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Sorbents Performance Efficiency Test

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Abstract:
Crude oil spillage had been a major concern to the Nigerian government and particularly to the people of the Niger Delta region because of the devastating effects, not just on the ecosystem of the region, but also, on the health implication on the people where this crude oil activities are always carried out. When crude oil spills it takes different pathways to the receptors that may be human beings, plants, sea foods, and other organisms. This means, there are health implications of oil spillage directly or indirectly. Based on these effects, various mechanical sorption methods for oil spill remediation had been applied. These methods involve sorption of spilled oil on water and on land with different trade marks. All, with the intention of remediating the impacted areas that had faced brutality of oil spillage(s). However, the efficiencies of these different trademark products needs to be known in order to identify the product that gives the best result of remediating the impacted sites. In this paper, the following sorption materials are used to identify the most effective sorption products of the three (3) different sorptions applied: FOSS, SPILL TECH and CEP-SAPKL. The tests carried out on each were: Reuse test, efficiency test, pickup time test, both low and high rate oil exposure test. Also, calculation of efficiency, net oil retaining, recovery efficiency, obtained oil adsorbed, oil adsorbed, water and oil absorbency buoyancy, degree of deterioration, absorbency ratio, and percentage of oil removed by the products was done.

Keywords: Crude oil, Devastating effects, Efficiency, Pathways, Pickup time, Receptors, Remediation, Sorbent, Sorption, Spillage, Health implication.

1.0 Introduction:

The effects of oil spills could be short term and/ or long term. It could be also be acute or chronic in nature depending on the chemical or physical characteristics of the petroleum (Wilson et al, 1973). The acute effects on the biota results from accidental spills occur within confined marine areas and as such, the concentration will be high and remain high for an extended period causing greater biological impacts than in rapid dispersion areas. Such spills are generally largely compared with chronic low-level additions. Chronic effects occurs when the release of crude oil or its derivatives is either continuously or sufficiently often that the biota does not have time to recover between doses. This is the long-term effect on aquatic organisms. The biological effects vary form one place to another and at various times with different priorities in the evaluation of the impact. Also, considering the various shoreline types, riverine systems and natural resources of the Niger Delta, and the sensitivities of the region to spilled oil based on the biological and socio-economic resources that interplay with the ecosystem including effects on wildlife and human activities, there is the need to draw a contingency plan by producing Environmental Sensitivity Index map.

Crude oil spillage had been a major concern to the Nigerian government and particularly to the people of the Niger Delta region because of the devastating effects, not just on the ecosystem of the region, but also, on the health implication on the people where this crude oil activities are always carried out (Bereiweriso, 1998). When crude oil spills it takes different pathways to the receptors that may be human beings, plants, sea foods, and other organisms. This means, there are health implications of oil spillage directly or indirectly. Based on these effects, various mechanical sorption methods for oil spill remediation had been applied. These methods involve sorption of spilled oil on water and on land with sheets, pillows, particulates and booms of different trade marks. All, with the intention of remediating the impacted areas or sites that had faced brutality of oil spillage(s). However, the efficiencies of these different trademark products needs to be known in order to identify the product that is of most benefit or gives the best result of remediating the impacted sites.

Objective: (1) To identify the products that best remediate oil impacted sites. (2) To determine their efficiencies. (3) To determine if the sorbents used were absorbent or adsorbent.
Aim: To restore impacted sites to normalcy in order to overcome health implications associated with oil spillage.

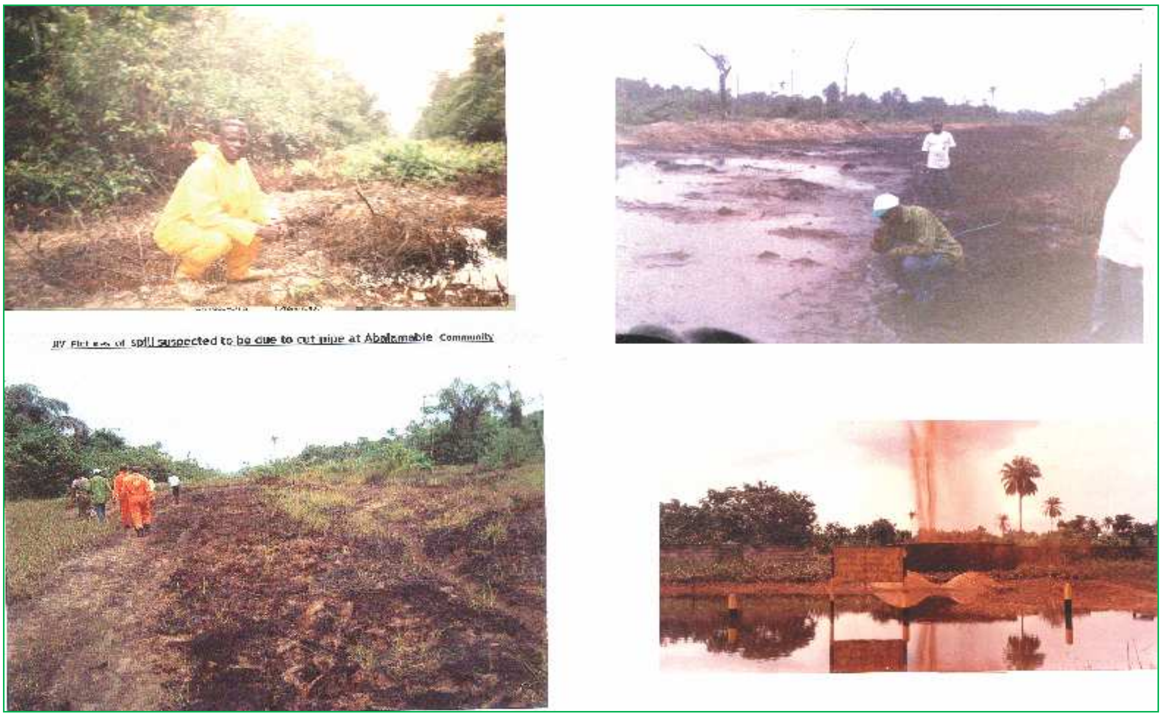

Fig. a: Oil Spills in Rivers and Bayelsa States, Nigeria

2. MATERIAL AND METHODS:

ABSORBENT

Absorbents are materials used to encapsulate the spilt oil into a monolithic mass (solidified oil) by absorption of oil. There are three (3) types of absorbent materials. These are: Particulate type; rolls, sheets, pad, blanket, pillow or web type; and boom type. The boom types are provided with connector units so that they may be coupled to another boom or line. The particulate types are unconsolidated material with no sufficient form to be applied in single units and are loose. While the rolls, sheets, pad, blanket, pillow or web types have form and strength sufficient to be lifted and handled when saturated without tearing and are not loose.
Some physical characteristics of absorbent materials are mildew, absorption mostly oil resistance to humidity, flammable, decompose and immersible (light in weight)

ADSORBENT

There are four (4) types of adsorbents. They are: sheet, pad, roll, blanket, and web type; Pillow or boom; Unconsolidated particulate type; and strands, open netting. The strands, open netting type is assemblage also of other physical open structure. The pillow and boom type has form and are not loose, the particulate type is an unconsolidated, loose and without form while the rolls, sheets, pads, webs and blankets have strength, width, length with thickness and could be handled saturated and unsaturated.
(1998 Annual Book of ASTM Standards Volume 11.04**)**

Fig. b: Different Sorption Materials of Various Forms

Fig. c: Experienenmental Researcher in SPDC Warri Laboratory

***Absorbent test*: (**1998 Annual Book of ASTM Standards Volume 11.04**)**

Using sheets and pillows – 3.69g of sheets of Foss (A* & B) and Spill Tech (C) were dropped in different 1000ml beakers containing 600ml water that was treated with 50ml crude oil. The set up were allowed to stand for 10minutes. The absorbent sheets were subsequently extracted and hung. After draining (1 day), the sheets were reweighed and the different in weight obtained. This is in order to determine different absorbent capacity. For pillow test, Foss and CEP-SAKPIL products were used. Table 1 test 1 and 2 shows the results.

Pick up test - Using sheets – 3 beakers containing 500ml water each were treated with 30ml crude oil and allowed to stand for 10 minutes. 3.50g Foss (A*), 3.66g Foss (B) and 3.68g Spill Tech (C) sheets were cut into sizes (7 x 8cm) were attached to strings and these sheets were dropped into the oily water for 15 minutes. The sheets were then extracted from the water using strings and weighed. These were allowed to drip dry in air and the weight measured after every 2 minutes. The amount of absorption was determined by reweighing the "dried" sheets. So that mass of absorbed material is given by W2-W1 where W1 is initial mass and W2 is mass after absorption. Table 2 test 3 is the results of the experiment.

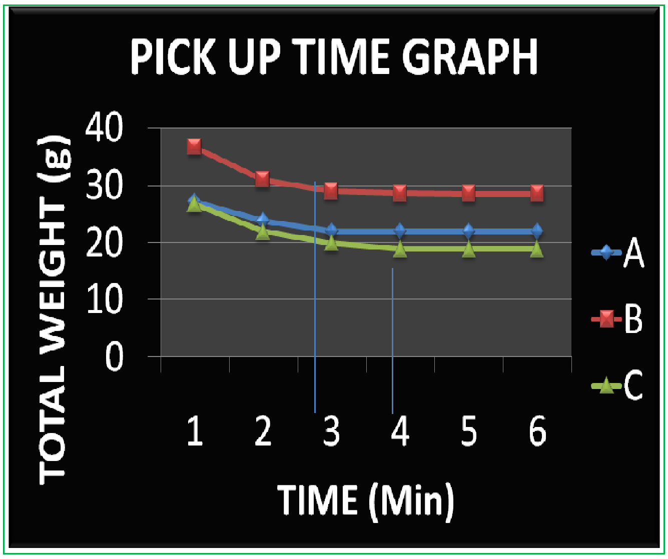

Fig. d: Pick Up Time Graph

Boom test - 64.74g (W1) Foss boom was dropped into a test tray containing 3000ml water. The water was treated with 100ml of crude oil. The set up was allowed to stand for 30 minutes. The boom was subsequently extracted and hung. After draining had stopped, reweighed. Table 2 test 4 is the results of the experiment.

Table 1: Absorbent - Sheets and Pillows Test

Test	Product	Type	W1 (g)	W2 (g)	Efficiency %	Remarks
1		Sheets				
	FOSS	A*	3.68	34.70	89.39	Water was still showing crude
	FOSS	B	3.69	43.80	91.57	Water was clean
	Spill Tech	C	3.68	33.18	88.90	Water was still showing sheens
2		Pillows				
	FOSS	A	83.60	204.52	59.12	Crude still seen
	CEP-SAPKL	B	87.26	206.35	57.71	Not even sheen

*Non biodegradable

Table 2: Absorbent - Pickup and Boom Test

Test	Product	Type	W1(g)	W2(g)	W3(g)	W4(g)	W5(g)	W6(g)	W7(g)	Effic %	Remarks
3		Sheets		At T	At T	At T	At T	At T	At T		
				60 sec	120 se	240 se	360 se	480 se	600 se		
	FOSS	A*	3.50	27.13	23.8	21.95	21.95	21.93	21.93	87.09	Water
	FOSS	B	3.66	36.66	30.9	28.90	28.60	28.5	28.5	90.00	pick up
	Spill Tech	C	3.68	26.70	21.9	19.90	18.86	18.86	18.86	86.10	time
4	FOSS	Boom	64.74	289.88						77.66	
	Spill Tech		65.12	184.58						64.72	

* non biodegradable

Adsorption Test:

Using Sheets – 3.65g (A*) and 3.59g (B) sheets of Foss and 3.60g (C) sheets of Spill Tech were dropped in different 1000ml beakers each containing 4ooml of oil. When the sheets are saturated, note the time of saturation, T, and reweigh, W2. Put the sheets again into the beakers of oil and allow standing for another 20% of T, T1, and weigh, W4. Drain the sheets for 30 seconds, T2 and reweigh, W5. The mass of adsorbed material is given by (W3 = W2 – W1). Table 3 test 5 shows the results of the experiment.

Using Boom – 18.45g (W1) boom of Foss was dropped in a test tray containing 2000ml oil and allowed saturated time T. The boom was extracted and weighed, W2. The boom was again dropped into test tray and allowed for 75% T, (T1); 90% T, (T2); and 100% T, (T3) and the weight W3, W4 and W5 respectively were measured. Table 4 test 6 shows the results of the experiment.

Reuse Test – The absorbent sheets used to absorb oil for 30 minutes were allowed to drain for 1 day. These absorbents were subsequently used in a repeated absorption tests. The numbers of occasions are indicated against each test situation. Table 4 test 7 shows the results of experiment.

Table 3: Adsorption – Sheets and Boom Test

Test	Product	Type	W1(g)	W2(g)	W3(g)	W4(g)	W5(g)	T(sec)	T1 (20%T)	T2(sec) after drain
5		Sheet								
	FOSS	A*	3.65	29.55	25.90	28.80	25.50	180	36	30
	FOSS	B	3.59	57.02	53.43	43.17	39.43	120	24	30
	Spill Tech	C	3.60	36.72	33.12	39.57	32.80	150	30	30
6	FOSS	BOOM	18.45	141.66	161.83	181.42	171.75	60	75%T 45	90%T 54

* non biodegradable

Table 4: Reuse Test

Test	Product	Type	Cycle	So(g)	Ss(g)	Sf(g)	Os(g)	Osa(g)	On (Sf-So)	Average
7		Sheets	1			27.59	23.94			
	FOSS	A*	2			27.69	24.04	24.13	5.9	27.78
			3	3.65	9.56	28.10	24.45			
			4			27.77	24.12			
	FOSS	B	1			55.60	52.01			
			2	3.59	7.41	56.18	52.59	50.92	3.81	54.51
			3			53.21	49.62			
			4			53.08	49.49			
	Spill	C	1			57.12	53.52			
	Tech		2	3.60	8.55	35.95	32.35	37.75	4.95	41.35
			3			36.56	32.96			
			4			35.80	32.20			

* non biodegradable

Low-Rate oil Exposure – Table 5 test 8 is the result. Where,
W1 = Weight of 450ml water and beaker before treatment
W2 = Weight of water and beaker after treatment
High-Rate Oil Exposure – Table 5 test 9

Table 5: Low and High Rate Oil Exposure Test

Test	Product	Type	So(g)	Ss(g)	W1(g)	W2(g)	Sw(W1-W2)
8	FOSS	A*	3.57	15.60	646.30	641.60	4.70
	FOSS	B	3.58	13.19	647.70	645.40	2.30
	Spill Tech	C	3.58	12.10	665.80	663.30	2.50
9					Sf(g)	Os(g)	
	FOSS	A*	3.57	15.60	8.96	7.33	
	FOSS	B	3.58	13.19	7.27	7.31	
	Spill Tech	C	3.58	13.10	8.22	7.02	

*non biodegradable

3.0 Calculations

Efficiency $= \frac{W2 - W1}{W2} \times 100\%$

From test 1

Sheets:

FOSS A* $= \frac{34.70 - 3.68}{34.70} \times 100\% = 89.39\%$; FOSS B $= \frac{43.80 - 3.69}{43.80} \times 100\% = 91.57\%$

Spill Tech $= \frac{33.18 - 3.68}{33.18} \times 100\% = 88.90\%$

From test 2

Pillows:

FOSS A = 59.12% , CEP-SAPKL B = 57.71%

From test 3

Pick Up Efficiency = [(W2 –W1)/W2] x 100%

FOSS A* $= \frac{27.13 - 3.50}{27.13} \times 100\% = 87.09\%$; FOSS B $= \frac{36.66 - 3.66}{36.66} \times 100\% = 90\%$

Spill Tech C $= \frac{26.70 - 3.70}{26.70} \times 100\% = 86.10\%$

From test 4

Boom:

FOSS = 77.66%; Spill Tech = 64.72%

Adsorbent:

From test 5

Net Oil Retaining (Wo) = WQ1 +W2 – W5

The ratio of oil adsorbed and retained (Wf) per gramme of adsorbed is the ratio of net oil retained (Wo) to dry adsorbed weight (W1). Expressed as

$$Wf = \frac{WO}{W1}$$

Recover Efficiency (R) $= \frac{W1}{W5} \times 100\%$

From test 6

Wo = [(W3- (W1+W2)]

Obtained oil adsorbed (Wf) =Wo/W1

From test 7

The total amount of oil the adsorbent is able to hold after saturation cycle is a measure of the degree of deterioration.

Degree of deterioration (Dd) is the percentage of oil adsorbed of a given cycle to that of the saturation cycle and is calculated by the ratio of oil adsorbed of a given cycle to that of the saturation cycle (1st cycle). Thus,

$$Dd = \frac{Osx}{Os1} \times 100\%$$

(x = total number of cycles)

The absorbency (Ad) ratio for each cycle based on total oil adsorbed is

$$Ad = Osx / So$$

Percentage of oil removed (Ore) for any given cycle is the ratio of the difference of average total oil adsorbed and average total net oil remaining (Onx) of that sample to average total of oil adsorbed. Thus,

$$Ore = \frac{Osx - Onx}{Osx} \times 100\%$$

From test 8

Oil Adsorbed (Os) = Ss – Sw – So .

From test 9

This calculation is Sorbent buoyancy.

Water absorbency (Had) = water adsorbed /dry sorbent (Sw/So)

Oil absorbency (Oad) = Oil adsorbed / dry sorbent (Os/So)

Recovery Efficiency (R) $= \frac{\text{Oil adsorbed}}{\text{Total fluid weight adsorbed}} \times 100\% = \frac{Os}{Ss - So} \times 100\%$

Buoyancy (By) relates to the amount of adsorbent which survived the oil addition shake sequence and was still floating. Thus, net weight after drying to weight of initial sample. Expressed as

$$By = \frac{Sf}{So}$$

Table 6: Summary of Results

	A*	B	C
Efficiency	89.39%	91.57%	88.90%
Pick up Efficiency (E)	89.90%	90.00%	86.10%
Net Oil Retaining (Wo)	7.7	21.18	7.52
Ratio of oil removed (Wf)	2.10	5.89	2.08
Oil Adsorbed (Os)	7.33	7.31	7.02
Water Adsorbed (Had)	1.31	0.64	0.69
Oil Absorbency (Oab)	2.05	2.04	1.69
Recovery Efficiency (Er)	60.93%	9.10	10.97
Buoyancy (By)	2.50	2.03	2.29
Degree of deterioration (Dd)	86.86	93.41%	92.51%
Absorbency Ratio (Ad)	6.61	14.18	10.48
% of Oil removed (Ore)	75.50%	92.51%	86.88%

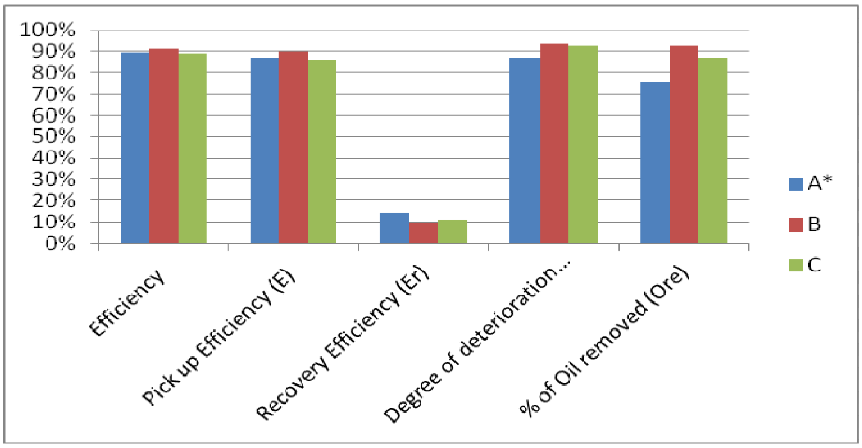

Fig. e: Percentage Factor

All tests were done under controlled condition in the PC laboratory of SPDC, Warri with the following information.

Laboratory temperature - about 25^{0}C
Type of oil - Light crude
Source of crude - Amukpe oil field, Delta State.
Type of water - Tap water.

4.0 Discussion:

Sorbents action is of three steps. Firstly, it contains the spilt oil. Secondly, it absorbs or adsorbs the oil and, lastly, solidifies it.

Contains ⟶ Absorbs/Adsorbs ⟶ Solidifies

At present, in all the methods, mechanical methods had been considered the least damaging of cleaning up oil spills. This involves the use of boom and skimmers or sorbents. However, if the sea current is relatively very high (say wave height of 1-2 ft) or the oil is a distillate, the retrieval of spilled oil by booms and skimmer will not be efficient (Workshop on Inputs, Fates,-- 1973). Sorbents also have limited application due to the fact that proper techniques and equipment for evenly distributing large quantities of sorbents over wide areas of open water, harvesting the oily agglomerate, etc are not available. Only sorbents available for this experiment were of type 2 and 3 of absorbents. From test 1, it was evidently seen that FOSS biodegradable sheet B absorbed oil better than the other two sheets, A and C; and that sheet C is better than sheet A. Sheet A is a non biodegradable product. Also, from test 3, sheet B calculated pickup efficiency was 90% much more than sheets A and C. Sheets A and B pick up time of 3 minutes while sheet C have 4 minutes. Also, all sheets used do not release the test fluid, the oil into the water. From test 2, no significant difference was observed between FOSS and CEP-SAKPIL 10 pillows with efficiency 59.12% and 57.71% respectively. From test 4 only FOSS boom was available for the test and its recovery was good. From test 5, sheet B calculation for net oil retaining (Wo) was 12.18 as against 7.70 and 7.72 for sheets A and C respectively, while their respective ratio of oil adsorbed and retained (Wf) were 5.89, 2.10 and 2.08. In test 7, the degrees of deterioration were 86.86%, 93.41% and 92.51% respectively for sheets A, B and C. Their respective absorbency ratios were 6.61, 41.81 and 10.48; while their percentage of oil removed were 75.50%, 92.51% and 86.88% respectively. In test 8, all three sheets have almost the same low-rate of oil exposure while test 9, sheet B also, adsorbed the least water compared to other two sheets and that no significant difference in oil adsorbency was observed. Sheet B also proved to be more recovery efficient sheet though sheet A is more buoyant than sheets B and C – High-Rate Oil Exposure.

5. Conclusion:

The efficiency of absorption for the sheets were: sheet A 89.39%, B 91.57%, and C 88.90%. The pickup time result shows that product B have a shorter pickup time and sorbed least quantity of water and more oil than the other two sheets. Also, from the reuse test, sheet B could withstand more test and hence could go for more cycles of reuse. It was also, observed that all the sorbents used were absorbents and that sheet B proved to show ability to withstand more high-rate oil exposure. So, sheet B can restore oil impacted sites to normalcy more and quickly and better overcome health implications associated with oil spillage than the other two sheets.

6. Acknowledgement:

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