Evaluating Suitable Sorbents for Spill Oil Removal

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Evaluating Suitable Sorbents for Spill Oil Removal

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Abstract - **This paper offers to the oil and gas companies the best method of spill oil removed. However, the main aim is to evaluate sorption capacity of different sorbent suitable for oil removal. It also presents results of the various experimental analysis conducted on sorbents in seawater and their sorption capacities. Analysis revealed that, sorbent material from plant (vegetable) origin are not very good industrial medium for absorbing and cleaning up oil spills, though they show certain degree of oil sorption. Synthetic materials such as polyethylene fibre sheet are best materials for oil sorption. The use of dispersants, Booms, Berm methods and skimmers studied in this work to control oil spills are satisfactory. However if sorbents must be considered as priority over other methods, then synthetic material such as polyethylene fiber sheets or foams should be considered the best, and if used, the sorbent material should be removed from water immediately as they will loss buoyancy and sink if left afloat for long period.**

I. INTRODUCTION

Oil spill is an accidental /intentional discharge of crude oil or petroleum product into the natural environment (B. Simons, 1987) when this happens, the major problems become those of the oil removal, this is because of the devastating consequences of the spill on the marine environment, which may cause irreversible chain effect on both the bio-diversity and human safety. The number and activities of the oil and gas companies have increased tremendously over the last 30 years, and in the Niger Delta region particularly. Among, the activities carried out by these oil and gas industries are:(1) Drilling (2) Production (3) Storage (4) Shipment (5) Well Services and many other maintenance activities. Many of these activities may lead to oil spillage on either land or sea. The information discussed here is basically of spill oil activities occurring in the seas and creeks (stream), where oil and gas production activities are carried out. There are many causes of oil spillage. which could be due to equipment failure or gross human error. Generally the major causes of oil spillage can be one or a combination of the following reasons. (Omotayo, 2000) Well blowouts. equipments/pipe line failure. barges/boat leaks, and corrosion, others could be sabotage. accident during transportation, Sub Sea pipe failures, and grossly human (Simons, 1987).

A. Detection of spill oil

Many methods were in use to detect oil spill many years ago (Catome, 1971). Among these methods are, mass spectroscopy analysis, infrared analysis, gas chromatography, and fluorescent spectroscopy. But the simplest and most available way of determining crude spill in Nigeria is visual method based on differences in colour and behavior of crude oil compared with water. Crude oil is known to be a black viscous liquid, which can easily be identified or spotted when it flows on the surface of water. Pentane plus can be colorless liquid and makes spillage hard to detect.At present, many methods of oil spill recovery and clean up are in used, these include; [1] The use of oil spill dispersants [2] Booms and skimmers, [3] Beach Berm and skimmers, [4] And the use of floating sorbents. Their usage depend on the [1] The amount of oil that is spilled,[2] The physical- properties of the oil (e.g. specific gravity, viscosity, pour- point temperature), the Cost of oil recovery, and The sea turbulence.

B. Environmental effect of spill oil

Oil spills have been known to have potential effects on human plants, animals and the marine environment as a whole (Omotayo, 2000). The magnitude of this effect depend on the One or combination of the following; the quantity of oil spilled, the quantity of pollution and its duration experienced on the organisms, the state of the oil e.g. whether crude or refined products, the season, the habitat and the natural stresses to which the organisms are subjected. (Akpofure, 2000) The cumulative effect of the spill may be in one of the following ways:

1. Direct lethal toxicity,[2] Sub-lethal disruption of physiological and behavioral activities. This leads to death owing to the interference of both feeding and reproduction, [3] Entry of hydrocarbons into the food web and, [4] Alteration in biological habitats. (Akpofure, 2000)

C. Cost implication of oil spill and clean up methods

When oil is spilled into the natural environment whether it is accidental or mere sabotage, it poses a lot of cost to the operating oil and Gas Company in form of clean up cost as well as compensation cost. Recovery methods are usually not 100% efficient and so oil, which is costly is, lost to the environment. Sometimes production of crude oil has to be suspended and that means the company loses sales and its profits. This is evident around the rural areas in the Niger Delta including Ogoni, in 1980.It cost the oil companies and the government of Nigeria as a whole about $500,000 daily in profit, rents and royalties in Ogoni land alone (Oscar, 1990). In October 1989 angry villagers in Oboburu for the same environmental pollution reasons destroyed oil-drilling equipment worth $1,000,000, belonging to ELF. (Oscar, 1990)

D. The Government influence and laws affecting oil spillage

The overall consequences of oil spillage impacts seriously on the environment even beyond the Niger Delta regions of Nigeria and in the past several years, there has been a veritable explosion of environmental laws and regulations at all levels, Federal, State and Local. This is to help the legislative to enact forceful measures to enhance the environment. This prompt oil and gas companies to take appropriate measure to control oil spillage and to intensify oil spill removal/clean up methods (Omotayo, 2000).It is therefore the aim of this research to evaluate suitable method of oil spill removal via; Carrying out experiment around the tributary of an ocean where oil spill occur to establish the fact that a number of sorbent are available for oil clean up activities. There is no doubt that the outcome of this research work will provide oil/gas companies with the best alternative method for oil spill removal.

E. Sorbents for spill oil removal

Materials that float on water attract and absorb oil and can easily be removed from the water with the oil that constitute one of the most effective means for completely separating oil from the water environment. These floating sorbents can be applied from ships and boats, from the air to and around spills as well as along the shore to intercept an advancing slick. In high sea states when containment devices cease to function, sorbents can be applied from the air if necessary, to be collected under calmer conditions or after being driven to the shore by onshore winds. Creider, 1990)

II. EXPERIMENTAL PROCEDURES.

Two basic procedures were undertaken during the cause of this study.

1. This involved day to day trips taken by oil spill and environmental department of Mobil Producing Nigeria Unlimited (a subsidiary of Exxon Mobil corporation) to reported spill sites, and monitoring chains of activities carried out to effect the removal of oil spills. Demonstration of the use of Boom and skimmers were also carried out at spill sites to remove oil spills. The use of Detergent (oil spill dispersants) was also demonstrated particularly in turbulent conditions where the use of other method was difficult. Majority of the sites cleaned up were the Ibeno shorelines and creeks where oil that was spilled offshore ended up due to oceanic waves.

2. The second procedure was basically experimental, and the development of these methods to evaluate sorbents was influenced by the need for the following information.

   a) Maximum oil sorption capacity of sorbents
   b) Effect of Turbulence on oil retention by sorbents.
   c) The effect of competition between oil and water for solid surfaces.
   d) Water sorption capacity of sorbents.
   e) Effect of viscosity on oil pick-up properties of sorbents.
   (f) Buoyancy retention of sorbents on seawater.

To provide the following information and to establish the fact that a number of sorbents are available for oil clean up activities, the experiment was carried out in the tributary of an ocean. Buoyancy test was conducted in the laboratory and the results are presented in tables' 1to5

A. Procedure for buoyancy tests

Weighed samples of each sorbents are submerged separately in the three test oils for 15 minutes with frequent stirring to assure saturation. The sorbents are then drained of the test oils with wire screen Baskets having 1/16 inch openings. After draining, the oil-soaked sorbent samples are placed each in one litre bottle one-half full of seawater. The bottles are stopped and shaken for 6 hours at closely controlled rate and amplitude, which is adjusted so that the oil soaked sorbent, is frequently doused with sea water. After shaking the consistency and buoyancy of the oil/sorbent mixture is noted. From buoyancy test, the percentage oil retention of sorbent material as well as water pick up of oil soaked sorbent were obtained. The water/oil ratio of oil soaked sorbents was also obtained in this experiment using empirical relationship.

B. Procedure for sorption capacity test for sorbents

Measured quantities of the test oils were each spilled into designated areas of the Creek, the spilled oil were prevented from being carried away by water currents with containment booms. Weighed quantities of sorbents were applied to the spilled oil each in a separate boom area, and allowed to soak for 30 minutes to assure saturation. The oil soaked sorbent materials were further agitated by shaking the water/oil surface within the boom areas, this was to simulate oceanic waves which may occur during typical oil spill clean up sessions The oil soaked sorbent materials were then removed from the boom containment area, and drained of oil in screen baskets which allows oil to drain of by gravity. Compressing them in a compactor where the remaining oil and water were squeezed out further drained the sorbents. All drained oil and water were separated and measured for each sorbent test and for the different oil samples.

Oil droplets remaining in the experimental sites in the creek were dispersed using industrial dispersants.

III. RESULTS

The results of the experiment are presented bellow:

TABLE 1.0 BUOYANCY TEST AFTER SHAKING SORBENTS IN SEAWATER FOR 6 HOURS

Test sorbent	Observation
Rice husk	Sinks
Saw dust	Sinks
Groundnut hulls	Sinks
Corn cob (ground)	Sinks
Polytethylene fibre sheet	Floats

TABLE 2.0 WATER PICK UP RATES OF OIL SOAKED SORBENTS IN KILOGRAM PER KILOGRAM OF OIL SOAKED SORBENT

Test oils	Rice husk	Saw dust	Ground nut hull	Corn cob	Polyethylene fibre sheet
Light Crude oil	0.8	3.14	0.82	0.62	0.68
Diesel	0.8	3.2	0.81	0.58	0.70
Condensate C5+	0.85	3.5	0.85	0.50	0.75

TABLE 3.0 WATER OIL RATIO OF OIL SOAKED SORBENTS

Test oils	Rice husk	Saw dust	Ground-nut hulls	Corn cob	Polyethylene fibre sheet
Light crude oil	0.58	0.60	0.58	0.580	0.33
Diesel	0.43	0.36	0.36	0.45	0.03
Condensate C5+	0.33	0.39	0.35	0.25	0.01

TABLE 4.0 SORPTION CAPACITIES IN KILOGRAM OF OIL/KG OF SORBENTS

Test oils	Rice husk	Saw dust	Groundnut hulls	Corn cob	Poly-ethylene fibre sheet
Light Crude oil	5.8	4.1	6.0	5.7	37.0
Diesel Oil	4.0	3.2	4.8	4.5	28.2
Condensate $C5^+$	2.3	1.8	2.2	1.7	10.3

TABLE 5.0 PERCENTAGE OF OIL RETENTION BY SORBENT MATERIALS

Test oils	Rice husk	Saw dust	Ground nut hulls	Corn cob ground	Poly-ethylene fibre sheet
Light Crude oil	94	83	58	96	99
Diese l Oil	90	79	55	94	98
Cond ensate	78	70	75	75	80

IV. DISCUSSION OF RESULTS

A detail investigation on the use of sorbent for oil removal had been performed under prevailing environmental conditions. Table 1 shows that sorbent materials of plant origin have inherent properties of picking up oil and sink if left afloat for every long time, when introduced to the oil, they do so to a limited extent compared to synthetic materials. This is in agreement with literature that sorbent material of plant origin loses its buoyancy after 6hours in turbulence water condition [Creider, 1990]. Polyethylene fiber sheet show negative buoyancy after this period. Buoyancy is an important characteristic of sorbent if the oil must be recovered, Loss of Buoyancy under turbulence is an undesirable sorbent characteristic, since it is not always feasible to apply sorbents directly to the oil slick, and only partial coating by the oil can be expected under field conditions. If subsequent contact with water causes loss of buoyancy, the oil on the sorbent will sink and will not be recovered or clean up [Woodhouse, 1981].

Table 2.0 show that oil soaked Polyethylene fiber sheet picks up less amount of water from the three test oils compared to other sorbents, which is a desirable property of industrial sorbents. The water pick up capabilities of sorbents may be attributed in part to the formation of water in oil emulsion since the test oils also show good emulsion forming characteristics. Polyethylene fiber sheet show favourable properties as they absorb less amount of water once they have already picked up oil. Sawdust has a good affinity to pick up water. Other natural sorbents have variations in their water pick-up capabilities, and all have higher water to oil sorption ratio compared to polyethylene fibre sheet [see table 3.0]. Hence the polyethylene fibre sheet is regarded as the best alternative. The highest water/oil ratio of oil soaked sorbent is found with the crude oil, this indicates the formation of water in oil emulsion. The variation in water/oil ratios between sorbents suggests different degrees of sorbent involvement in emulsion stabilization.

From Table 4.0 It could be observed that the highest sorption capacities are exhibited by polyethylene fibre sheet. They also absorb considerable amount of water [see table 2.0]. This means that during application of this sheet to oil spills, care should be taken because, if they are not introduced directly to oil spills there is the tendency that they will contact water before they contact oil, and when this happens, they will lose significant capacity for oil sorption. Apart from the polyethylene fibre sheet, which is a synthetic material, other sorbent materials show reasonable but insufficient sorption capacities, which make them useable only in small and residual oil spills. All sorbent materials show greatest sorption capacities with oil of higher viscosities, and as viscosities reduce, their ability to pick up the oil in great quantities also reduce. This is also evident in table 4.0

Table5.0 shows sorption capacities of sorbents. Polyethylene fibre sheets show the highest percentages because of their high capacity for sorption of oil. Viscous oils will cling easily to sorbent materials, in this research the most viscous oil, that is, light crude oil show the highest percentage of oil retention. Considering all sorbent materials. Diesel oil of medium viscosity show medium percentages while condensate (C5+) shows the least oil retention percentages due to its relatively low viscosity. There is a wide variety of spill oil control/clean up measures available for oil producing companies operating in the Niger Delta zone of Nigeria. The clean-up measures range from those which employ recovery measures [Booms and skimmer methods] to get back the spill oil into treatment facilities in which case the oil is still worth some money, and others which employ measures which do not allow oil to be recovered and sold e.g. dispersant method. The spill clean up adopted by production or clean-up companies depend on a lot of factors which may be weather, sea turbulence, cost etc The use of beach barn method is the most practicable when spill oil has drifted towards the shallow shore line. Based on the experimental work carried out and documented in this work, sorbent method of cleaning allows oil to be recovered and sold, but a lot of treatment has to be carried out before this is feasible. The cost effectiveness of the sorbent tests were not considered ntensively since it involves not only the initial cost of materials but also the nature of the spill oil, environmental conditions, and other factors. Other factors which can have a profound influence on cost-effectiveness is sorbent reusability and on-site generation of sorbent which is a potential exhibited by the synthetic materials, this needs to be investigated. Polyethylene fibre sheet appear to have reusability potential, but this needs to be investigated further.

V. CONCLUSIONS

In line with the level of the research work on these sorbents and within the limitations of the experimental confinements and procedures used, the following conclusions can be drawn. Polyethylene fibre sheet have the highest sorption capacities for oils. This capacity is essentially dependent on the viscosity of the oils; they also absorb water readily which reduces their capacity for oil sorption.

Natural organic sorbents (plant origin) lose buoyancy when preferentially and vigorously contacted with water they do not show as high sorption capacities for oil as the organic synthetic materials. Therefore if natural organic materials of plant origin are selected for oil spill clean-up, the time of application of sorbent and its retrieval has to be short because when the materials are left for a long time, they loose buoyancy and sink with the oil, in which case oil is not recovered where there is a lot of turbulence, these materials do not make a good option too. The experimental methods for evaluating these oil sorbents are satisfactory and the results can be applied in the selection of sorbents for full scale sorbents dispersal and recovery systems.

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