Suitability of Fibre Complexes of Coir and Banana as Eco-Friendly Sorbent Material for Oil spills Removals

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1. Introduction

Oil spill pollution, a severe environmental problem across the world, is growing with increased levels of oil production and transport. Its causes are either accidental or due to operation wherever oil is produced, transported, stored and used on sea or land. Recent research by The US National Science Foundation has found that only 2 percent of hydrocarbon pollution finding its way into the sea each year comes from tanker accidents. Eleven percent comes from natural sources - tar sands and oil seeds, 13 per cent come from the atmosphere, 24 per cent from all forms of transport, and an astounding 50 per cent comes down drains and rivers to the sea from cities and industries.

Cleaning up after an oil spill is a complicated business. Chemical dispersants are often but quite toxic. The world environment conference held in Kyoto in 1997, confirmed the drastic need to reduce petroleum waste discharge into the environment.

Around the Sri Lankan Sea, several oil spills were recorded during past few years. Spillage near to Panadura Sea area was the most recent event. According to the MEPA (Marine Environment pollution Prevention Authority), Ministry of Environment, Sri Lanka assumed such reasons for drastic improvement of oil spills recently due to the oil exploration projects and the increment of navigation activities with the development of Hambantota new harbour. Therefore, numerous solutions have been proposed for removing oil from contaminated areas. However, Sri Lanka as a developing country, the main limitations to use these techniques are their high cost and inefficient trace level adsorption, hazardousness of used chemicals, etc (Wardley&Smith, 2012). Scientific research based on this matter is still limited and there is no appropriate technique for removal of the oil spills in Sri Lanka.

Removal of oil by sorption is one of the most effective techniques for complete removal of spilled oil under ambient conditions. By now there are many sorbent materials such as (various vegetable fibres, namely mixed leaves residues, mixed sawdust, sisal (Agave sisalana), coir fibre (Cocos nucifera), sponge-gourd (Luffa cylindrica) and silk-floss).

Natural fibres present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. In Sri Lanka, banana cultivation is abundant and banana fibre can be simply collected. Coir fibres are also highly available low cost product with lot of good properties. Therefore, this research was aimed...
to develop a low cost, eco-friendly oil sorbent material from country’s available natural coconut coir and banana fibre.

2. Materials and Methods

2.1 Sorbent Materials

Sri Lanka is rich in coconut and banana cultivation, which are mainly grown for dietary purposes. It has potential of being used for different purposes such as a substitute for polyethylene cling film and the production of bio food wrappers. Banana can successfully be grown at the plant density of 6000 plants/ha to obtain leaves from leaf oriented banana cultivation in dry zone and wet zone (Weerasinghe, et al, 2007). Both these cultivations can be used for steam oriented and for the fibre extraction. Therefore coconut coir and banana fibres are used as main type of raw materials in this study for preparation of absorption mat (pad). For the absorbency analysing part crude oil and natural sea water were used.

2.2 Preparation of Raw Materials

Coir fibres are extracted from the husks surrounding the coconut. Banana fibre is extracted from Banana stem. Fibre extraction can be done manually or by machinery. Those extracted fibres going under several processes such as drying, removing impurities and separating. Those extracted fibres suitable for mat (pad) preparation. Sorption pads were prepared by using coir and banana fibres, with the help of centrifugal Latex 60% as binding agent. Flat square pads were prepared for the purpose of laboratory analyses. Three mixing ratios and four bed thicknesses were considered for the study to achieve the aim of the research. The crude oil (Marine Balaiem crude oil) samples used for all experiments has specific gravity at 60/60 (ASTM,1998) equal 0.878, Api gravity 29.66 and viscosity 4.8 Cs. Natural sea water was used through all experiments.

3. Analysing saturation points with different sorbent bed thicknesses

The test was focussed on the effect of time with the saturation point. Initial weight of the prepared samples was recorded. The oil/water proportionate was 1:10 as described in Technical Manual of the American Association of textile Chemists and Colorists (AATCC). Within each 30 minutes time intervals, samples were taken out from the tank and wet sobbed mass was recorded. This process was continued until the tested sample becomes saturated. Same procedure was followed for different thicknesses and ratios of sorption pads, giving same conditions.

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\text{Sorption Rate} = \frac{W_2 - W_1}{T}
\]

Where,

- \(W_1\) - Initial Weight of the mat sample in g
- \(W_2\) - Weight of the mat sample after time \(T\) in g
- \(T\) - Time

4. Results and Discussions

Summary of the results can be graphically illustrated in Figures 3, 4 & 5).

![Figure 3 - Maximum Sorption in oil, water and oil/water, in 100% coir](http://www.gsslweb.org)
According to the results, in 50% coir and 50% banana mixing ratio, cumulative oil sorption and rate is 3 times higher than sea water. In oil it sorbs 6 g within first 30 min and 1 g at water.

The rate of sorption in all 3 mediums comes out with maximum values within first 30 mins. Pure oil has higher sorption rate (0.2 g/min) which is 3 times greater than in pure sea water (0.05 g/min). 0.15 g/min rate achieves in oil/water medium. This was 3 times higher than water sorption rate. According to the above Figures 100% Banana has higher sorption in all three mediums rather than 100% coir and 50-50 mix ratios. Especially 100% banana has higher water sorption than two other ratios. 50% coir and 50% banana mix ratio has lower water sorption than 100% coir and 100% banana.

Sorption pattern of the both material is unique to the material type. Sorption rate increases with the sorbent quantity until it reaches a maximum within first 30 – 60 min, then these values decrease until they reach nearly constant value. With the increase of bed thickness (1 cm-7 cm) saturation point does not change, although the absorbed quantity and the rate increase. Also in the same bed with increase of material quantity, amount of cumulative sorbed also increase in both coir and banana material. The soaking time do not vary with surface area of the pad. Compared to loose fibres, this flat cake shape sorption pad will help to increase the sorption. This test was designed to study the effect of sorption rate and cumulative sorption under static conditions. And also structural and textural arrangement of sorption pad will leads to these results. That means pore space arrangement and fibre arrangement may effect the sorption behaviour. When consider the banana fibre structure of Banana fibre, a ligno-cellulosic fibre obtained from the pseudo-stem of banana plant (Musa sepientum), is the best fibre with relatively good mechanical properties.( Samrat Mukhopadhyay, et al.2008) Vascular structure in banana is the reason behind these higher sorptions.

Generally, coir fibres contain a higher percentage of lignin (32%). However, the lignin content of coir fibre is lower than that of the other wood fibres (14-37%). Generally the high content of lignin in coir fibre made the fibre tougher and stiffer. (Tsoumis, 1991). This feature will lead to increase the adhesion property of coir fibre. Textural arrangement within pad material can be changed place to place within the same sample. Fibre arrangement, pore spaces arrangements and latex distribution may cause these complex
sorption behaviours. Due to these sorption pattern in coir and banana, it is better to consider about mixing ratio of coir and banana (50: 50) to study the sorption behaviour for oil recovery of oil spill removals.

5. Conclusions
The test was focused on checking the suitability of Coir and Banana fibre complexes as sorbent for oil spill removals from sea at laboratory scale (static condition, sorption behaviour of both fibre in pure crude oil, pure sea water and oil/water medium). Observed sorption rates in sea water, crude oil and sea water/crude oil in 100% of banana range are 0.1-1, 0.15-1 and 0.5-0.8 g/min respectively. Sorption rates of 100% coir in sea water, crude oil and sea water/crude oil range are 0.15-0.3, 0.2-0.7 and 0.15-0.4 g/min respectively. Sorption rates of 50:50 Banana: Coir in sea water, crude oil and sea water/crude oil range are 0.05-0.25, 0.15-0.7 and 0.15-0.4 g/min respectively. The results revealed that higher sorption rates of 100% banana in oil and water mediums than other two ratios is an advantage as well as a disadvantage. Because high water sorption rate is negative point when it use to remove oil spill on sea beds. Thus banana fibre material is not suitable for oil removal purpose as a sorbent material. In 100% coir sorbent has high oil sorption rate than in pure sea water. Thus for oil removal purposes 100% coir material is more suitable than 100% banana. With lower sea water sorption rate of 50:50 coir: banana is the best material for oil removal purpose as a sorbent material.

6. Recommendations
Both these fibre materials are natural and highly available low cost materials and they do not add any toxicity to sea water when used in oil recovery purpose. So this fibre complex is really important method for oil spill cleanups from sea water, especially for developing countries like Sri Lanka. These sorbent pads can be used to collect oil after it becomes saturation. For this purpose specific pressing mechanism need for squeeze the sorbent pad as a secondary stage. And this extracted oil can be used as an energy source (fuel).

6. References