Comparative Study of the Efficiency of Coconut Fibre, Rice Husk, and Cotton Wool in the Absorption/Purification of Crude Oil Contaminated Water

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Abstract:

The contamination and pollution of water sources by crude oil spillages from the activities of militants in the Niger Delta in Nigeria have seriously resulted in surface and ground water pollution rendering the water sources unfit for many domestic, agricultural and industrial uses. Comparative study was conducted to absorb/purify crude oil contaminated water samples using rice husk, cotton wool and coconut fibre as filter/absorbent materials. Sixteen grams of the materials were wrapped in a pouch and submerged into two set-ups labeled as: set up A for pure crude oil and set up B containing mixture of crude oil and seawater for one hour. The amount of crude oil absorbed/purified from each set up was recorded. The result showed that cotton wool had the highest amount of absorbed crude oil with volumes recorded in three trials as (232 ml, 300 ml and 189 ml), rice husk had the lowest amount of crude oil absorption of (78ml, 80ml and 89ml) in the set up containing pure crude oil. In the other set up containing mixture of seawater and crude oil, coconut fibre had the highest amount of absorbed crude oil with volumes of (124ml, 240ml and 233ml), followed by cotton wool with volumes of (124ml, 100ml and 150ml), rice husk absorbed the least volumes of (33ml, 100ml and 80ml) respectively. The mean absorption ability of Coconut fibre and Cotton wool proved the best in the absorption of pure crude oil and in the mixed state of crude oil and sea water. Analysis of variance of results between the amounts of absorbed crude oil by the materials in the two set-ups was significantly different. Coconut fibre and Cotton wool are hereby recommended as a first hand filtration/absorption and cleaning materials for use to purify crude oil contaminated water for local use prior to skimming and dispersion methods as these materials are locally available in the affected areas.

Keywords:

Water Pollution, Crude Oil Spillage, Water Purification, Rice Husk, Coconut Fibre, Cotton Wool

1. Introduction

In Nigeria, the Oil industry is considered to be the largest sector and the main generator of Gross Domestic Product (GDP) in Africa's most populated nation. Its economic benefits are numerous, but in all, oil spills in Nigeria are common occurrences especially in the Niger Delta Areas of Nigeria. It has been estimated that between 9 million to 13 million barrels have been spilled since Oil drilling started in Nigeria in 1958. Spillage of Oil can be categorized into two; Land spillage and water spillage, whatever the form of Oil spillage, they all have negative impact on the environment and the society in general and mostly rendering farm land agriculturally unproductive.

Spillage of Oil into open surface water bodies like, rivers, lake, streams and even oceans and sea water have the attendant consequences of impacting objectionable odour, undesirable appearance and be a potential safety hazards for communities residing in the affected area and the entire aquatic biodiversity of that particular area. According to Badejo and Nwilo [1] the consequence of oil spillage is far reaching as it impact negatively on the economy of a region, community, pollutes water and also affect the health of the local communities. Oil spillage can cause damage to farm lands, become toxic to marine life and resources which man uses as food, thus having also an effect on human lives as a consumer of sea foods [2].

Communities and villages in the Niger Delta areas of Nigeria that are affected by the oil spills often have their farm lands, surface and ground water resources affected badly from contamination of crude oil spills, domestic, agricultural and sometimes industrial water supply are affected. The cumulative effect of these oil spills combine to destroy the biodiversity of the affected areas leading to loss of wildlife, aquatic life, health and degradation and overall national losses economically and socially [3]. The affected communities cannot continue to suffer from this environmental, land and water pollution from oil spillage [4]. Uncontrolled infiltration and penetration of crude oil spills into the environment is always viewed and treated as a dangerous pollution and have to be combated using available methods [10].

Cleaning and absorption of commercial oil spills may cost a lot of money, therefore this research aim to test the absorption/purification potential of various organic waste materials like coconut fibre, rice husk and cotton wool in the purification of crude oil contaminated water as these materials are locally available in almost every villages or communities prior to the national and conventional oil spill cleaning intervention from the government by using oil dispersants and vacuum skimmers.

2. Material and Methods

The materials used for the research consist of 3, 250ml beakers, 3 funnels, 3 graduated cylinders of 700ml capacity and 30 plastic cups of 500ml volume each, thin cloth material as filter media and a tying straw.

2.1. Sample Collection and Preparation

Eighty liters of representative sample of sea water was collected from onshore of the Nigerian National Petroleum Company NNPC in Rivers State in Portharcourt in Nigeria. Coconut fibre was collected from Coconut farm in Ogbadibo Local Government area of Otukpa, Benue State, Nigeria; 95000ml of pure crude oil was obtained from NNPC depot in Rivers State; while Cotton wool was purchased in the same market in Otukpo, in Benue State, Nigeria. Rice husk was collected from local rice mill in Yola, Adamawa State, Nigeria. Rice husk and coconut fibre were grounded into powder and were sieved through a 2μm size to obtain uniform and homogenous size that improves the porosity of the organic materials.

Figure 1. *Samples of Rice husk, Cotton wool, Coconut fibre, Sea water and Crude Oil used*

2.2. Preparation of Cloth Bags

2.6 meters of thin white cloth material was bought from a tailoring shop, sixty pieces of the thin cloth was cut into a size of 7.5cm by 5cm and were sewn into each other making a total of 30 sewn cloth bags to serve as a container into which the selected absorbent materials was placed before submerging them as filters into the crude oil and sea water mixture to observe the absorption/purification potential of the three organic materials.

Figure 2. *Sewn cloth bags for placing the organic materials for absorption test*

2.3. Preparation of Crude Oil and Sea Water Samples

Two sets of three beakers properly labeled as set up A and B was used for the experiment, 1 set containing 3 beakers was filled with 500ml of crude oil was labeled as set up A; while the second set of 3 beakers filled with 250ml of crude oil and 250 ml of seawater was labeled as set up B. All the measurements were made using standard graduated cylinders.

2.4. Preparation of Absorbent Materials (Cotton Wool, Rice Husk, Coconut Fibre)

16.43 grams of each organic material (cotton wool, rice husk and coconut fibre) were measured and placed into pouch cloth bag container with a premeasured weight of 3.7grams each. The total weight of each organic material and the cloth bags was measured to be 20grams. The 6 pouched bags were then filled with the same type of material, then 3 pouches were used for set up A and the other 3 were used for set up B. The six pouch bags were tied each using the procured straw as shown in Fig 3 below.

Figure 3. *Cotton wool, Rice husk and Coconut fibre placed in pouch cloth bags*

2.5. Testing the Absorption/Purification potential of Organic Materials

The absorbent materials in the labeled cloth bags were subjected to three trials by submerging each bag by dipping it into the two set ups A and B as shown in Fig 4 below until it stay at the bottom of the beaker for an hour. The bags are then removed and drained into plastic cups for ten seconds. The amount of oil left behind in the beaker is measured by using the graduated cylinder after each trial. The measured amount of oil is then subtracted from the original volume of crude oil in the set ups; this now corresponds to the amount of crude oil that was absorbed. The procedure done in set up A was repeated for set up B, but here two volumes were taken. The volume of crude oil absorbed and the volume of sea water. The volume of crude oil and sea water was visible since oil and water are not miscible. In measuring the amount of crude oil absorbed, the sea water and the crude oil left not absorbed, was separated using decantation as a separation technique. The crude oil which was not absorbed was measured in a graduated cylinder then subtracted from the original amount of crude oil which was 250ml, while the amount of water absorbed was neglected.

Figure 4. *Showing organic materials submerged into the absorption/purification sets A and B*

2.6. Instrument Used for Data Calculation

From the amount of crude oil absorbed in each sample of the absorbent materials, the absorption ability was computed using the equation below and the obtained values were recorded in tables.

Absorption ability = $\dfrac{\sum X(ml) / N}{\text{Mass of the product (g)}}$

Where:

X = amount absorbed by organic absorbent material in ml

N = original amount of crude oil.

∑ = sigma, which means, 'summation of'

3. Results and Discussion

Table1. *Mean value of Crude Oil absorbed by Rice Husk, Cotton Wool and Coconut fibre in the first experimental set up (Set – up A)*

Samples	**Mean amount of Oil Absorbed (ml)**			
Trials				
	1	**2**	**3**	**Mean**
Rice husk	78.0	80.0	89.0	82.0
Cotton wool	232.0	300.0	189.0	240.3
Coconut fibre	150.0	190.0	172.0	170.7

Table 1, above shows the mean amount of crude oil absorbed by each absorbent material in set up A containing pure crude oil. Cotton wool has the highest absorption ability among the three tested organic material with a mean volume of 240.3 ml of crude oil, followed by coconut fibre with volume of 170.7ml. Rice husk has the lowest absorption potential with a recorded volume of 82.0 ml of oil. The result obtained in this study for cotton wool with an absorbed oil volume of 240.3 ml is in close range with the value of 242.7ml as observed by [5]. The different values of oil absorption in terms of volume that was observed by these three organic materials could be attributed to their differences in texture, porosity and pore spaces of the material and hence the exhibit different oil absorption potentials. The findings in this study are in line with [11].

The graphical plot of the amount of crude oil absorbed in each trial in set up A is shown in Fig 5 below. From the plot, even though rice husk has the lowest amount of crude oil absorbed, there is consistency in the recorded results (78, 80 and 89 ml). It is also evident that coconut fibre with an absorbed oil volume of (150, 190 and 172 ml) can be used as an alternative to cotton wool where cotton wool is not much available as shown in Fig 5 below.

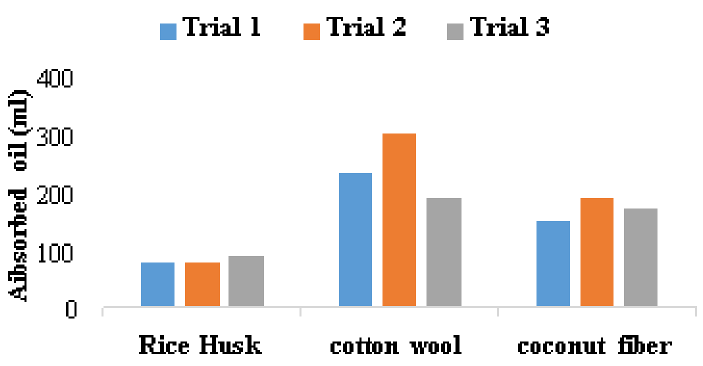

Figure5. *The amount of crude oil absorbed by organic material in three Experimental trials in set – up A*

***Table2.** Mean value of Crude Oil absorbed by Rice Husk, Cotton Wool and Coconut fibre in the first Experimental set up (Set – up B)*

Samples	**Mean amount of Oil Absorbed (ml)**			
	Trials			
	1	2	3	Mean
Rice husk	55.0	100.0	80.0	78.3
Cotton wool	124.0	100.0	150.0	124.0
Coconut fibre	124.0	240.0	233.0	199.0

The table 2, shows the mean values of absorbed volume of oil in a mixed state (mixture of oil and water) labeled as set – up B. Here cotton wool became the second most effective crude oil absorbent material with volume of 124ml which is as different from 240.3ml as observed in set –up A. Thus this indicates that cotton wool is not more effective in terms of absorption/purification ability in a mixed state, when submerged in a mixture of crude oil and water than when it is only submerged in pure crude oil only. This could be attributed to some tolerance and affinity cotton wool has for water. It could be seen from the table above that coconut fibre works effectively in seawater covered with crude oil recording a volume of 124.0, 240 and 233 ml with an average of 199 ml. This result is in close range with the results obtained by [6] and [8] with values of 250, 124 and 250 ml with an average volume of 208.0 ml of absorbed crude oil. Similar findings were also recorded by [11] who experimented the use of human hair as sorbent material in the removal of natural oil spills in Niger Delta of Nigeria.

The plot of the three organic materials Figure 3 below also indicated that coconut fibre absorbs more crude oil in a mixed state more than cotton wool, while rice husk proves to be the least in terms of the volume of oil absorbed. The results obtained revealed that cotton wool are more consistent (124.0, 100.0 and 150 ml) followed by rice husk with recorded oil volume of (33.0, 100.0 and 80.0 ml) in three trials.

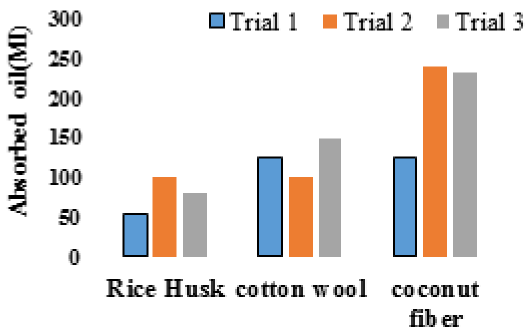

***Figure 6.** The amount of oil absorbed in mixture of crude oil and seawater by three organic materials in three Experimental trials*

***Table 3.** Mean Absorption Ability of Three Organic Materials in Two Experimental Set up (A and B)*

Organic Materials	Mass of Product (g)	Initial Volume of Oil (ml)	Absorption Ability in (ml/g)	
			Set-up A	Set–up B
Rice husk	16.43	500	8.12	7.72
Cotton wool	16.43	500	23.7	12.29
Coconut fibre	16.43	500	16.82	16.62

The mean absorption ability of the three organic materials in pure crude oil and in the mixture of crude oil and water are presented in (Table 3). In set up A, cotton wool proves to be the most active organic material with a recorded absorption ability of 23.7 ml/g of oil per 1 gram of cotton wool, while coconut fibre had an absorption volume of 16.82 ml of crude oil per 1 gram of coconut fibre and rice husk value was 8.12ml of crude oil per 1 gram of rice husk. In set up B, where it was mixture of crude oil and water, coconut fibre recorded a higher absorption ability of 16.62 ml/g, while cotton wool was 12.29 ml/g. The least absorption value recorded was 7.72ml/g for rice husk in a mixture of crude oil and sea water. The result obtained in this study from both set ups is in line with the result range of (3.92 – 8.85 ml/g) as earlier reported by [7] and [9]. Similarly, [12], [13] also recorded similar results in their work experimental Impact of Produced water and Drilling waste Discharge from the Niger Delta Petroleum Industry.

From the two experiments conducted, it is evidently clear that cotton wool absorbs more crude oil more than rice husk and coconut fibre while testing the absorption ability in pure crude oil alone, but in the mixed state which is the case of the contamination often experienced in the oil producing state in the Niger Delta in Nigeria, coconut fibre proves to absorb crude oil in the mixture of sea water and crude oil, hence the absorption/purification ability of coconut fibre can be adopted locally as measure to reduce water contamination prior to the conventional treatment.

4. Conclusions

The comparative study of the absorption/purification ability of three organic materials was tested; the results revealed that rice husk, Cotton wool and coconut fibre have the potentials to absorb oil and water mixture and can be used effectively in absorbing/purifying oil contaminated water. Cotton wool proves to be the efficient organic material with higher mean absorption ability when submerged in pure crude oil, while coconut fibre is the most efficient with higher mean absorption ability when submerged into mixture of crude oil and water. The recorded mean absorption potential of the organic materials proves that the technique can be very useful for adoption. It is recommended therefore that communities affected by crude oil water pollution should use coconut fibre and cotton wool to purify oil contaminated water prior to conventional intervention from the government as a first aid prevention measure for having water of better quality for domestic usage. Further water treatment like disinfection, chemical coagulation should be carried out to improve the quality of water after absorption by the said organic materials. Also further study in this line should consider the influence of crude oil density, viscosity and temperature effect on the separation/filtration process.

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