Decontamination of Oil Spillage on Land with a Composite Material Derived from Sawdust and Sand

Ebitimi Prince Omoro[1], Tudou Perewarifagha[2].
[1]Department of Petroleum Engineering,
Niger Delta University, Amassoma, Nigeria with
Email: ebitimiomoro379@gmail.com
[2]Department of Mathematics and Computer
Science, University of Africa,
Toru-Orua Bayelsa State, Nigeria.
Email: invest.ip55@gmail.com
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Abstract
The remediation of oil spillage on land is a critical environmental concern due to the potential harm a spill can cause to ecosystems and human health if not adequately cleaned. Traditional methods of oil spill cleanup often involve the use of chemical dispersants, which can have negative impacts on the environment. Therefore, there is a growing need for sustainable and eco-friendly approaches to address this issue. One promising solution is the utilization of wood-plastic composite (WPC) materials. WPC is a composite material made by combining wood fibers or sawdust with thermoplastic resins, such as polyethylene or polypropylene. Consequently, this study used WPC prepared from sawdust and sand. Adsorption and absorption efficiencies were tested with different ratios of the components.

Keywords: *decontamination, oil spillage, derived, composite, sawdust and sand.*

Introduction

The increasing frequency of oil spills poses significant environmental threats, particularly when these occurrences are on land. These threats are usually remediated using the traditional method, and are often by the application of physical removal or chemical treatments that can be costly and environmentally degrading. In recent years, innovative approaches have evolved that leverage sustainable materials for effective cleanup. One such method involves the use of Composites (Wood Plastic Composite) material derived from sawdust and sand, which not only provide a biodegradable option for oil absorption but also utilize waste materials in their production. This dual benefit aligns with contemporary environmental standards of reducing waste while addressing pollution, making the Composite material a promising means for the decontamination of oil spills. Composite is the combination of a matrix and a reinforcement, which when combined gives properties superior to those of the individual components (Ashori and Nourbakhsh, 2009). Wood plastic composite (WPC) is therefore a combination of wood and plastic with the plastic as the matrix and the wood as the reinforcement. WPC can be made from unused materials, including copper, aluminum, zinc, iron, etc. and recyclable materials such as glass, paper, cardboard, metal, tires, plastic, textiles, batteries and electronics. The composite and other reuse of biodegradable waste such as food and garden waste is also a form of recycling.

In Nigeria, the volume of plastic waste is massive and managing it has remained a persistent problem. The rapid growth in population has placed heavy pressure on natural resources like forests, leading to damaging environmental effects. Coupled with the growing problem of plastic pollution in the country, these issues highlight why research into Wood-Plastic Composites (WPC) is necessary. WPC has diverse uses including profiles, sheathing, decking, roof tiles, window frames, automobile components, stepping stones, among others (Tong et al., 2014). Natural fibers such as wood are regarded as eco-friendly and sustainable because they can be renewed and they biodegrade.Natural fibers have other added advantages over artificial fibers in the sense that they have low specific weight, high specific strength and stiffness, safer handling and working conditions; they are also non-abrasive to the processing equipment (Tong *et al.,* 2014). Oil sorbent composites produced from organic waste were developed to serve as materials for responding to marine oil spills. These materials were designed to be less affected by wind, waves, currents, and other external factors, while also reducing cost (Saito et al., 2003).

Literature Review

According to Sandberg, (2016), oil spill decontamination using wood plastic composite (WPC) materials is an innovative approach that combines the advantages of wood and plastic to address the environmental impact of oil spills. Albert and Anyanwu (2016) investigated the synergistic effects of oil palm bunch ash and sawdust on the decontamination of crude oil-contaminated soil. Their findings showed that applying both amendments together led to a significant increase in hydrocarbon breakdown in the soil. The highest decrease in Total Petroleum Hydrocarbons (TPH) recorded was 85% after 28 days of treatment. The study concluded that the combined use of oil palm bunch ash and sawdust was more effective than using each material separately, suggesting their strong potential for improving bioremediation in polluted environments. Another research by *Khalifa et al.,* (2021) investigates the development of a composite made from newspaper and polystyrene for the effective removal of oil spills. Their result showed an optimal condition for oil adsorption achieved at a contact time of 60 minutes, with an adsorption capacity reaching up to 95% for crude oil. The composite material demonstrated significant potential as an eco-friendly solution for mitigating environmental pollution caused by oil spills, highlighting its efficiency and sustainability in water treatment applications. Genieva *et al.*, (2012) investigated the thermal degradation of rice husks in a pilot plant setting, focusing on the potential of the resulting products as a Composites for oil spill cleanup. The study found that the pyrolysis process yielded char with a high surface area (up to 400 m^2/g), which demonstrated effective adsorption capabilities for oil, achieving removal efficiencies exceeding 90% in laboratory tests. It was concluded that utilizing rice husks through thermal degradation not only provides an effective method for oil spill decontamination but also promotes sustainable waste management practices. The likes of (Saleem *et al.,* 2018; Nam *et al.,* 2018; Dawodu *et al.,* 2021) also shield more light in the utilization and importance of WPC as an oil spill removal agent.

Methodology

This study adopted an experimental research method that involved fabricating a composite material from low-density polyethylene waste, sawdust, and sand. The materials used were sourced from various locations within Bayelsa State. The first sample (polyethylene waste) were collected

from a polyethylene waste dump site in Etegwe area of Yenagoa, Bayelsa State. The sawdust samples were retrieved from a saw mill at Yenagoa and also the sand samples were collected from sand dump site in Yenagoa, Bayelsa State. The fabrication of the composite involved cleaning and drying the polyethylene waste, as well as drying, grinding, and sieving the sawdust and sand to obtain fine particles. The materials were subsequently combined in predetermined proportions to produce the composite. The polyethylene waste was pelletized using an extruder at 200°C, after which it was blended with sawdust and sand in varying ratios of 4:3:1, 2:1:1, and 3:2:3 to ensure uniform distribution. The mixture was then molded into composites using rectangular molds. The composite was fabricated by melting the blend at 400°C in an extruder, with polyethylene functioning as the matrix while sawdust and sand acted as reinforcements. After extrusion, the mixture was allowed to cool for 24 hours before being demolded. To evaluate the performance of the composites, they were subjected to absorption tests in three simulated conditions: crude oil on water, water only, and crude oil only, over a period of 3 hours. The weights of the samples were measured both before and after immersion to determine their absorption capacity.
The WPC were prepared at three different component ratios. The plastic/sawdust/sand ratios for the three composites are indicated in the table below:
Composite X with a ratio of 4:3:1.
Composite Y with a ratio of 2:1:1.
Composite Z with a ratio of 3:2:3.

Results

Composites Immersed in Crude Oil and Water after 3 hours
Temperature of water = 25 °C after 5 minutes.
Volume of water = 9 litres.
Volume of crude oil = 1.5 litres.

Table 1: Masses of Composites before immersion.

Composites	Mass (kg)	Ratio
A	1.45	4:3:1
B	0.85	2:1:1
C	1	3:2:3

Table 2: 1st Absorption of Crude Oil and Water after 3 hours

Composites	Composites + Crude Oil and Water (kg)	Absorbed Oil and Water (kg)
A	1.53	0.08
B	0.96	0.11
C	1.19	0.19

Figure 1: 1st Absorption of crude oil and water immersion after 3 hours.

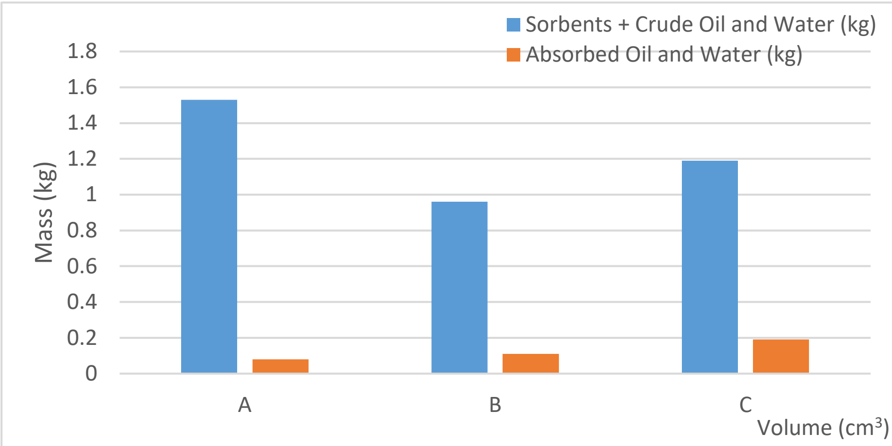

Table 3: 2nd Absorption of Crude Oil and Water after 3 hours.

Composites	Composites + Crude Oil and Water (kg)	Absorbed Oil and Water (kg)
A	1.55	0.01
B	1.0	0.15
C	1.21	0.21

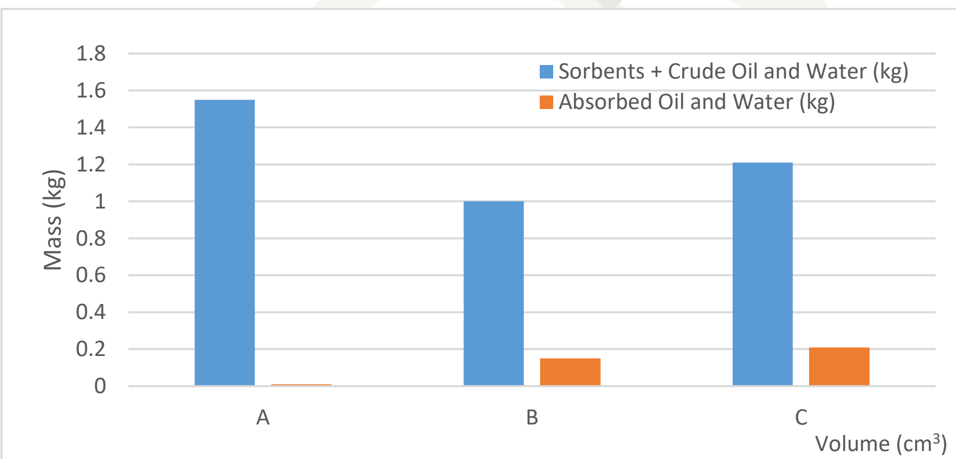

Figure 2: 2nd Absorption of crude oil and water after immersion for 3 hours.

Composites Immersed in Water

Temperature of water = 26 ºC.

Volume of water = 16 litres.

Table 4: 1st Absorption of water after immersion for 3 hours

Composites	Composites + Water (kg)	Absorbed water (kg)
A	1.46	0.01
B	0.87	0.02
C	1	0.00

Figure 3: 1st Absorption of water after immersion for 3 hours.

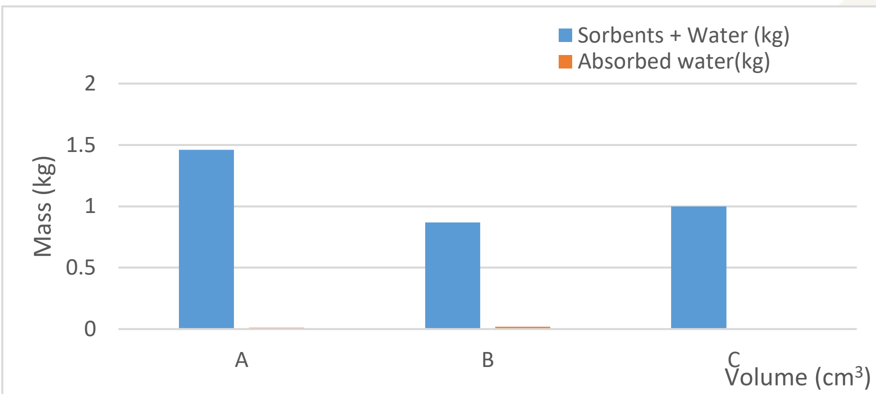

Table 5: 2nd Absorption of water after immersion for 3 hours.

Composites	Composites + Water (kg)	Absorbed Water (kg)
A	1.5	0.05
B	0.91	0.06
C	1.05	0.05

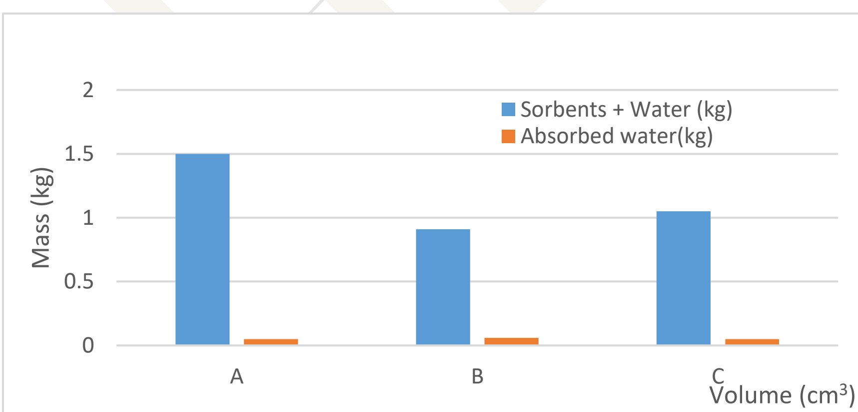

Figure 4: 2nd Absorption of Water. Immersion for 3 hours

Composites in Crude Oil
Temperature of crude oil = 27 ºC after 5 minutes.
Volume of crude oil = 5 litres.

Table 6: 1st Absorption of Crude Oil Immersion for 3hours

Composites	Composites + Crude Oil (kg)	Absorbed Crude Oil (kg)
A	1.52	0.07
B	0.9	0.05
C	1.06	0.06

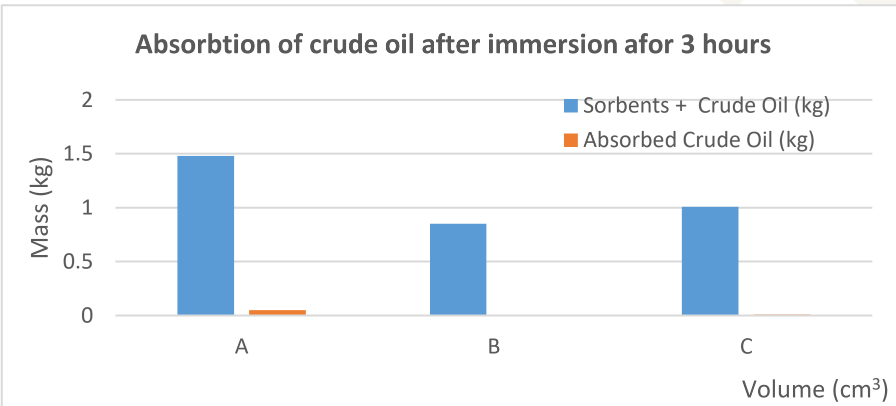

Figure 5: 1st Absorption of Crude Oil Immersion for 3 hours

Table 7: 2nd Absorption of Crude Oil Immersion for 3 hours.

Composites	Composites + Crude Oil (kg)	Absorbed Crude Oil (kg)
A	1.48	0.05
B	0.85	0.00
C	1.01	0.01

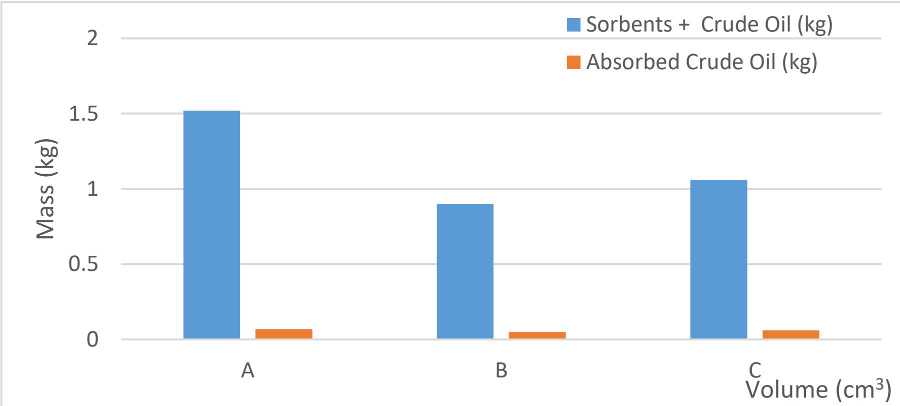

Figure 6: 2nd Absorption of Crude Oil Immersion for 3 hours

Table 8: Rate of Absorbed Composite, Water and Crude Oil

Composites	**Ratio**	**Adsorbed Oil and Water (kg)**		**Adsorbed Water (kg)**		**Adsorbed Crude Oil (kg)**	
		1st Immersion	2nd Immersion	1st Immersion	2nd Immersion	1st Immersion	2nd Immersion
A	4:3:1	0.08	0.01	0.01	0.05	0.05	0.07
B	2:1:1	0.11	0.15	0.02	0.06	0.00	0.05
C	3:2:3	0.19	0.21	0.00	0.05	0.01	0.06

Discussion.

The oil absorbed and retained inside porous media can be divided into three parts.
(i) The oil part retained by weak capillary forces, which is released under gravitational forces during several minutes
(ii) The oil part retained by capillary forces, which is not released under gravitational field
(iii) The oil part retained by strong capillary forces and absorptive forces, which is not released under gravitational and centrifugal field (Cojocaru *et al.,* 2011).

In this study, after the oil absorption process, the composite was suspended on a retort stand to allow oil held by weak capillary forces to drain out. During this period, a significant reduction in retention capacity was observed. This is attributed to the fact that some of the liquid was loosely held in the macrospores by weak capillary action and could therefore be easily released. The remaining oil, represented by parts ii and iii, accounted for the oil that was actually retained by the composites.

Composites in Crude Oil and Water

Composites A, B, and C were tested by immersing them in crude oil floating on water. Composite A recorded the lowest absorption values of 0.08 kg and 0.01 kg after the first and second immersions, respectively. This low performance may be attributed to its very small sand content. Composite B showed moderate absorption, with values of approximately 0.11 kg and 0.15 kg after the first and second immersions. The difference between A and B could be due to the lower amount of sawdust in B, which was fixed at 1 while the other components were increased. Composite C exhibited the highest absorption, with about 0.19 kg and 0.21 kg after the first and second immersions. Overall, Composite A had the least crude oil uptake in water, likely because of its high polyethylene content.

Composites in Water

Composite B had the highest absorption of water of about 0.02 kg and 0.06 kg for 1st and 2nd immersions, while Composite A had a medium absorption of water of about 0.01 kg and 0.05 kg for 1st and 2nd immersions. It was also observed that Composite C indicated no absorption after the 1st immersion but gained a value of 0.05 kg after 2nd immersion.

Composites in Crude Oil

Composite A had an absorption of crude oil of about 0.05 kg and 0.07 kg after 1st and 2nd immersions. Composite B showed no absorption value after 1st immersion and only 0.05 kg after 2nd immersion. Composite C yielded a crude oil absorption value of 0.01 kg and 0.06 kg holding a less stable absorption value achieved in the process. This is achieved due to the high incorporation of polyethylene and sand.

Conclusion

Composite B demonstrates superior absorption characteristics for crude oil in both aqueous and dry environments. It not only effectively absorbs a larger volume of crude oil but also exhibits a lower affinity for water, making it an ideal candidate for applications involving oil spill remediation. Composite B stands out as the most efficient sorbent material for addressing oil spills. Its properties make it a highly effective solution for environmental remediation efforts.

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