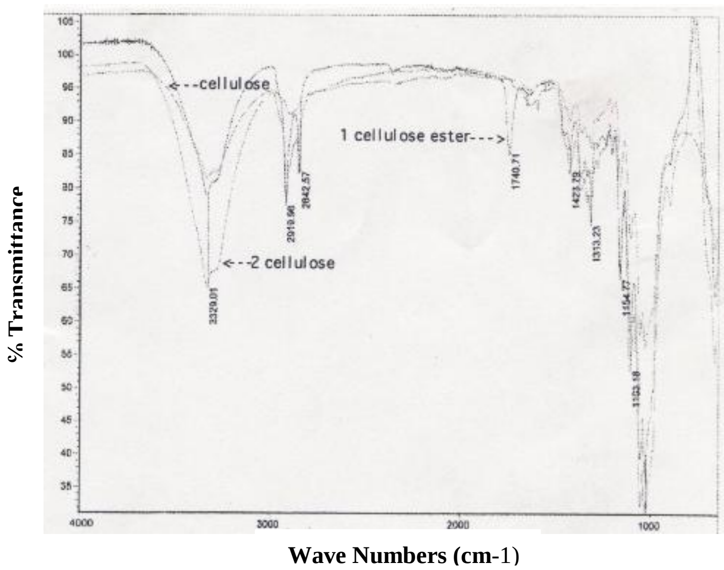


**Figure 4. Infrared spectra of cellulose and cellulose grafts.**

The surface analysis of the grafted bagasse, grafted waste newspaper and commercial material show a significant difference between the bagasse material and the other two materials, Table 1. This difference is probably inherent in the processing of these materials.

The bagasse is not pressed and hence maintains the larger pore volume of the cellulose material.

**Table 1. Surface analysis of secondary bonding grafted materials**

| | Commercial materials | Waste newspaper | Bagasse |
|---|---|---|---|
| **Total pore volume, cc/g** | 0.0017 | 0.0023 | 0.1229 |
| **Avg. pore diameter. Angstroms** | 150 | 56 | 24 |

The elemental analysis confirms the small amount of stearic acid used in the secondary bonding grafted materials. For the primary bonding grafted cellulose, although completion grafting was attempted, the result showed that considerably less grafting had occurred.

Preliminary small-scale study of the oil absorption of cellulose compared to secondary bonding grafted cellulose indicated that the grafted material absorbs both water and oil to a greater extent than cellulose alone.

## 5.2 Closed System Oil Absorption

The oil absorption performance of the grafted bagasse, grafted newspaper and commercial material for a closed system is shown in the following Fig. 5. An oil concentration of 0.2% by weight was used. Turbidity is used as a measure of water purification. Higher turbidity indicated more oil in the water. Fig. 5 shows that the three materials have similar oil absorption capacity, with the grafted Bagasse performing slightly better. It was also found that the grafted bagasse has the lowest pressure drop across the filter. This relates to lower power consumption, and hence lower running costs of the filtration system.

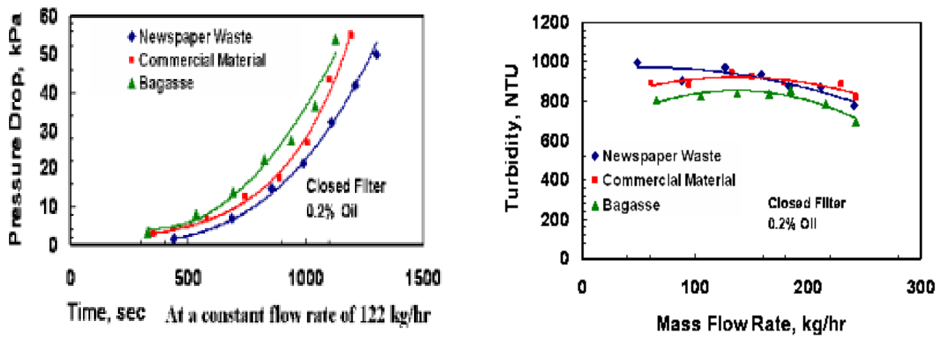


**Figure 5. Turbidity of oil contaminated water vs. the mass flow rate for grafted bagasse, grafted newspaper and commercial materials tested in a closed system**

## 5.3 Open Channel Oil Absorption

The oil absorption performance of the three used materials tested in an open channel is shown in Fig. 5. The same oil concentration, 0.2% by weight, was used in the open channel. Fig. 6 shows clearly that the grafted bagasse has a higher oil absorption capacity. There is a slight increase in turbidity as the mass flow rate increases within the range of mass flow rate tested for the three materials. It was also noticed that the pressure drop across the pure element (mesh container loosely packed with the materials) is the lowest in the case of the grafted bagasse, which is a desirable attribute associated with water flow in canals and pipes.

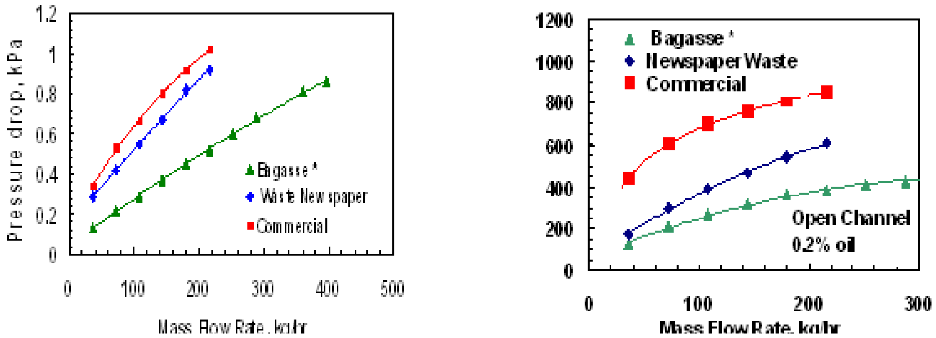


**Figure 6. Turbidity of oil contaminated water vs. the mass flow rate for grafted bagasse, grafted newspaper and commercial materials in open channels, tested under the same conditions, as in a closed system.**

## 6 APPARATUS USED

**Oven**: The oven was used for drying the raw bagasse, and converting it from the wet state to a dry state, Fig. 7.

**Sieve shaker**: Sieve shaker was used for sieving the dry shredded bagasse into different sizes, Fig. 8.

**Analytical electric weight**: An electric weight with high accuracy was used for weighing the samples before and after drying, Fig. 9.

**Figure 7. Oven**

**Figure 8. Sieve shaker**

**Figure 9. Analytical electric weight**

## 7 CONCLUSIONS

From the above-mentioned results the following main conclusions can be drawn :

- Bagasse, which is the main huge amount of waste generated from sugar industry in Upper Egypt, converted successfully into a very active and effective cheap material for the purification of the water from oil pollution.

- The new introduced purification material performed effectively in both closed and open water systems.
- Introduced the newly material can be manufactured in the shape of floating booms for protecting the intakes of water treatment plants from any expected oil pollution, the borders of tourism resorts and beaches, in addition to irrigation canals.
- The simple technical treatment for producing such new material, can provide many job opportunities for the unemployed youth in Upper Egypt
- Based on the procedure described in this work, the economic analysis proved that the cost of grafting Bagasse material from bagasse wastes is competitive.

## ACKNOWLEGEMENT

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