INVESTIGATION OF A SUITABLE METHOD OF OIL SPILL REMOVAL

A CASE STUDY OF
MOBIL PRODUCING NIGERIA UNLIMITED, EKET,
AKWA IBOM STATE A SUBSIDIARY OF EXXONMOBIL
CORPORATION

BY

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CERTIFICATION

I hereby certify that this project titled " **Investigation of a Suitable Method of Oil Spill Removal " (A case study of Mobil Producing Nigeria Unlimited, Eket, Akwa Ibom State, A subsidiary of ExxonMobil Corporation)** was carried out by **Marian Udoka Mohammed** Under the supervision of **Engr. M. A. Olutoye,** Department of Chemical Engineering, Federal University of Technology Minna Niger State.

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EXTERNAL EXAMINER	**DATE**

DEDICATION

This is work dedicated to the glory of God.

ACKNOWLEDGEMENT

My sincerest gratitude goes to God the Giver of all things. I also owe gratitude to Engr. M. A. Olutoye who was there to offer me his intellectual support at all times during the course of this work.

I also wish to recognize the efforts of the Environmental Department of Mobil Producing Nigeria Unlimited Eket Akwa Ibom State for offering me both material and human resources to assist me excel in this work,

Among the litany of whom I also owe gratitude are Dr. Ijah and Engr. Saka for their intellectual support. My husband for being there for me, My son Edidiong for being the source of my inspiration. My parents Mr/Mrs Zakary Yau' Mohammed, my brothers and sisters and my two wonderful families in Abuja and Akwa Ibom State.

How can I forget the family of Mr/Mrs Ubong Joshua who stayed awake all night to do the computer graphics.

The last and not the least of my gratitude goes to my colleagues, lecturers and the entire staff of the department of chemical Engineering. Federal university of Technology. Minna.

ABSTRACT

Investigation of different Methods of oil spill removal, A case study of Mobil Producing Nigeria Unlimited. Eket, Akwa Ibom State (a subsidiary of ExxonMobil Corporation) had been carried out in offshore Environment where most of the company's production and treatment facilities are situated. It also extended into the creek and tributaries of Ibeno River, where the Experimental surveys and demonstrations were carried out. The causes of spillage, their resultant effect on Environment and the legal implications of spillage by way of Governmental influence and laws were also assessed. The study also included demonstrations of oil spill clean up methods such as the use of oil spill dispersants. The use of Booms to contain oil, the use of beach Berm methods for oil spills encroaching ashore due to oceanic waves and the use of sorbents to clean up oil spills.

The use of sorbents to control oil spills and the inherent properties of sorbents that support its use to control spills were experimented.

The results obtained from this work show that, sorbent materials from plant (vegetable) origin are not very good industrial medium for absorbing and cleaning up spills, though they show certain degree of oil sorption. They lose bouyancy and sink with the oil in relatively short period. Synthetic materials such as Polyethylene fibre sheet are best materials for oil sorption.

The use of Dispersants, Booms, Beach Berm methods and skimmers studied in this work to control oil spills are satisfactory, but if sorbents must be considered as a priority over others, then synthetic materials such as Polyethylene fibre sheets or foams should be considered the best. Sorbent materials of plant origin may be used in cleaning up residual oil spills, and if used, the sorbent materials should be removed from water in few hours, as they will lose buoyancy and sink if left afloat for long periods.

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CHAPTER ONE

1.0 INTRODUCTION

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.

"All these activities may lead to oil spillage which is an accidental discharge of crude oil from oil formation, oil treatment /production facilities, shipment facilities, storage facilities etc into the natural environment."

Oil spill may occur on land and on sea, the information discussed herein are basically those of spill activities occurring in the seas and creeks (streams), where oil and gas production activities are carried out.

"When oil is spilled into the natural environment (water), 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 effects on both the bio-diversity and human safety."

There are several methods, used in the removal of spilled oil from the sea, and the use of these methods depend on several factors, which include:

1. the amount of oil that is spilled.
2. The physical properties of the oil (e.g. specific gravity, viscosity, pour-point temperature).
3. The Cost of oil recovery
4. The sea turbulence

It is important to note that no one method may be sufficient for the complete removal of spilled oil. A combination of methods are usually employed to achieve greater percentage of oil removal from the sea.

At present, the methods that are used for oil spill recovery and clean up include:

1. The use of oil spill dispersants
2. The use of booms and skimmers
3. The use of Beach Berm and skimmers
4. The use of floating sorbents

These methods are discussed in isolation herein, but in typical oil spill clean up situation, they could be employed in combination to achieve good results.

1.1 OBJECTIVES OF WORK

Considering the fact that a number of methods are available and used in the removal (clean-up) of oil spills, this work investigates into the various methods their efficiency and practicability.

It also seek to understudy proven modern techniques for the protection and clean up of oceans and creeks (stream) as well as the vicinity of the facilities from where spills originate.

This work especially experiments into sorbent methods of removing oil spill, comparing the efficiency of synthetic organic materials like Polyethylene fibre

sheet with those of Natural organic materials of plant origin (Rice Husk, corn cob, groundnut hulls and sawdust) in the removal of oil spill.

This work does not go deep into the financial details of the methods as comparison between one another as this depends on a number of other factors including climate which is most difficult to predict.

Though some of the methods under-studied in this project can be used in isolation. It is worthy to note that when used in combination in typical field situations, the results will appreciate, and the cost too.

1.2 AREA OF FOCUS

This study is carried out on the vicinities of offshore facilities of Mobil Producing Nigeria . It also extended to Ocean and creeks of the surrounding community of Ibeno in Ibeno Local Government Area of Akwa Ibom State which is proximate to the producing facilities of Mobil Producing Nigeria Unlimited.

Though few methods (sorbent methods) were basically experimented, survey shows that all methods discussed on this work are proven methods and are still recommended in day to day oil spill clean up acts that occur in oil and gas industries within the globe.

The scope of this work therefore includes:

1. Causes and sources of spillage
2. Detection of oil spills
3. The various methods used to remove oil spills
4. The Environmental effects of oil spills
5. The cost implication of spills clean up
6. Governmental influence and law affecting spills.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 DEFINITION OF OIL SPILL

Oil spill is an accidental discharge of crude oil or petroleum products into the environment. Other types of spills can be described as an intentional discharge of crude to the environment directed towards attracting compensation from oil and Gas companies. This is a sabotage situation. (1)

2.2 USE OF CRUDE OIL

There are numerous uses of crude oil in the world today and it might be impossible to make a list of them all. The uses of crude oil cuts across Petro-chemical industries to the power plants. Crude oil is refined into numerous products like petrol, kerosene, Diesel, Jet fuels, Bitumen and many other specific components. The usefulness of these fractions as fuel both in domestic and industrial environments cannot be over-emphasized. Petroleum products are also used in the manufacture of domestic handware in form of plastic based items. Most importantly, crude oil forms the biggest portion of our foreign earning in Nigeria upon export.

2.3 THE NIGER DELTA AND ITS OIL BUSINESS

Petroleum exploitation in Nigeria dates back to the first few years of the 19^{th} century. Organized marketing and distribution was started around 1907 by the German company, Nigeria Bitumen corporation. In 1956, the Anglo-Dutch group shell D' Archy, discovered oil in commercial quantities at Oloibiri a town in the Niger Delta. By February 1958 Nigeria had become an oil exporter with

production level of 6,000 barrels per day other multinational oil companies have joined Shell petroleum development company of Nigeria (SPDC) at peak production. In the 1970's Nigeria's Crude oil output was 2,000,000 barrels per day (6).

Today, crude oil is produced in eight states of the federation namely River (split into 2 states – Rivers and Bayelsa in October 1996) Delta, Edo, Imo, Abia, Akwa –Ibom, Cross River and Ondo States. The old River State account for over half the total crude oil production in Nigeria. Shell Remains the largest producer.

Recently the company reported that in all, it had 94 oil fields covering an area of 31,000 square kilometers in the Niger Delta from which nearly one million barrels of oil were produced daily. (7).

Similarly Mobil Producing Nigeria Unlimited which is now a subsidiary of Exxon Mobil Corporation operates its production facilities mainly on the Atlantic Ocean. Among the Offshore production facilities are Oso Platform, Usari, Platform, Edop Platform, Ekpe platform, Ubit Platform, Inim Platform Utue and several others.

2.4 CAUSES AND SOURCES OF SPILLAGE

There are many causes of oil spillage which could be due to equipment failure or gross human error. Generally the major causes oil spillage can be one or a combination of the following reasons. (8)

2.4.1 WELL BLOWOUTS:

The reservoir where oil accumulates by nature is known as oil formation and is usually characterized by enormous pressures which may be as high as 5000psi and at times approaching 10,000psi.

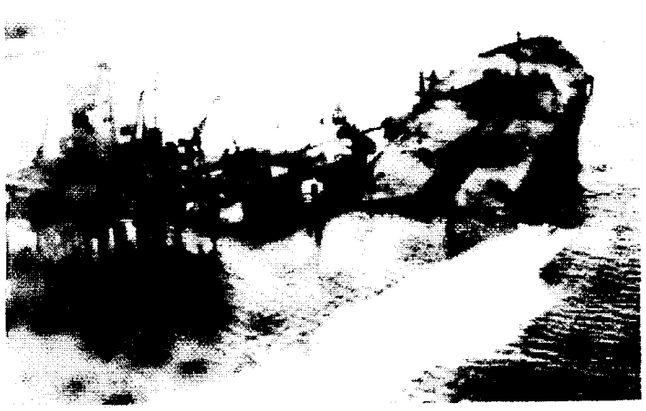
Drilling is therefore a very delicate and dangerous operation of channeling tubings and casings into the formation to enhance crude oil flow to the surface where they are treated and sold. A number of blow-outs have been recorded during this drilling operations, where oil under pressure blows-outs the drilling equipment and finds its way to the surface uncontrollable resulting in spills. Other blowouts may occur on completed wells that are producing. This may be attributed to equipment failure.

2.4.2 EQUIPMENT FAILURE/PIPELINE FAILURE:

A wide variety of equipment are used in crude oil production and treatment. These equipment may fail and release large quantities of crude to the atmosphere. These kinds of equipment include pumps, Heat exchangers, control valves, instrument fittings etc. Pipelines may also fail in similar manner and corrosion could be responsible for such pipe failures.

2.4.3 BARGE / BOAT LEAKS:

Barge and Boat leaks are vessels that may be designed for and used to contain crude oil both for production, treating and transportation purposes. And when they leak, oil is spilled into the surrounding water. At times, these vessels may sink due to accident. Example of accidental sinking of boat is shown below.



2.4.4 CORROSION:

Corrosion plays a very vital role in the integrity of pipe work structure and equipment used in oil and gas industry. Without proper maintenance, facilities degrade due to corrosion and eventually fail and discharge crude oil which is supposed to be contained in these facilities.

Several other activities can result in oil spillage and these centers around oil and gas production facilities and during transportation. Other causes of oil spillage are Sabotage, Accident during transportation, Sub sea pipe failure, Lack of equipment maintenance. (1)

2.5 DETECTION OF OIL SPILL

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. Other types of crude oil e.g. condensate (Pentane plus). Which is a type of crude produced by Oso complex of Mobil Producing Nigeria Unlimited (Offshore Production facility) can be colourless liquid and makes spillage hard to detect. Methods of sampling and analysis oil spilled to establish its identity and therefore quantifying associated hazards have been developed many years ago. (2)

Among these method are, mass spectroscopy analysis. Others include infrared analysis, gas chromatography, flourescent spectroscopy etc. Most of these methods are basically to determine the type and components of crude oil. But the simplest and most available way of determining crude spilled in Nigeria is visual method based on differences in colour and behaviour of crude oil compared with water.

2.6 METHODS OF REMOVING OIL SPILLS

This is considered in details on chapter 3 but among the list of oil spill clean up methods investigated in this work are the following:

1. Use of oil spill Dispersant
2. Use of Boom and skimmer
3. Beach Berm method.
4. Vortex recovery of floating oil
5. Use of Sorbents for oil spill removal.

2.7 ENVIRONMENTAL EFFECT OF OIL SPILLS

Oil spills have been known to have potential effects on human plants, animals and the marine environment as a whole (8).

Some factors determine the effect of oil on aquatic life, sometimes a combination of these factors acts simultaneously, and these factors include, the quantity of oil spilled, the quantity of pollution and its duration experienced on the organisms, the state of the oil, the season, the habitat and the natural stresses to which the organisms is subjected. (5)

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 behavioural 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 biological habitats. (5)

Oil spill is usually associated with emission of hydrocarbon, gases into the environment, and some oil spills may even be associated with explosion and fire

outbreaks in the oil and gas industry such as the one that occurred in Ubit platform at Mobil Producing Nigeria Unlimited, Eket Akwa Ibom State (1987). When oil spill is associated with industrial gas fires, the pollution becomes immense and goes beyond marine environment. Such pollution will extend its effect and will have global and regional impact. This is because carbon-dioxide is released along with methane and ozone, this leads to increase in average global temperature (8).

The effect of this pollution on plant is also enormous, the metabolic pathways of plant may be overloaded as plants try to transform and detoxify these pollutants. This damage the integrity of the plasma and cellular membranes. Ambient SO_2 can cause direct damage to leaves and in long term stunt plant growth. (5)

In the marine environment where fishes grow, the habitat can be damaged due to oil slicks, fish eggs and larvae suffer high rate of mortality, as against the adult fish which may swim away before they get hurt.

The negative environmental impact of crude oil spills may be explained by the pollution arising from spill which makes water unsuitable for fishing, it also renders many hectares of farmland unusable. Brine from oil fields contaminate water formations and streams making them unfit for drinking.

In addition, toxic and biodegradable by-products of oil is dangerous to flora, Fauna and human kind. They enter food chain both by direct intake via food and drinking water and indirectly. For example fish is known to be able to store Mercury which is a component of some type of crude in its brain without metabolizing it. Man in turn could eat such contaminated fish. (5)

At other times oils spills may be swept away by ocean currents or tides and eventually end up in the shorelines and finally in arable swaps where agricultural activities may be stagnated.

2.8 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 results in additional operating cost to the oil and gas companies 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.

From about 1980, rural areas in the Niger including Ogoni, began fight due to the spills and environmental pollution which has shut-down oil wells across the region. This is costing oil companies and Nigeria as a nation about $500,000 daily, in profit, rents and royalties in Ogoniland alone. (6)

In October 1989 oil drilling equipment worth $1,000,000, belonging to ELF was destroyed by angry villagers in Oboburu for the same environmental pollution reasons. (6)

In 1999 when oil spillage occurred on a ruptured sub sea transfer pipeline on Idoho platform of Mobil producing Nigeria Unlimited, more than 5,000 barrels of crude oil went into the environment and eventually ended up in Qua Iboe Terminal river. Though clean up activities took place almost immediately residual oil ended up being deposited at the shore lines. This oil spill has costed the company huge amount of money in both compensation and in clean up activities and as at the time of this study, the company is still paying compensation to

inhabitants of Ibeno, Ukpenekang, Ikot Abasi and other communities living on the shore lines. Recent expenditure not included the Company has so far spent a total of $500,000,000 as at the time of this study. (6)

2.9 THE GOVERNMENT INFLUENCE AND LAWS AFFECTING OIL SPILLAGE

The overall consequence 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.

Civil liability could give rise to injunction to cease certain operation or to pay damages which may be very considerable to the defaulters. The regulatory dimension of Nigeria's oil control programme has considerable potential for growth and definition in the context of environmental protection (1)

The Nigeria legislation Review that affect the petroleum industry which may affect activities of these industry in relation to oil spillage either directly or indirectly are as follows:

1. The Nigeria National Petroleum corporation Decree 1977
2. The Petroleum Act 1969
3. The petroleum (Drilling and production) Regulations 1969.
4. The petroleum Refining 1974
5. The Oil in Navigable water decree 1968
6. The Oil in Navigable water Regulations 1968.
7. The Oil Terminal Dues Decree 1969

8. The Oil pipeline ordinance 1936 as Amended

9. The Petroleum Regulations 1967

10. The Petroleum Technology Development fund Decree 1973

11. The Exclusive economic Zone Decree 1978.

Most of these laws and degree have under gone transition of amendments but their contents are aimed at protecting the overall environment.

CHAPTER THREE

3.0 OIL SPILL REMOVAL AND CLEAN UP METHODS

The type of oil spill removal and clean up method will depend on a variety of factors which include:

(1) The amount of spill to be cleaned up

(2) The type of oil that is spilled

(3) The cost of clean up method

(4) The oceanic turbulence

(5) The temperature and viscosity of the oil.

3.1 METHOD OF OIL SPILL REMOVAL

(1) Use of oil spill dispersants

(2) Use of Booms

(3) Beach Berm Methods

(4) Sorbents method

(5) Use of skimmers

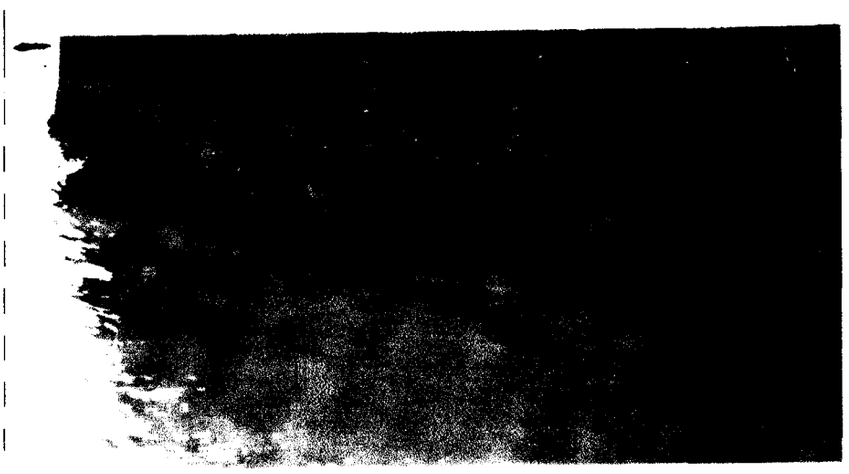
3.2 USE OF OIL SPILL DISPERSANTS

Chemical dispersant can sometimes be used to combat oil pollution by breaking up oil slicks into very small droplets. These become suspended in water and are rapidly diluted by the turbulent motion of the sea. Dispersion of the oil into water prevents the formation of persistent water in oil emulsions and residues which are difficult to clean up. In dispersed form, the oil is available for degradation by micro-organisms which occur naturally in the sea.

3.2.1 MECHANISM OF CHEMICAL DISPERSANTS

When a great deal of mixing energy is imparted directly into the oil-water interface, the oil may disperse naturally. Such natural dispersion does in fact occurs in moderately rough seas but the addition of dispersant accelerates this process (9).

The key component of a dispersant is a surface – active agent (surfactant) which has a molecular structure such that one part of the molecule has an affinity for oil (oleophile), and the other has an affinity for water (hydrophile). When evenly applied and mixed into floating oil, the molecules become arranged at the oil – water interface with the result that the interfacial tension between oil and water is reduced favouring the formation of timely dispersed oil droplets with a combined surface area greater than the original oil slick. For a fixed amount of mixing energy, a reduction in interfacial tension between oil and water will result in a corresponding increase in combined droplet area. The smaller the droplets the greater the chance that they will remain suspended in the water because of their very slow rise in velocity. If oil is satisfactorily dispersed, a characteristic plume can be seen to spread slowly down from the water surface a few minutes after treatment.



Picture of dispersed oil after application of dispersant

Apart from promoting droplets formation, dispersants perform a secondary role by preventing coalescence of the droplets once they are formed (9).

The effective distribution of surfactant throughout the oil is very important and most dispersants therefore contain a suitable solvent system, which penetrates the oil and acts as a carrier for the surfactants. If the oil is very viscous, dispersants are ineffective, since they tend to run off the oil into the water before the solvent can penetrate. As a general rule, dispersants are capable of dispersing most liquid oils with low viscosities (less than 200 centistrokes). They are not suitable for dealing with very viscous oil or emulsions. (9)

3.2.2 METHODS OF APPLICATION

The method of application depends primarily on:

(1) Types of dispersants

(2) The size of the spill

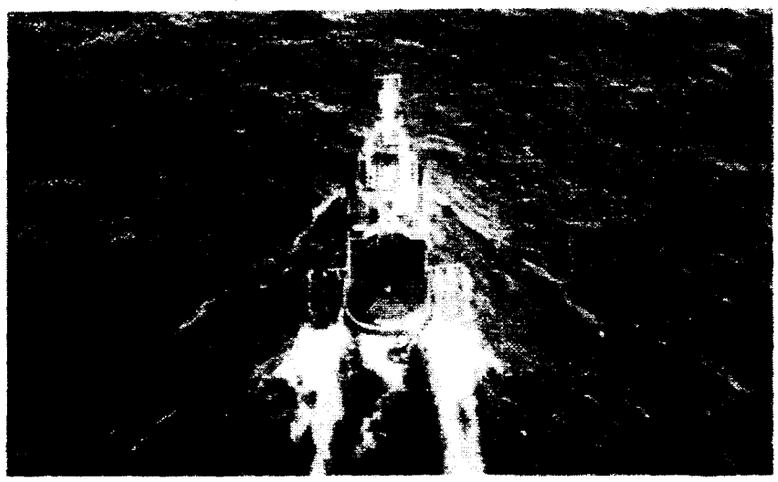
(3) The location of the spill

(4) The availability of equipment or air craft for spraying the dispersants.

When specialized spraying equipment is not available, the fire pumps and the hose fitted to most vessels can be employed to achieve simultaneous application and mixing of the concentrate dispersants.

Fire hoses or fire monitors can be particularly suited for dealing with small spills in confined spaces, such as under jetties. However hydrocarbon solvent based dispersants should never be applied using the fire equipment.

When hydrocarbons based dispersants or diluted concentrate are to be used from spray booms mounted on vessels, it is possible to achieve the required mixing by towing surface agitation boards through the treated slicks.



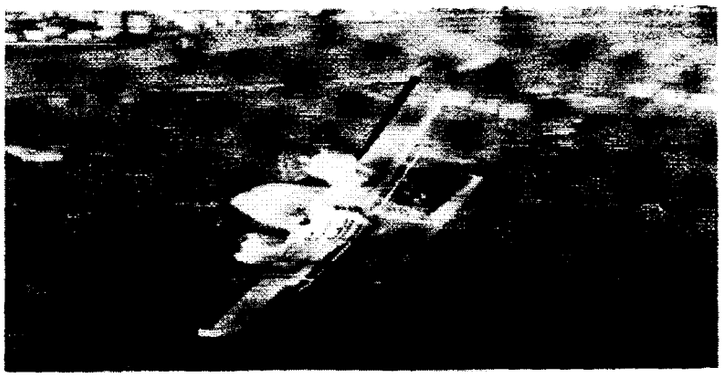
Warren Spring Laboratory designed spray booms and surface breaker boards being used from a tug.

The dispersant is usually sprayed at a constant rate and the ratio of dispersant to oil can be adjusted by varying the speed of the vessel or closing off one of the spray booms.

There are other types of spraying equipment like the Helicopters and large multiengine air craft which are designed specifically for spraying of chemicals. When aircrafts are used, specialized equipment are usually mounted to achieve the spraying purpose. Booms, wind driver pumps, nozzles can be mounted on Helicopters or multiengine aircraft to suit the spray of chemical dispersants. See figures below

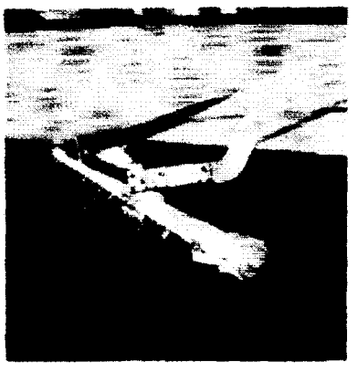
Despersant tank inside a Dc6

Dc4 spraying Despersant

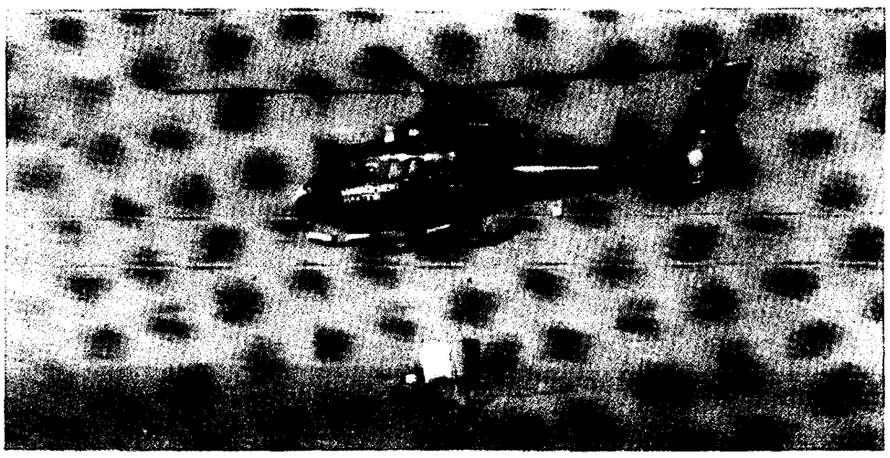


Underslung Belly Tank

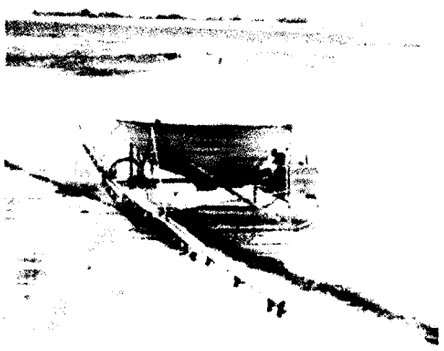
Wind driven pump



Spray Bomb and Nozzle



Bucket Spray System mounted on Helicopter



Bucket Spray Boom Assembly

Bucket Spray System mounted on Helicopter

Helicopter

3.3 USE OF BOOMS

When oil is spilled on the sea surface, its removal or reflection from sensitive areas is often required. Both operation call for the use of floating barriers or booms (10).

3.3.1 DESIGN PRINCIPLES:

Booms design vary considerably, but normally incorporate the following features

(1) Free board to prevent or reduce splash over

(2) Subsurface skirt to prevent or reduce escape of oil under boom

(3) Floatation by air or some buoyant material

(4) Longitudinal tension member (chain or wire) to withstand effects of winds waves and currents.

Booms designs fall into two broad categories:

3.3.1.1 CURTAIN BOOMS:

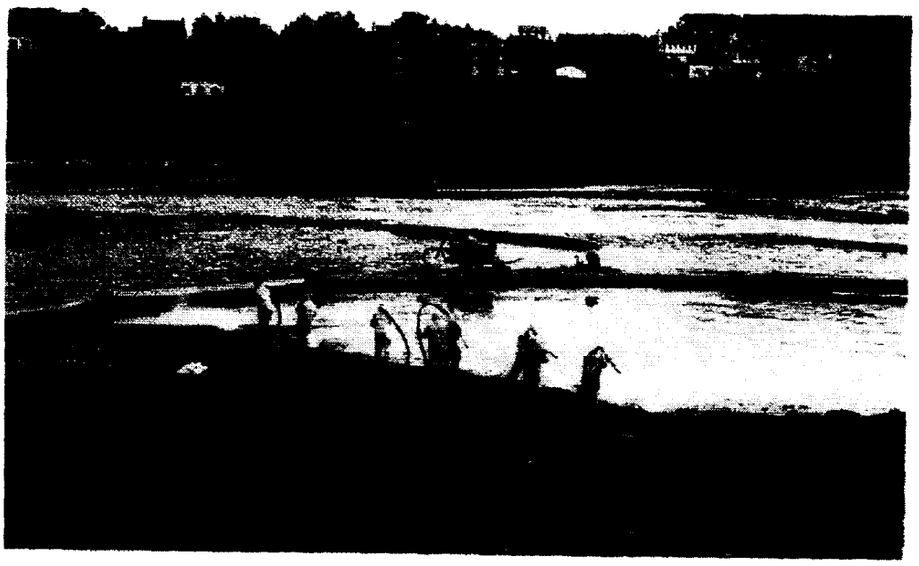
providing a continuous sub-surface skirt or flexible screen supported by a floatation chamber usually of circular cross-section.

3.3.1.2 FENCE BOOMS:

Fence Booms are of flatter cross-section held vertically in the water by integral buoyancy. Many designs include bracing strut and or integral ballast to keep them vertical in water, couplings for joining sections together as well as towing and anchoring points.

The most important characteristics of a boom is its oil containment or reflection capabilities determined by its behaviour in relation to water movement. It should be flexible to conform to wave motion yet sufficiently rigid to retain as much oil as

possible. The size and length of boom sections are also important consideration. The optimum size of a boom is largely related to the sea state under which it is to be used.



Booms can further be categorized into:

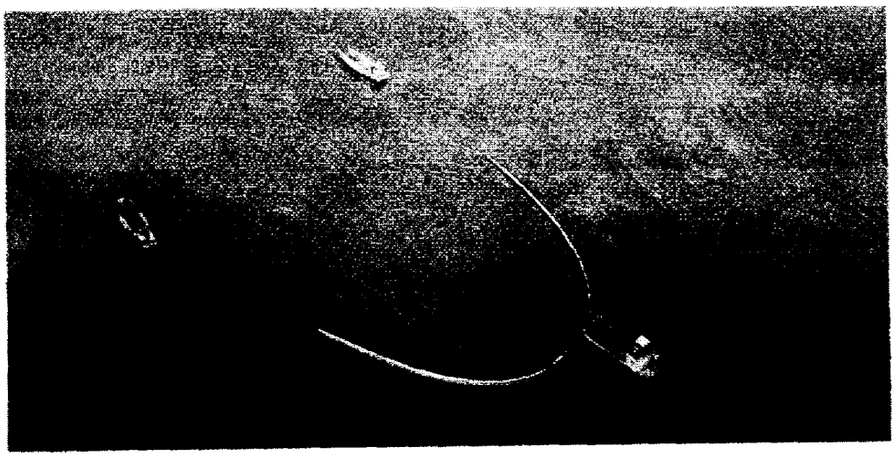
(a) Towed Booms

(b) Moored Booms

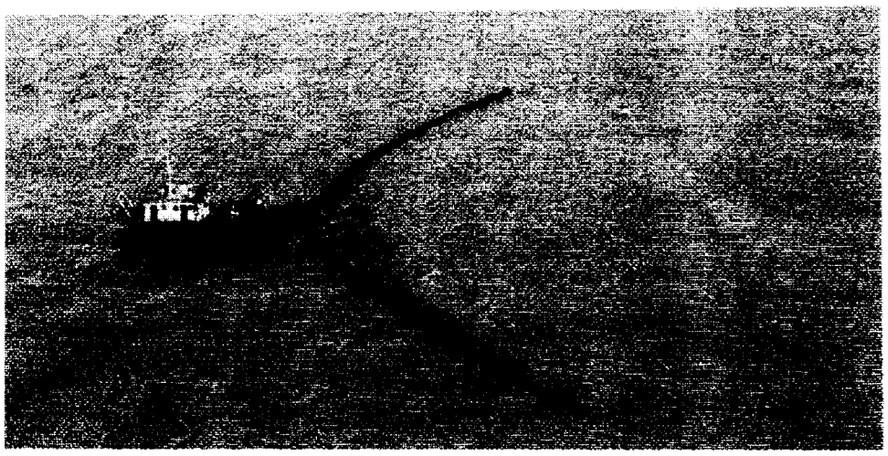
3.3.2 TOWED BOOMS:

The rapid spread of oil spilled at sea over a large area poses the most serious problem in attempting to tow booms to curtain floating oil. This combined with the limitation of boom performance is such that containment and collection techniques on the open sea will, in most cases, be only partially successful. In an effort to prevent spreading and maximize encounter rates, long booms of 300 metres or more in U, V, or J configuration may be towed using two vessels. The collection device is either towed with the boom or deployed from the third vessel behind when booms are used to contain spilled oil, the oil contained within the

boom has to be collected by using skimmers, which makes this method very economical as the skimmed oil can be reprocessed and sold.



Towed boom U-Configuration



Towed boom V-Configuration

TOWED BOOM CONFIGURATIONS

3.3.3 MOORED BOOMS

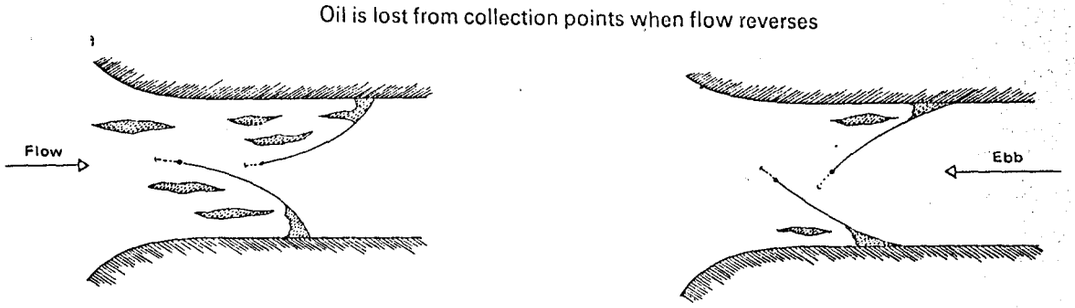
In exceptional cases or circumstances it can prove practical to moor booms to contain spilled oil quite close to a source such as a leaking tanker, barge or offshore oil well, but in many cases, particularly offshore, waters are too exposed to currents too strong for moored booms to be effective. Furthermore, the placing of booms close to the source may create fire hazard and interfere with attempts to stem the flow of oil.

If moored booms are used to contain oil where there is flow and ebb conditions of flowing water, then it is possible to loose contained oil when flow direction changes.

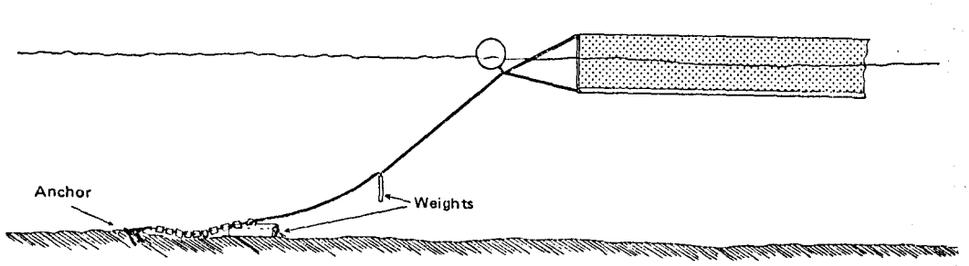
Staggered Boom Configuration

STAGGERED BOOM CONFIGURATION ACROSS A CHANNEL

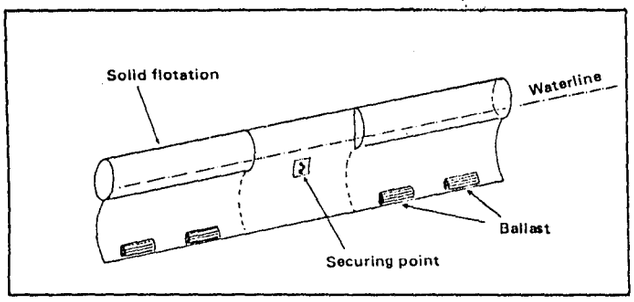
Oil is lost from collection points when flow reverses



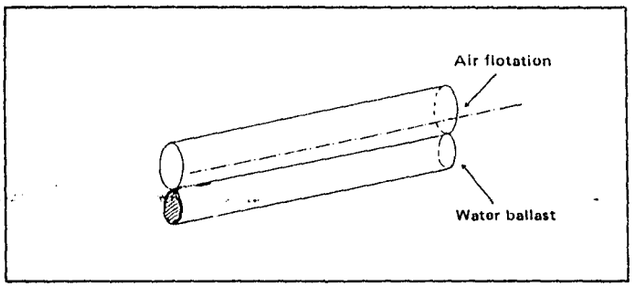
TYPICAL MOORING ARRANGEMENT



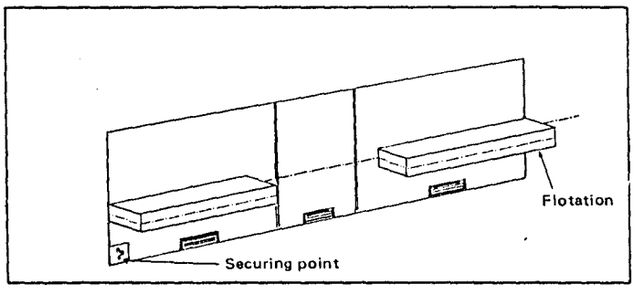
SOME TYPICAL BOOM DESIGNS



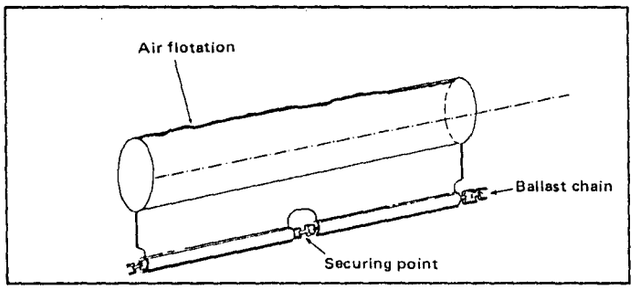
A curtain boom with mooring points attached at intervals along its length at the waterline. Low oil escape velocity. Easily deployed and cleaned, resistant to damage by debris, reasonable surface following ability. Bulky in storage. Preference moored.



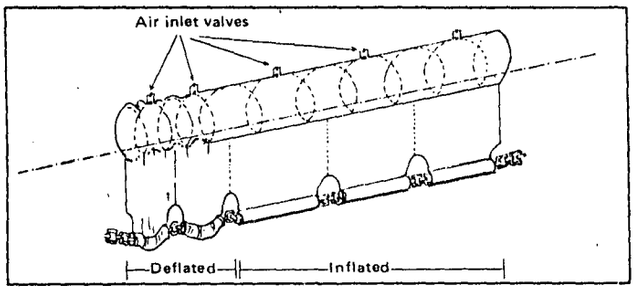
Air flotation boom supporting a water-filled tube as a skirt. No integral mooring points but waterline towing pennants at either end. Moderate escape velocity and excellent surface following ability. Deployment and cleaning easy but susceptible to damage and sinking due to fabrication as a continuous length. Low volume storage. Preference towed.



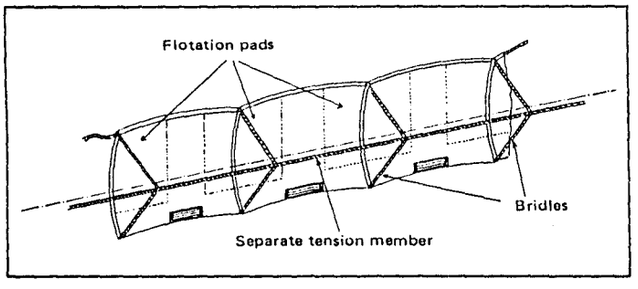
Fence boom with mooring points at intervals along its length at the bottom. Fairly low escape velocity due to turbulence caused by the intermittent floats. Average surface following ability. Easy to deploy, resistant to damage, difficult to clean. Bulky in storage. Preference moored.



A curtain boom with a combined ballast and tension chain fitted in an integral pocket attached to bottom of skirt. Mooring points at intervals along the bottom. Moderate escape velocity. Good surface following ability. Easy to deploy and clean. Prone to damage by debris. Low volume storage when deflated. Preference moored.



Curtain boom with self-inflating air tube and combined ballast and tension chain fitted in a pocket attached to bottom of skirt. Mooring points at intervals along the bottom. Internal former to maintain shape. Moderate escape velocity. Good surface following ability. Rapid deployment capability. Cleaning difficult. Prone to damage of internal structure and ingress of water through air valves. Low volume storage. Preference moored.



A fence boom with mooring/towing points from end of separate tension member, which is attached to boom by short bridles. High escape velocity. Good surface following ability. Difficult to deploy because of complexity of rigging, difficult to clean. Reasonably resistant to damage. Moderate volume storage. Low weight. Preference towed.

3.4 BEACH BERM METHOD:

Sometimes spills occurring offshore may flow to the shallow areas of the beach before cleanup is instituted. At other times the production facility may be located close to the beach and when there is spillage, this method becomes very efficient. It is used on sandy, low energy beaches to protect the upper inter-tidal and backshore areas from oil contamination. It is especially useful during spring tides when the high water level extends above the normal point for a short period to time.

3.4.1 TECHNIQUES:

This involves the construction of a dike or berm along the upper inter-tidal zone to assist prevent incoming tides from depositing oil into the backshore areas. Berm should be approximately 2m wide and 0.75m to 1m high but are dependent on the maximum height of the incoming tides.

Construction of the berm is achieved by operating a motor grader parallel to the shore lines along the upper inter-tidal area. Bull dozer fitted with angled blades can be operated in the same manner to form berms. The trench on the seaward side could also assist in trapping spilt oil that come ashore on each wave for subsequent removal. Oil that are collected are removed with skimmers or scooped off depending on the equipment available.

3.5 SORBENT FOR OIL SPILL 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 form 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. (12)

In recognition of the potential application of sorbent for removing spilled oil from water, a large variety of materials are now commercially available for this purpose. These materials have considerable variation in composition structure and sorptive capacity. They are classified into 3 major groups which are:

(1) Inorganic Material

(2) Natural Organic Material

(3) Synthetic Organic Material

3.5.1 INORGANIC

(1) Perlite (treated)

(2) Glass Wool containing oleophilic additives

(3) Vermiculite, expanded and treated

(4) Volcanic ash expended and treated

3.5.2 NATURAL ORGANIC:

(1) Corn cob (ground)

(2) Peanut hulls (ground)

(3) Redwood fibre (shredded)

(4) Saw dust (treated)

(5) Wheat Straw

(6) Wood Cellulose Fibre

3.5.3 SYNTHETIC ORGANIC:

(1) Polyether type (shredded)
(2) Polyester type reticulated
} Polyurethane foams

(3) Wool type

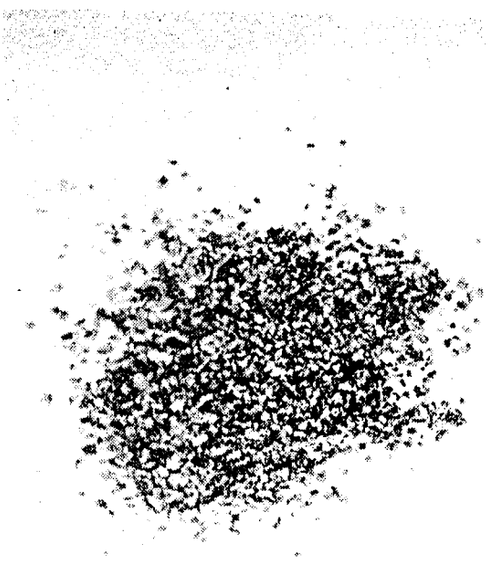
(4) Sheet, matted
(5) Continuous element non-woven
} Polyurethane fibres

(6) Polyester plastic sharing

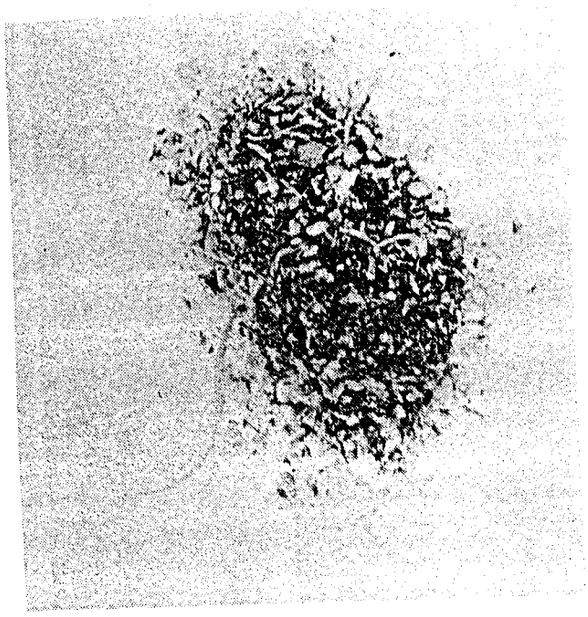
(7) Polyestyrene powder

(8) Polytetrafluroethylene (PTFE) sharing

Perlite

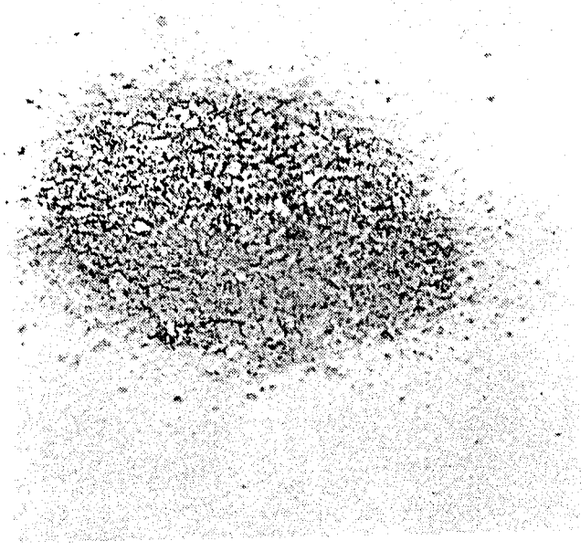


Vermiculite

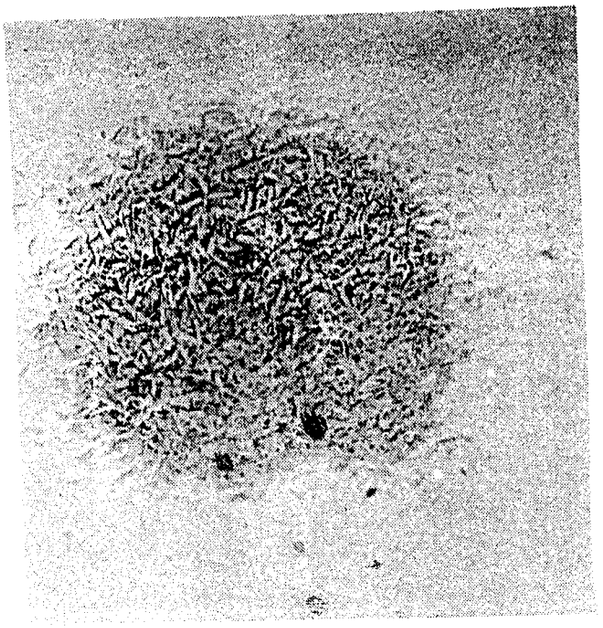


Corn Cob

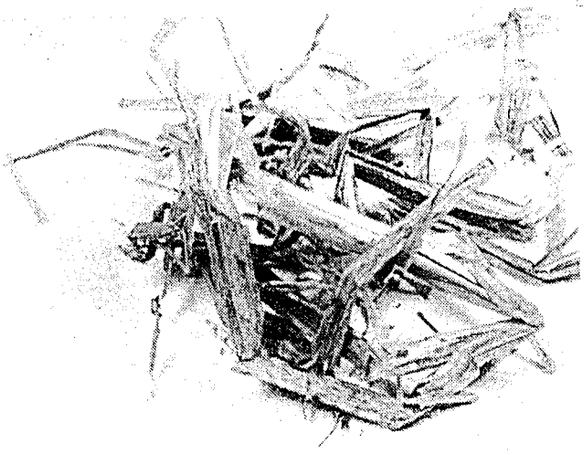
Redwood Fiber



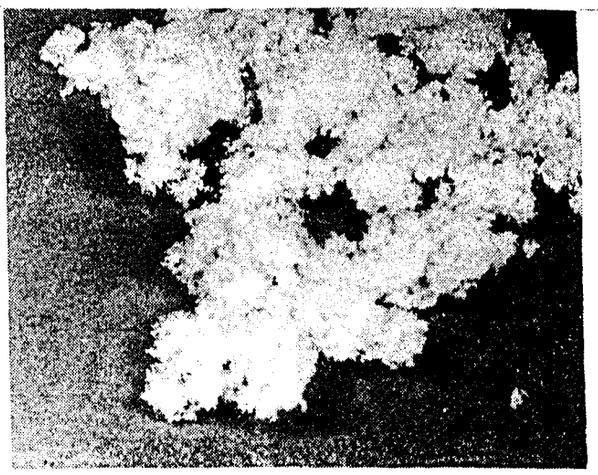
Peanut Hulls



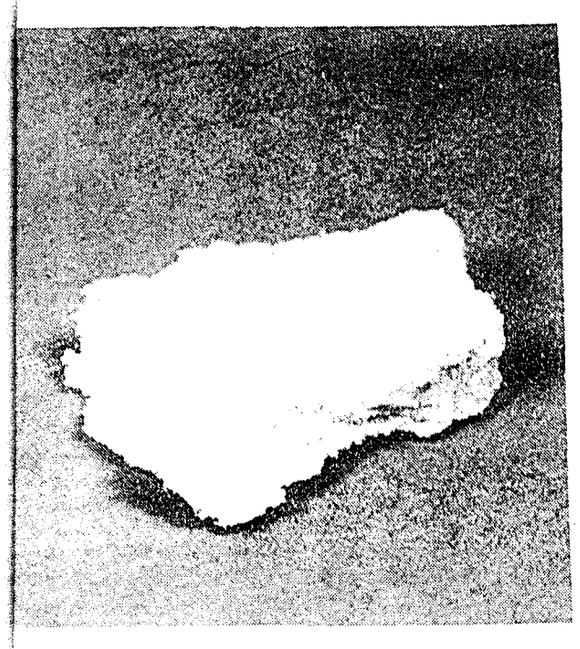
Sawdust



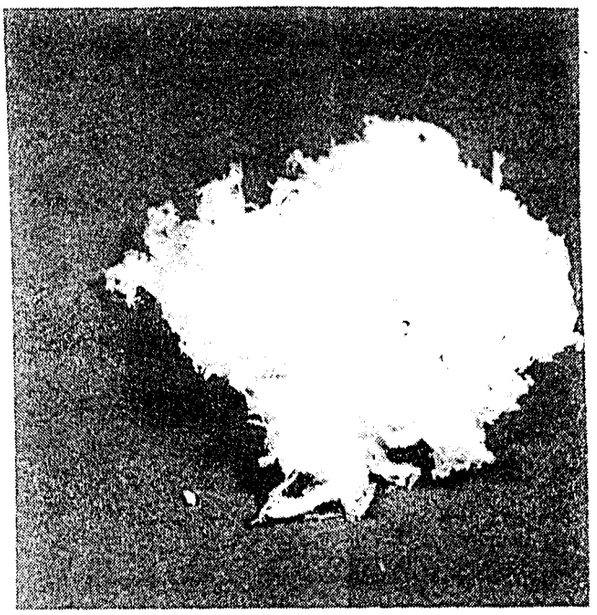
Wheat Straw



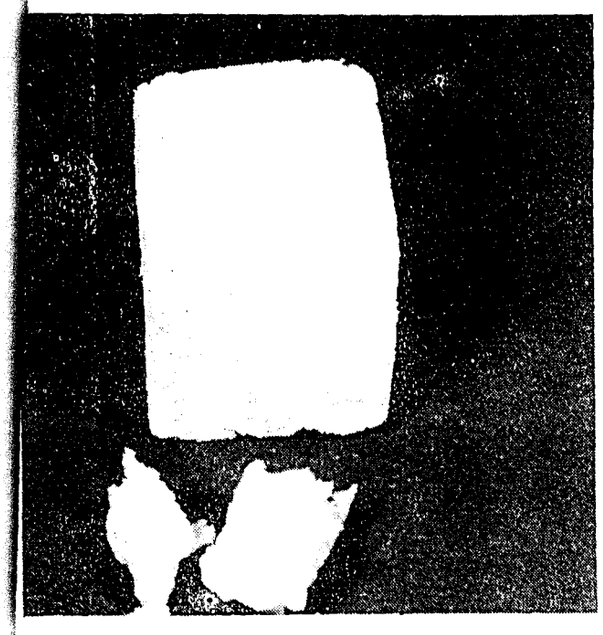
Polyurethane Foam, Shredded



Polyurethane Foam, Cubes

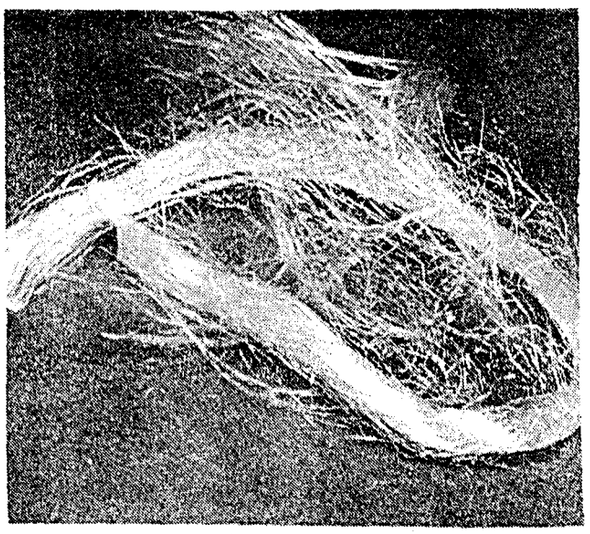


Polyethylene Fiber, Wool



Urea Formaldehyde Foam

Polyethylene Fiber, Sheet



Polypropylene Fiber, Non-Woven

Polystyrene Powder

3.6 USE OF SKIMMERS

As a general rule, whenever there is an incident of oil spill, the oil has to be restricted within an area in order to effect clean up. Once the oil has been contained or confined within an area, the problem of recovery comes in. Apart from the use of detergent to disperse spilled oil, and the use of sorbents to absorb the spilled oil, most of the recovery or cleanup method employ the use of skimmers.

A skimmer is any device designed to recover oil or oily water mixtures from the surface of water. Even moderate waves motion markedly reduce the effectiveness of skimmer. (11)

3.6.1 DESIGN

All skimmers incorporate an oil recovery element, some form of floatation or support arrangement and require a pump to transfer collected materials to storage. More complicated designs may be self – propelled and may have several recovery elements, integral storage tanks or oil / water separation facilities.

Two basic approaches can be recognized. The simplest concept is a suction device whereby oil is collected by pumps or air suction systems from the water surface directly or via a weir. These designs tend to collect large volumes of water with the oil. This can be an advantage when using high capacity units to recover viscous oils which otherwise tend to block hoses and pipe work. A large storage and oil / water separation capacity is required to receive and process the water which frequently represents more than 90% of the collected material.

In contrast, the skimmers which utilize the Oleophilic properties of belt, drums, discs or synthetic ropes often achieve a higher ratio of recovered oil in relation to water. They work best with oil of medium viscosity (between 100 and 200 centristrokes). Low viscosity oils do not accumulate on the oleophilic surface in sufficiently thick layers for high recovery rates to be attained.

All skimmers are designed so that the oil recovery element is positioned at the oil / water interface. This is usually achieved by a self leveling arrangement but none are effective in steep waves. Although swell alone does not generally interfere with skimmer, small units are easily swamped and pitched around whilst larger skimmers possess greater inertia and are unable to follow the waves profiles. Many factors should therefore be considered when selecting skimmers and these factors are:

(1) The viscosity and adhesive properties of the spilt oil

(2) The intended use and expected operational conditions

(3) The size and Robustness

(4) Ease of operation, handling and maintenance.

3.6.2 TYPES OF SKIMMERS

(1) Belt Skimmer

(2) Free Vortex Skimmer

(3) Oleophilic Skimmers

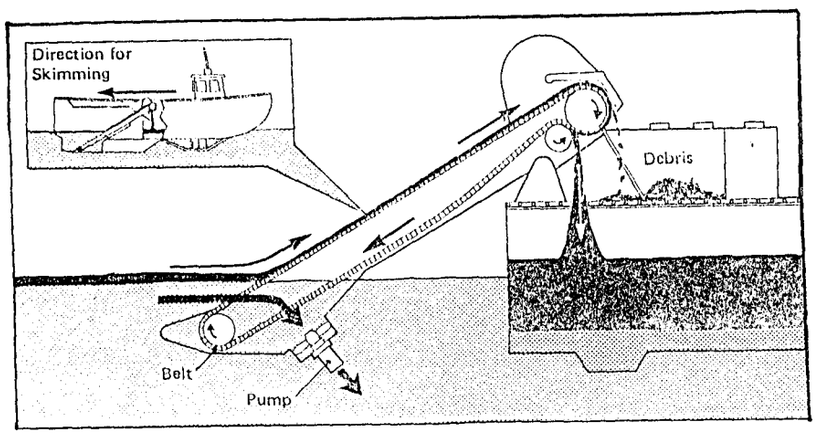
(4) Disc Skimmers

(5) Weir Skimmers

(6) Air Suction Skimmers

3.6.2.1 BELT SKIMMERS:

A Belt conveys the oil from the water surface by adhesion, upward rotating belts carry oil to their top limit where it is scrapped or squeezed off into storage tanks. Conversely downward rotating belts first submerge the oil which then surfaces behind the belt due to its buoyancy into a defined area within the vessel.

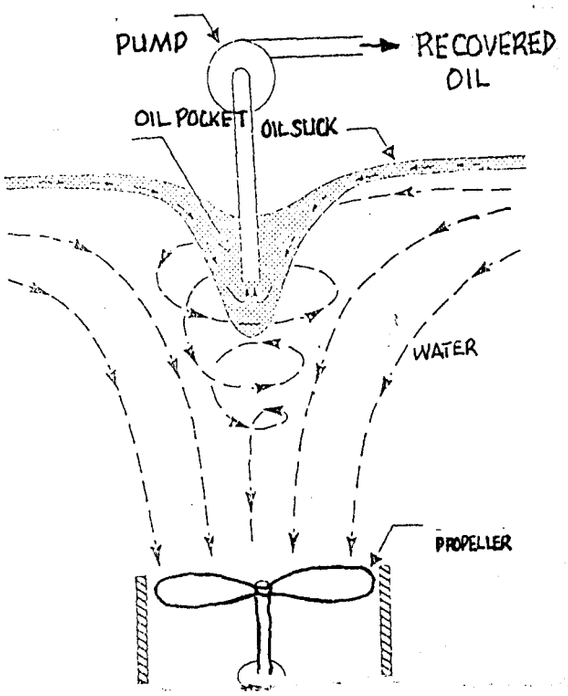


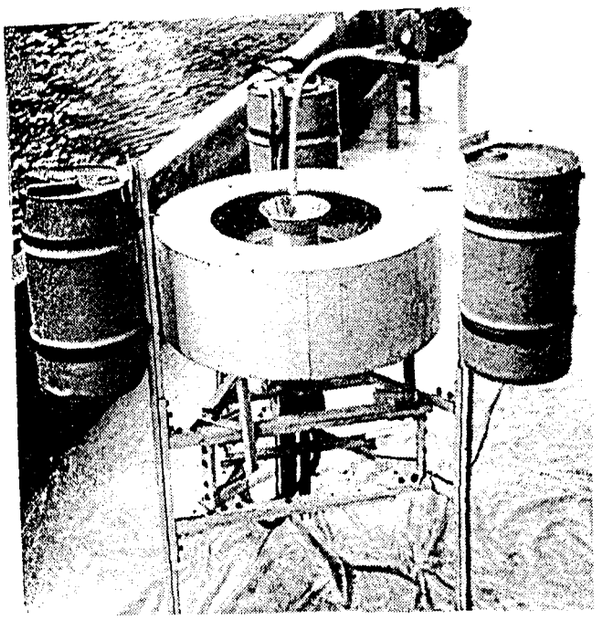
Belt Skimmer

3.6.2.2 FREE VORTEX SKIMMERS:

This is a recovery method which is used to remove oil that has already been contained either by a boom or berm. This method is a mechanical skimming process by means of a free vortex which is generated at the water surface (2).

The free vortex collection process is shown in the figure below. A rotating submerged impeller assembly produces a vortex flow in a subsurface column of water. The axial flow of water through the impeller produces an inward funneling flow in the overlying water. Under the action of these flow fields an oil slick will migrate towards the vortex axis, submerged and concentrate in a central pocket. A recovery pump intake within this intake can thus remove oil with relatively little water.

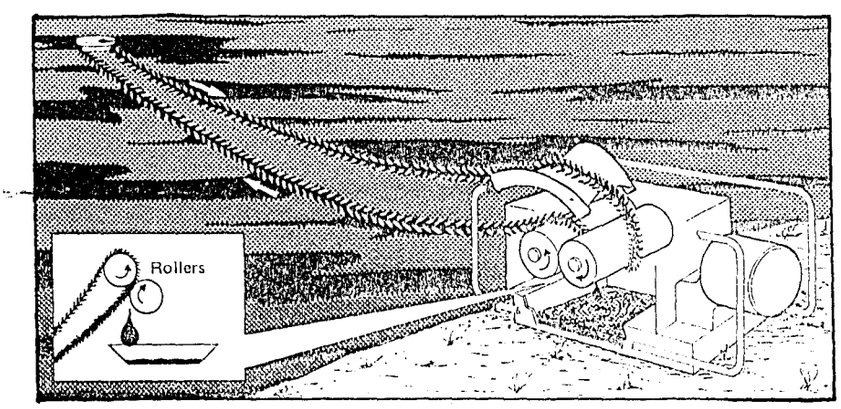




Photograph of Model in Final Configuration

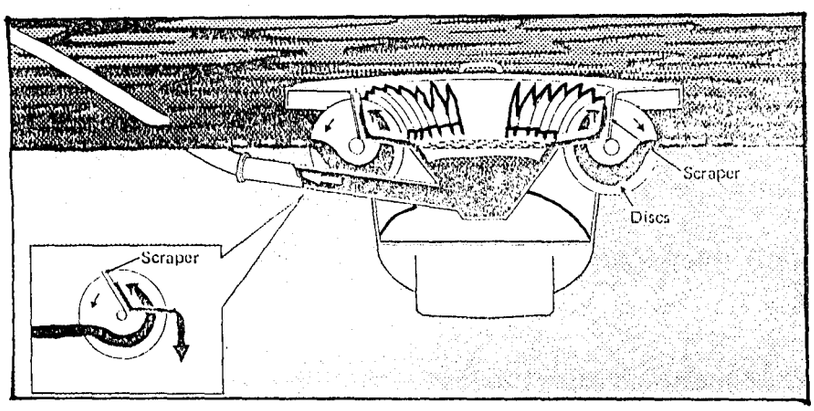
3.6.2.3 OLEOPHILIC SKIMMERS:

A central tension core rope through which is interwoven oleophilic strands forming a long continuous mop. The floating mop is pulled by powered rollers around a return pulley. The rollers squeeze the oil into a storage tank (11).



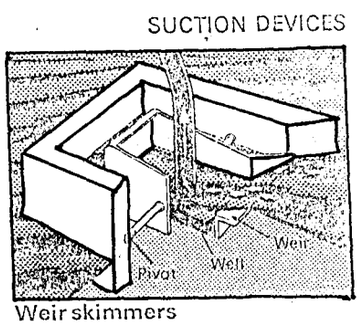
3.6.2.4 DISC SKIMMERS:

Disc rotate through the oil / water interface and spilled oil adheres to the disc surface and is removed by scrapper to a central collection point and is pumped to storage (11).



3.6.2.5 WEIR SKIMMERS:

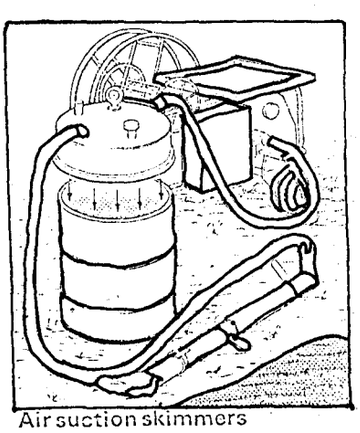
In Weir Skimmer, Oil flows over a self leveling weir into the well of a skimmer and is pumped to the storage facility.



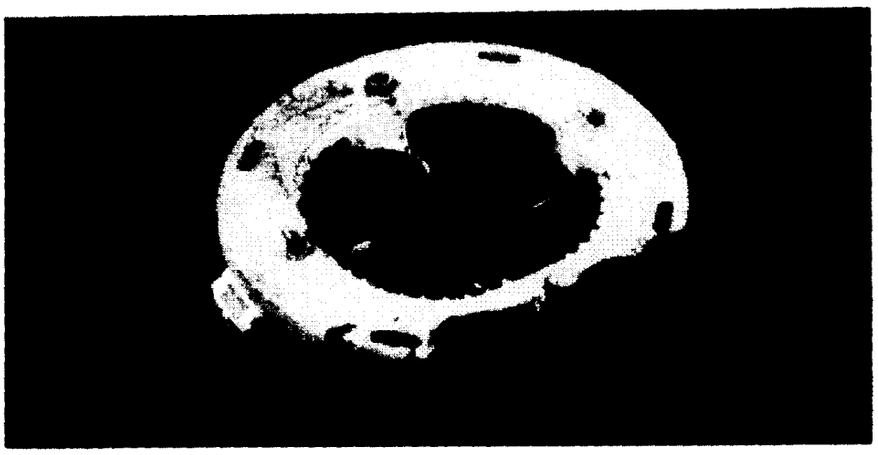
Weir skimmers

3.6.2.6 AIR SUCTION SKIMMERS:

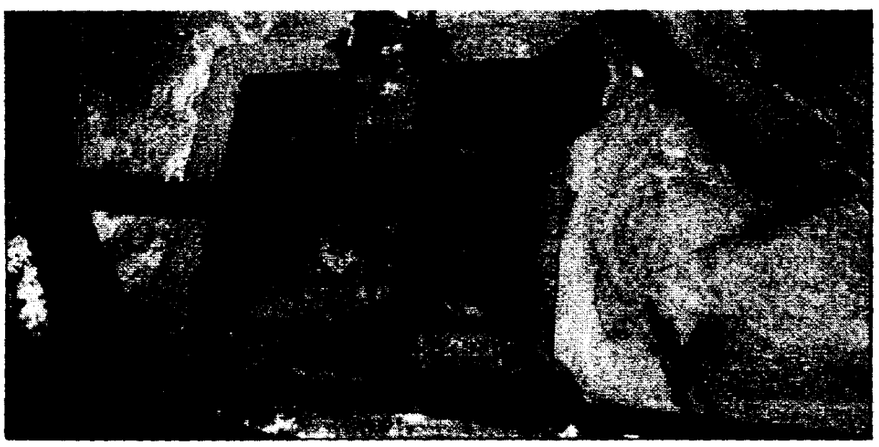
Vacuum system or an air conveyor attached to a hose which may be fitted with specially designed skimmer heads. The pumping of more viscous materials is possible by increasing the water content .

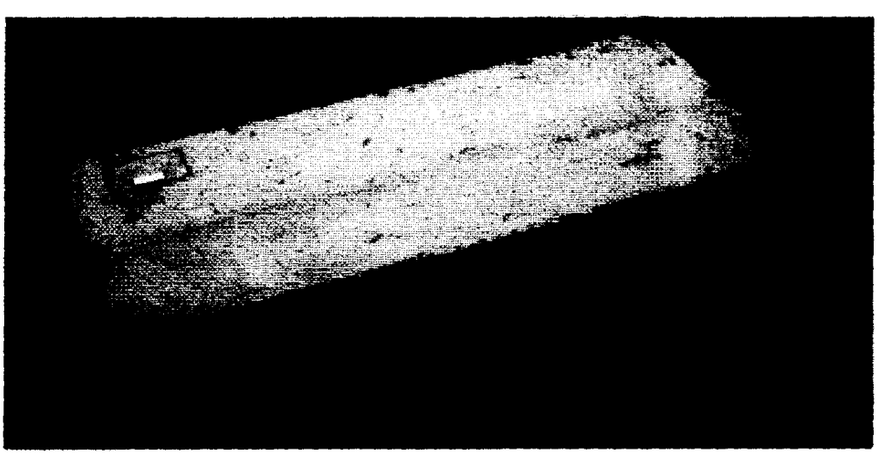

Air suction skimmers

Oleophilic Rope Skimmer

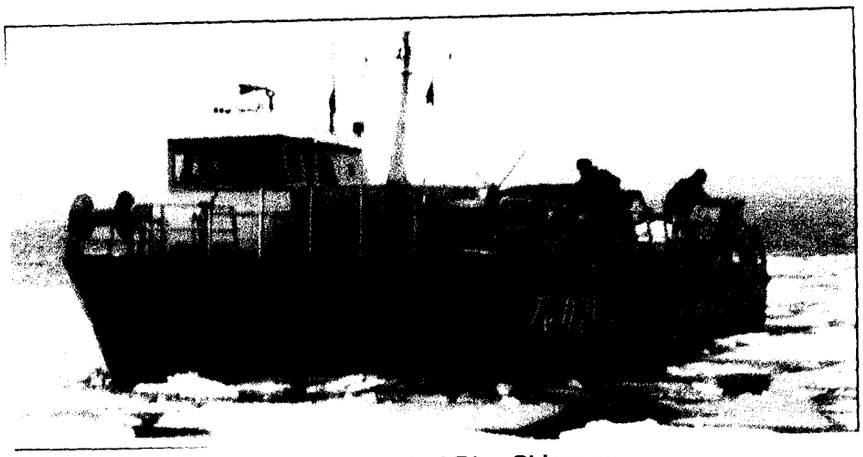


Oleophilic Disc Skimmer





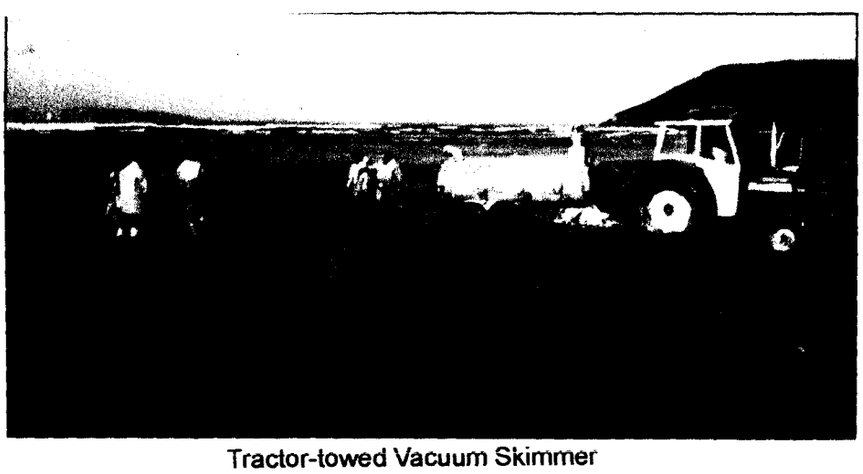
Weir Skimmer



Catamaran-mounted Disc Skimmer

Oleophilic Rope Skimmer

Belt Skimmer



Tractor-towed Vacuum Skimmer

CHAPTER FOUR

4.0 METHODOLOGY

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 ExxonMobil corporation) to reported spill sites, and monitoring chains of activities carried out to effect the removal of oil spills. Demonstration of the use of Booms and skimmers in combination 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 methods were 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. Video clips of the use of these methods in cleaning oil spill were also watched to beef up knowledge on the use of these methods. Pictures of the spill clean up were also taken.

2. The second procedure was basically experimental, and the development of these methods to eveluate 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 sea water.

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.

4.1 MATERIALS:

(A) For Assessment of methods of cleaning up oil spills other than sorbent methods, The following materials / items were used for demonstrations.

a. Containment Booms

b. Industrial dispersants

c. Speed Boat

d. Skimmers

e. Helicopters

f. Spraying equipment and accessories

g. Spades for constructing beach berms

(B) For Bouyancy test conducted in the Environmental laboratory of Mobil Producing Nigeria Unlimited. The following materials were used.

1. Beakers (Graduated)

2. Sorbent Materials including synthetic polyethylene fibre sheets, saw dust, rice husk corn cob, groundnut hulls.

3. Sea water

4 Test oils – light crude oil, Diesel, and condensate

Light crude - Relatively High Viscosity

Diesel oil - Relatively medium

Condensate - Relatively low viscosity

(C) For the sorption capacity test of sorbent materials. The following items were utilized

1. Containment Booms

2. Sorbent materials including synthetic Polyethylene fibre sheet, sawdust, rice husk corn cob (ground) and groundnut hulls.

3. Test oils – Light Crude oil, Diesel and condensate

Light crude - Relatively High viscosity

Diesel oil - Relatively medium viscosity

Condensate - Relatively Low viscosity

4.2 LOCATIONS

The use of Booms, Skimmers, Dispersants and Beach Berm methods were carried out in offshore locations of Mobil Producing Nigeria Unlimited.

Buoyancy test was conducted in Qua Iboe Terminal laboratory in Mobil Producing Nigeria.

Sorption capacity tests for sorbents were conducted in Douglas Greek of Ibeno Local Government Area of Akwa Ibom State.

4.3 PROCEDURE FOR BUOYANCY TESTS

Weighed samples of each sorbents are submerged separately in the 3 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 1/16 inches openings. After draining, the oil-soaked sorbent samples are placed each in one litre bottle one-half full of sea water. 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 of oil soaked sorbent were obtained. The water/oil ratio of oil soaked sorbents were also obtained in this experiment.

4.4 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. The sorbents were further drained by compressing them in a compactor where

the remaining oil and water were squeezed out. 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.

CHAPTER FIVE

5.0 RESULTS / DISCUSSIONS

5.1 BOUYANCY TEST AFTER SHAKING SORBENTS IN SEA WATER FOR 6 HOURS:

Table 1.

TEST SORBENT	OBSERVATION
RICE HUSK	SINKS
SAW DUST	SINKS
GROUNDNUT HULLS	SINKS
CORN COB (GROUND)	SINKS
POLYTETHYLENE FIBRE SHEET	FLOATS

Table 1 shows the Buoyancy Test results of the sorbent material with water.

The sorbent materials of plant origin oil have inherent properties of picking up oil when introduced to the oil, they do so to a limited extent compared to synthetic materials. Once they pick up oil the become heavy, and after few hours they sink to the bottom of the sea.

This is demonstrated in the table above. After shaking oil soaked sorbents materials they lose buoyancy and sink. The only material that floats is the synthetic polyethylene fiber sheet. Buoyancy is an important characteristic of sorbent if the oil must be recovered. All other materials except the polyethylene fiber sheet show negative buoyancy after 6 hours of turbulent water conditions.

Loss of Buoyancy under Turbulence is an undesirable sorbent characteristic, since it is not always feasible to apply sorbents directly to the oil slick, 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.

Table 2. WATER PICK UP RATES OF OIL SOAKED SORBENTS IN KILOGRAM PER KILOGRAM OF OIL SOAKED SORBENT.

TEST OILS	RICE HUSK	SAW DUST	GROUNDNUT HULL	CORN COB	POLYETHYLENE FIRRE 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. WATER OIL RATIO OF OIL SOAKED SORBENTS.

TEST OILS	RICE HUSK	SAW DUST	GROUNDNUT HULLS	CORN COB	POLYETHLENE 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

5.2 WATER PICK UP OF SORBENTS

When sorbents are introduced to oil spills on sea, a natural tendency exists for the sorbents to also pick up sea water along, and this is a sort of concern, since this water has to be removed from oil. With proper oil spill management and application of sorbents, the amount of water absorbed by sorbents will be limited. Such good management will include introducing sorbents carefully into spills without causing excessive turbulence on sea surface.. 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.

Oil soaked Polyethylene fibre sheet picks up less amount of water from the three test oils compared to other sorbents which is a desirable property of industrial sorbents. Table 2 above show this water pick up capabilities.

Table 3 shows the ratio of water to the oil in oil soaked sorbents. Polyethylene fibre 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. Hence the polyethylene fibre sheet being 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 suggest different degrees of sorbent involvement in emulsion stabilization.

Table 4. SORPTION CAPACITIES IN KILOGRAM OF OIL / KILOGRAM OF SORBENT

TEST OILS	RICE HUSK	SAWDUST	GROUNDNUT HULLS	CORN COB	POLYETHYLENE 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

5.3 OIL SORPTION CAPACITIES OF SORBENT / OIL RETENTION

From Table 4. It could be seen that the highest sorption capacities are exhibited by polyethylene fibre sheet. While they exhibit the highest sorption capacities they also absorb considerable amount of water. This means that during application of this sheets 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.

Table 5. % OIL RETENTION OF SORBENT MATERIALS

TEST OILS	RICE HUSK	SAWDUST	GROUNDNUT HULLS	CORN COB (GROUND)	POLYETHYLENE FIBRE SHEET
Light Crude oil	94	83	58	96	99
Diesel Oil	90	79	55	94	98
Condensate	78	70	75	75	80

Table 5 above shows the percentage oil retention of sorbent materials, which also confirms the 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 and with the experiment carried out, the most viscous oil which 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+) show the least oil retention percentages due to their relatively low viscosities.

CHAPTER SIX

6.0 RECOMMENDATION / CONCLUSION

There is a wide variety of oil spill 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 to get back the spill oil into treatment facilities in which case the oil is still worth some money, to those which employ measures which do not allow oil to be recovered and sold. The spill clean-up adopted by production or clean-up companies depend on a lot of factors. The determinant factors may be weather, sea turbulence, cost etc.

The use of dispersants is one method that does not make for recovery of oil but solely for clean-up. It is most effective when the turbulence of the sea does not favour the use of other methods of recovery.

The use of Booms and Skimmers are the most versatile methods because they allow oil to be immediately treated for sale. This depends on if the sea conditions allow the practicability of these methods. Where sea conditions are favourable and where the sole aim of the company is to recover oil, booms and skimming methods are used.

The use of Beach berms method is most practicable when oil spilled offshore has drifted towards the shallow shorelines.

Based on the experimental work carried out and documented herein, sorbent method of cleaning oil can also be used to get back oil into storage tanks for sale, but a lot of treatment has to be carried out before this if feasible. Synthetic organic materials are the best sorbent materials. The cost effectiveness of the sorbent tests were not considered intensively since it involves not only the initial cost of materials but also the nature of the oil spill, environmental conditions and

other factors, all of which lie beyond the scope of this work. One factor in addition to high sorption capacity which can have a profound influence on cost-effectiveness is sorbent reusability. Polyethylene fibre sheet appear to have a reusability potential, but this needs to be investigated further.

Another, factor is on-site generation of sorbent which is a potential exhibited by the synthetic materials, this too needs to be investigated. Whatever sorbents are used they must function as part a part of a system which brings materials to the spill sites, disperses, and recovers them, reuses them if feasible and finally disposes them.

Based on the sorbents tested 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. Polyethylene fibre sheet 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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