THE RATE OF CRUDE OIL ABSORPTION ON SOIL

A CASESTUDYOF EPKAN IN DELTA STATE

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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OCTOBER, 2003.

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OCTOBER, 2003.

CERTIFICATION

This is to certify that Adeyemi B F carried out this project titled "The Rate of Crude Oil Absorption on Soil: A case study of Ekpan in Delta State" under the supervision of Engr. (Mrs.) E. Eterigho and submitted to the Chemical Engineering Department, Federal University of Technology, Minna. In partial fulfillment of the requirement for the award of Bachelor of Engineering (B. Eng) degree in Chemical Engineering.

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Dr. F. Aberuagba

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EXTERNAL EXAMINER Signature/ Date

DECLARATION

I, ADEYEMI, B.F, hereby declare that this project is my original work and has never, to my best knowledge, been submitted in any form elsewhere.

.... ADEYEMI, B.F

31/10/2003 .... Signature & Date

DEDICATION

This project is dedicated to the Almighty God, for His mercies over my life and to my lovely mother, Mrs. E. Adeyemi.

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ABSTRACT

The effect of crude oil spill on soil was investigated using the case study of Ekpan in Delta State. The experimental and regression analysis are evaluated to achieve the aim. The data obtained for the crude-oil absorption on soil include experimental analysis carried out on crude oil and soil profile for over a period of three (3) weeks. The data obtained from experimental result was used to determine the regression result. The experimental and regression results obtained indicate that the absorption (dissolution) rate increases with increase in volume and also increase with time. It was observed that the higher the volume of crude oil used the higher the rate of absorption. Also, the experimental absorption rate was carried out for three (3) weeks and three days in laboratory using different volumes of crude oil ranging from 90ml to 170ml. Using 90ml, 110ml, 130ml, 150ml and 170ml of crude oil the length\depth of soil profile ranges from: 14.5cm to 24.0cm, 16.4cm to 29.6cm, 18.3cm to 30.4cm, 20.2cm to 33.7cm and 22.0 to 35.0cm respectively. While for regression result, for 90ml, 110ml, 130ml, 150ml and 170ml of crude oil length/depth of soil profile ranges from: 15.03cm to 24.91cm, 16.53cm to 27.40cm, 18.03cm to 29.88cm, 19.53cm to 32.37cm and 21.03cm to 34.86cm respectively indicating that the higher the volume of crude oil used the higher the rate of absorption. This type of study can always be used to validate field sample and also give a total picture of hazard done to pollution and cleaning procedures.

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CHAPTER ONE

1.0 INTRODUCTION

Chemical industries and other allied processes are the major causes of soil and water pollutions. Pollution constitutes a major socio-economic problem to the development of the nation. Though no national statistical data is available on the economic effects of pollutants in Nigeria, it is well known that the huge amount of money is spent annually to fight aftermath of released pollutants in our land, water, air and basic infrastructures (3). Petroleum pipeline vandalisation has of recent constituted a major source of pollution in our society. In principle, the probability of petroleum pipe rupture is far below 5-10%, therefore, most of the experienced ruptures can only be attributed to pipeline vandalisation, by a few persons for their self economic enhancement (3). The immediate socio-economic cost of this vandalisation on the nation can in principle be computed. What is more disturbing is the long-term effect on the environment, land, water and to some extent air. The exploration and exploitation of crude oil in Niger-Delta area has exposed the people in the area to a lot of hazards emanating from environmental pollution. The oil spillage usually result to environmental degradation, which threaten population health and damages the quality of environment by rendering the farmland, and water (River) useless. Since 1970 till date, there have been a number of reported cases of oil spillage in the Niger-Delta area, occasioned by either intentional vandalisation of oil facilities or of pipelines or operational accidents (3).

The search for oil in Nigeria started in 1937 and was pioneered by Shell Petroleum Development Company of Nigeria Limited (then known as "Shell D' Arcy" and later Shell-BP), which was then based at Owerri. The company was jointly financed by the Royal Dutch/ Shell Group of Companies and the British Petroleum Group. At first, the operations covered the whole

Nigeria, but later concession area under oil prospecting licence (OPL'S) was reduced to 40,000 sq. miles in and around the Niger-Delta basin (7)

The Second World War forced the company to suspend its activities in 1941, but they were resumed in 1946. The first deep exploration well was drilled in 1951 at Ihio, 10 miles north-east of Owerri, to a depth of 11,228 feets but found no oil (7). Akata-1, drilled in 1953 and suspended in 1954, was the first well to encounter oil, but seven appraised wells that were drilled in the area were dry holes. The first commercial oil was discovered at Oloibiri in River State, by Shell in January, 1956 (7). Towards the end of the same year, a second discovery was made at Afam, also in the River State. Until 1956, Shell was the principal undertaking the search, although there had been sporadic exploration by others before that year.

Pipeline connections between Oloibiri and Port-Harcourt made it possible for the first cargo of crude oil to leave Nigeria in February, 1958, when production stood at 6,000 barrels per day (7). The oil industry had spent some #50 million by the time of the first shipment of Nigerian oil to Europe in 1958. Intensification of the search for oil in 1957-1959 leads to the discovery of Ebubu and Bomu oil fields in River State, and Ughelli in Delta State as the first hydrocarbon found west of Nigeria (7). The Gulf oil company (Nigeria) Ltd, a locally-incorporated American Company, commenced production and exports of crude oil in 1965. Two other companies, Elf Nigeria Ltd, then known as Safrap and Nigerian Agip Oil Company Ltd, NAOC, had established production connected to Shell's oil terminals at Bonny by mid-1967. Elf exports started in September 1960, where Agip was just ready to start export in July, 1967, the month all exports from the Bonny oil terminal ceased as a result of the Nigerian crisis. Mobil Producing Nigeria (Mobil) commenced crude oil export in 1970 for oil production, which the company had established in its off-shore blocks (7).

Crude oil is a liquid and is made up of mixtures of various substances, the separtation of which are sometimes difficult. They are principally compounds comprising of carbon and hydrogen, otherwise referred to as hydrocarbons (7). Sulphur, oxygen, and nitrogen are also present in crude oil. Nigeria's crude contains an insignificant proportion of sulphur. Nigeria's crude oil is formed from decomposition of acquatic substance such marine animals and plants which have been buried under various layers of mud and silt. Over the years, the sediments exerts great pressure and high temperature occur as less oxygen is present at the depths, the buried organisms are transformed into crude oil and gas. The Niger-Delta Basin contains vast quantities of sedimentary rocks and crude oil is mainly found around such rocks. The Chad and Sokoto Basin are also sedimentary basins. Oil is measured in barrels and one barrel of crude oil is equivalent to 159 litres (42 U.S gallons or 34.97 imperial gallons)(7).

The following characteristics should be considered when classifying the types of crude oil that are found in Nigeria: Gravity, wax, sulphur content. Gravity is expressed, in technical sense in specific gravity but in commercial sense in degree API (American Petroleum Institute- a regulating body). Nigerian crude are characterized as gravity 26-40 degree API, sweet and non-waxy. The low content of sulphur makes it attractive for the refineries since sulphur creates some problems for the refinery process. The crudes are light, medium and heavy. Using these characteristics, one distinguishes between light, medium and heavy crude, according to the gravity and sweet and sour for respective sulphur-free and sulphur- containing crudes (7).

1.1 AIMS AND OBJECTIVES

The aims of this project is to determine the rate of crude oil absorption on soil in Niger-Delta area, this could be achieved via realization of the following objectives:

To develop and determine regression data for the rate of crude oil absorption on soil (land) environment.

To assess the crude oil absorption rate processes affected by land (soil) environment.

To determine the rate of crude oil absorption over a period of time.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ENVIRONMENTAL POLLUTION

Petroleum exploration activity in Nigeria dates back to 1903 when mineral survey company began mineralogical studies in the country. Considering the expansion and diversification into other areas, such as petrochemicals and gas, there is need to control the contamination and pollution of the general environment against petroleum operations. In this regard, pollution will be defined as the addition to any segments of the environment of any material, which has detrimental effect on the eco system (6).

In view of the complete nature of the petroleum industry, pollution problems are as a matter of facts, very complex indeed. The various effects of pollution depend on the pollutants. If there is oil spills, there would be serious damage to marine life and vast destruction of the environment. The most serious aspect of crude oil pollution is the possibility of the contamination of rivers and other island waters that serves as a source of drinking water. There have been many incidents in Niger-Delta where drinking water supplied was contaminated by oil. Heavy contamination of water bodies by crude oil cause death of fish directly or more probably, indirectly by interference with food or oxygen supplies (6).

2.2.1 SOURCES OF POLLUTION

Operational activities within the petroleum industry could result in the discharge of pollutants into the general environment. Presently, in Niger-Delta, the sources of pollutions are:

1. On-shore and off-shore exploration and production operation.
2. Transportation operations

3. Marketing operations including terminal operations.

4. Petroleum refining activities.

The significant pollutant is crude oil. The reason for this is that the effect of crude oil pollution are very visible. Crude oil can enter the environment through operational discharge and accidental discharge (6).

It has been established that the main causes of oil pollution in Niger-Delta are:

1. Corrosion of ageing pipelines (mostly flow lines).
2. Equipment malfunctions and outright failures during production operations.
3. Acts of sabotage by unknown person(s) in which oil installation are either tampered with or vandalized.
4. Engineering and drilling activities and natural causes like flooding, heavy rainfall etc.
5. Hose failures on the single Bouy Moorings (SBM) tanker loading system.

Flow line/ pipeline leaks have accounted for more than 30% of the total occurrence of oil and contributed well over 50% of the oil spilled. Pollution rising from sabotage appears to be peculiar to Niger-Delta. The motivation for these acts of sabotage can be attributed to three major reasons namely: theft, a wrong sense of revenge manners to claim compensation (6).

2.2.2 SIGNIFICANT POLLUTANTS

Apart from oil, other pollutant type exists. When waste containing soluble organics are discharged into a body of water, oxygen depletion could result through aerobic bacterial oxidation. An increase in the pollution load stimulates the growth of bacteria and oxidation proceeds to an accelerated range. Oxygen depletion inhibits the higher forms of biological life and conditions set that are detrimental to men.

They are also problems of air, and noise pollution in the petroleum industry. Atmospheric containments include the oxides of nitrogen, carbon and sulphur, articulate matters, hydrocarbons and ash. Noise pollutions are associated with drilling, refining operations and gas flaming. The other type of pollution which is not readily recognized but whose effects are devastating ecologically in thermal pollution. This type of pollution is associated with gas flaming operations, refining, and petrochemical and oil production (9).

2.2.3 IMPACT ON PHYSICAL ENVIRONMENTAL COMPONENTS

AIR

The deterioration of air quality can be caused by the spill itself (evaporation of such components of the oil) and by cleaning process, which releases smoke, soot and some hydrocarbons to the air. This however, can last within a period of months (say 3 months) and will not exist a lasting effect on the air quality (9).

WATER

The deterioration in water quality can chiefly be caused directly by the oil contamination. This is very evident due to the oil on the surface of the water even during the immediate post-spill period. The contamination of water leads to shrinkage of clean water resources and visibly affects some acquatic plants and animals. For example, in Niger-Delta area villages, the well water had the unpleasant taste of oil and could not be used for consumption after the spillage occurred (1).

SOIL

The area directly affected by the oil spill included some seasonally arable land. In the immediate post-spill period, some flooded crops were observed to be drying as exemplified by yellow coco yam. Some farmers in Niger-Delta claimed that food crop production and yield has decreased both in quality and quantity (5).

2.2.4 PLANTS AND ANIMALS

Owing to the seasonally high level of water, most of the swamp vegetation was stained and water plant completely coated with oil. The submerged and smaller floating species died or were on the verge of dying. In the same immediate post-spill period, some dead crabs and fishes were also observed, indicating that the short time effect were fatal for both plants and acquatic animals. The total fish harvest from dry seasons ponds was not demonstratedly lower in the oil zone but several species including all of the tilapia family were absent and fish throughout the impacted zone have an objectionable "kerosene" taste (1).

2.2.5 GENERAL EFFECTS OF OIL SPILL ON ENVIRONMENTS

Ground water contamination resulting from hydrocarbon spills is a wide spread phenomenon. Drinking water becomes unpalatable when it contains crude oil or petroleum products in extremely low concentration and as a result relatively small spills may contaminate large volumes of ground water. Spills in ground water regardless of their size are potentially dangerous. Minor cases can pollute a large volume of water making it unviable for a long period of time (9).

2.2.6 MOVEMENT OF OIL IN SOIL

After the crude oil or petroleum product is spilled, it migrated downwards under the force of gravity. The mobility of the oil in the soil depends on its viscosity, quantity of oil spilled and the permeability of the soil. During its movement through the unsaturated zone, there is absorption and reactions between the oil and rock matrix, tending to immobilize and attenuate the oil. If the water table is far enough below the ground surface, the oil may be immobilized in the unsaturated zone before it reaches the water table. In the case of shallow water table acquifiers, where the oil is not immobilized in the unsaturated zone, the spill will reach the water table. The oil is forced to spread laterally in form of the thin pancake due to its lower specific gravity (5). Soluble components dissolves in the water and vapour will be released which may collect forming potential fire or explosion fire hazards. The pollution plume of crude and dissolved phases will move in the direction of ground flow in the acquifier (5).

2.2.7 SOLUBILITY OF OIL IN WATER

Solubility of crude oil and refined petroleum products in water vary for type of crude and products, the heavier fractions having less soluble components than the lighter fractions. However, soluble hydrocarbons in water give rise to objectionable tastes and odours at concentration as low as 0.001gm/l. Spills which are immobilized in the unsaturated zones can still pollute ground water because rain percolating through the contaminated soil will dissolve the soluble components of the hydrocarbons and carry them into the ground water.

This is also the reason why one spillage has occurred, it takes a long time to clean up as every recharge by percolating rain or a fluctuating water table regenerates the contamination (9).

2.3 ATTENUATION AN BIODEGRADATION OF OIL IN SOIL AND WATER

Crude oil and petroleum products are biodegradable by bacteria in the presence of trace salts and adequate dissolved oxygen. Mckeetal reported laboratory tests which shows that the pseudomonas and arthrobacter general species of bacteria utilize petrol as a source of energy for rapid growth, the degradation being rapid above the water table but less effective below it within the saturated zone.

Physical and chemical reactions also occur as the oil migrates downwards from surface to the water table and when it moves to the ground water within the saturated zone. Presence of clay minerals in a soil not only decreases the permeability of the soil but also increases it absorptive capacity. Absorption of oil on soil grains afford these reactions more time to be effective (5).

2.3.1 CAUSES OF CRUDE OIL SPILLAGE

A good understanding of the causes of crude oil spills is important for the determination of effective containment, recovery and counter measures. The plan analysis of crude oil production and transportation system indicates clearly that the threat of crude oil spills remain real and substantial. By both source and volume the water borne transportation system posses the greatest risk of crude oil spills, with roughly half of the crude oil spilled in offshore (9)

However, inland drilling, transportation and distribution also account for a substantial Volume of crude oil spilled. Onshore (land) drilling becoming an ever-increasing source of large crude oil spills. The positive side of the situation is that over 60% of crude oil spills are preventable, since the result from equipment failure operator errors e.t.c. Also much remains to be done in the broad categories of crude oil spills prevention: spill response planning, training and management, spill counter measures and clean up from many investigation of crude oil spills incident in Niger-Delta, the causes of crude oil spillage are numerous. These may be classified into accidental and operational (5).

2.3.2 ACCIDENTAL DISCHARGES

Accidental causes may be due to equipment failure or human error. Equipment failure could be due to malfunctioning, age, overloading (due to excessive pressure causing a break out), corrosion or abrasion of parts of facilities and equipment malfunction.

While human error result when a worker fails to do what he or she is expected to do. For example a valve could be left open while crude oil is being pumped or pressure is allowed to build up beyond the designed capacity of the equipment or facility (7).

2.3.3 OPERATIONAL DISCHARGES

Operational discharges of crude oil are very common. By it's nature, some crude oil is expected to escape in small quantities during crude oil operations, examples when changing connections or transferring crude oil from one containers to another. At industrial site, such little drops could build up to a substantial quantity which then poses a problem (7).

2.3.4 EXPLORATION OF CRUDE OIL

The "black gold", crude oil, is obtained for use after exploration and exploitation processes. The main aspects of exploration are:

1. Geophysical survey.
2. Geological survey.

3. Exploration drilling

DRILLING

EXPLOITATION

The exploitation of an oil field involves the following engineering studies:

1. Reservoir.
2. Drilling
3. Completion
4. Production
5. Well maintenance

DRILLING

This is carried out with a machine called the rig. The rig is used to bore a hole from the earth surface to the reservoir. The rig consists essentially of: hoisting system, rotary system, drilling system, circulation string, circulation unit, and safety devices (7).

2.4 SOIL AND ITS PROPERTIES

Finely divided rock- derived material containing an admixture of organic matter and capable of supporting vegetation. Soil are independent natural bodies, each with a unique morphology resulting from a particular combination of climate, living plant and animals, parents rock materials, relief, the ground water, and age (4). Soils support plant occupy large portion of the earth's surface, and have shape area, breadth, width and depth. Plant obtain their supply of mineral from the soil, so some knowledge of properties is necessary to understand the ways in which the soil conditions affect the supply of nutrients. (4)

The chemical properties of soil directly control the supply of plant nutrients, but the physical characteristics for root growth and therefore the total supply of nutrients and water to the crop. Soil is extremely complex and diverse, but all soils consists of five major components: mineral, matter, organic matter, soil water, the soil atmosphere and the population of soil organism (4).

The physical properties of soil have critical importance to growth of plant and to the stability of cultural structures such as roads and building. Such properties commonly are considered to be: size and size distribution of primary particles and secondary particles or aggregates, and the consequent size, distribution, quantity, and continuity of pores, colour and textural properties, which affect absorption and radiation energy, and conductivity of the soil for water, gases and heat. These usually would be considered as fixed properties of the soil matrix, but actually some are not fixed because of influence of water content (4).

2.4.1 SOIL DESCRIPTION AND CLASSIFICATION

It is essential that a standard language should exist for the description of soils. A comprehensive description should include the characteristics of both the soil material and the in-situ soil mass. Material characteristics can be determined from disturbed samples of the soil, that is samples having the same particle size distribution as the in-situ soil but in which the in-situ structure has not been preserved. The principal material characteristics are particle size distribution (or grading) and plasticity, from which the soil name can be deduced. Particle size distribution and plasticity properties can be determined either by standard laboratory tests or by simple visual and manual procedures. Secondary material characteristics are the color of soil and the shape, texture and composition of particles. Mass characteristics should ideally be determined in the field but in many cases they can be detected in undisturbed samples i.e. samples in which the in-situ soil structure has been essentially preserved (2).

The description of mass characteristics should include an assessment of in-situ firmness or strength, and details of any bedding, discontinuities and weathering. The arrangement of minor geological details, referred to as the soil macro-fabric, should be carefully described as this can influence the engineering behaviour of the in-situ soil to a considerable extent. Examples of macro-fabric features are thin layers of fine sand and silt in clay, silt-filled fissures in clay, small lenses of clay in sand, organic inclusions and root holes. The name of geological formation, if definitely known, should be included in the description; in addition the type of deposit may be stated (e.g. till, alluvium, river terrace) as this can indicate, in a general way, the likely behaviour of the soil (2).

It is important to distinguish between soil description and soil classification. Soil description includes details of both material and mass characteristics, and therefore it is unlikely that any two soils will have identical descriptions. In soil classification, on the other hand, a soil is allocated to one of a limited number of groups on the basis of material characteristics only (viz particle size distribution and plasticity): soil classification is thus independent of the in-situ condition of the soil mass. If the soil is to be employed in its undisturbed condition, for example to support a foundation, a full soil description will be adequate and the addition of the soil classification is discretionary (2)

However, classification is particularly useful in the soil if the soil in question is to be used as construction material, for example in an embankment.

2.4.2 CLEAN UP OF SPILL FOR LAND (SOIL)

The clean up of the contained oil on land may be accomplished by mechanical and manual method (e.g. use of sorbents, pumps, buckets e.t.c.). When the soil is heavily contaminated, the contaminated soil can be excavated and oil washed into a properly lined pit. The oil-contaminated soil can be disposed of in an approved sanitary land fill (5).

2.5 SOIL TEXTURE

The three types of particles (sand, silt and clay) and organic matter are found mixed up in soil. The percentage occurrence or proportion of the various particles determines the physical properties of the soil texture. A soil is said to be light when it contains high proportion of large sized particles and heavy when it has a preponderance of fine particles. The feel of the soil in the field often gives an indication of the proportions of sand, silt and clay. To the farmer the soil texture simply depends on whether the soil is light or heavy, sandy, loamy, or clayey. Three groups of fundamental types of soil are recognized sand, loam and clay (8).

2.5.1 SANDY SOIL

In a soil where the sand particles predominate or are in greater proportion (about 70%) than the other fractions, the soil is said to be sandy. The particles of sand are fragments of rocks dominated by quartz. They are coarser than silt and clay. The sand grains may be rounded or quite irregular and contain more space between the particles than other soil separate, and hence the water holding capacity is low and the passage of percolating water is rapid. Sandy soil is usually loose and friable with good aeration and drainage and easier to work than clay soil. But because of its porous nature, it does not have the capacity to hold moisture and soil nutrients;

hence sandy soils are often not fertile. The structure of such soils can be improved by the addition of organic material (humus), which binds the soil particles and thus increase their water holding capacity (8).

2.5.2 CLAY SOIL

Where the clay particles predominate the soil is said to be clay soil. The particles of clay are smaller than sand, plate-like in shape and more closely packed than sand particles. Clay is influenced by change in moisture content. When clay is sufficiently wetted, it expands and becomes sticky and it shrinks when dry. It has high capacity for absorbing water, gases and soluble salts and is hence more fertile than sandy soil. The clay particles are compact, the soil is usually heavy, and clay soils are difficult to work with. When wet, it is easily puddled as in rice fields, but if cultivated when it is too wet, the aggregation of the particles is broken down (8).

If cultivated when dry it will be broken into large clods, which make it difficult for seeds to be planted in it. The tillage of clay soil must be properly timed. The best time is just before it picks enough water to be sticky (8).

2.5.3 LOAM SOIL

The soil intermediate between clay and sandy soils is called loam. When the loam tends towards sand the soil may be termed light loam, very light loam, sandy loam, or very sandy loam, depending on the proportions of loam and sand. When the loam tends towards clay, the soil may be termed heavy loam, very heavy loam, heavy clay or very heavy clay. Loam exhibits characteristics between sand, silt, and clay and these make loamy soil very important. It possesses the good qualities of sand and clay without exhibiting those undesirable properties such as the extreme looseness and low water holding capacity of sand and the stickiness, compactness and low air and water movement of clay. Loam soil has a high capacity for absorbing and holding moisture and plant nutrients and hence loam soil is generally good agricultural soil (8).

2.5.4 THE SOIL PROFILE

Examination of a vertical section of soil in the field reveals the presence of more or less distinct horizontal layers. Such a section is called a profile, and the individual layers are regarded as horizons. These horizons above the parent material are collectively referred to as the solum. Every well-developed undisturbed soil has its own distinctive profile characteristics, which are utilized in soil classification and survey and are of great practical importance. In judging a soil one must consider its whole profile (8).

SOIL HORIZONS

The upper layers or horizons of a soil profile generally contain considerable amounts of organic matter and are usually darkened appreciably because of such an accumulation. When a soil is plowed and cultivated, these layers are included in what is termed the surface soil or the topsoil. This is sometimes referred to as the furrow slice because it is the portion of the soil turned or "sliced" by the plow (8).

The underlying layers (referred to as the subsoil) contain comparatively less organic matter than the topsoil. The various subsoil layers, especially in mature, humid region soils, present two very general belts:

(a) An upper transition zone characterized by the loss of minerals and by some organic matter accumulation and

(b) A lower zone of accumulation of compounds such as iron and aluminum oxides, clays, gypsum and calcium carbonate (8).

The solum thus described extends a moderate dept below the surface. A dept of 1 to 2 meters is representative for temperate region soils. Here the noticeably modified lower subsoil gradually merge with the less weathered portion of the regolith whose upper portion is geologically on the verge of becoming of the lower subsoil and hence of the solum.

The various layers comprising a soil profile are not always distinct and well defined. The transition from one to the other is often so gradual that the establishment of boundaries is rather difficult. Nevertheless, for any particular soil the various horizon are characteristics and their properties greatly influence the growth of higher plants (8).

CHAPTER THREE

3.0 METHODOLOGY AND APPARATUS

3.1.1 PROCEDURE

Soil profile of 2m by 1m were dug with depth of about 2m. Various layers of samples were taken from the soil profile and analyzed. The soil profile layers were arranged into five measuring cylinders in the laboratory according to the way they appear from original soil profile i.e. from sandy loam, loamy sand, sandy loam, sandy clay loam and sandy loam.

Crude oil was measured at different volumes from 90ml, 110ml, 130ml, 150ml and 170ml respectively. All the volumes of crude oil from 90ml to 170ml were poured at the same time on surface of different soil profile on measuring cylinder and the rate of absorption of crude oil (depth or length) was monitored and recorded at different intervals of days. The whole process was monitored for three (3) weeks and three (3) days in the laboratory to know the rate of absorption (depth or length) of crude oil on soil.

3.1.2 APPARATUS

1. Five measuring cylinders
2. Meter rule
3. Stop watch
4. Crude oil (Oredo 5 lima)

3.1.3 MATERIALS

1. Sandy loam soil
2. Loamy sand soil

3. Sandy loam soil
4. Sandy clay soil
5. Sandy loam soil
6. Crude oil used (Oredo 5 Lima)

CHAPTER FOUR

4.0 RESULT

TABLE 4.1 EXPERIMENTAL RESULT

Volume (ml)	90ml	110ml	130ml	150ml	170ml
	Length (Depth) of soil profile (cm)				
Time (Days)					
Day1 2nd layer	14.5	16.4	18.3	20.2	22.0
Day2	17.0	20.0	22.0	24.0	25.9
Day3	18.0	22.0	22.3	24.2	26.0
Day4	18.3	22.2	22.6	24.5	26.3
Day5	18.7	22.5	22.9	24.9	26.7
Day6	19.0	23.0	23.2	25.3	27.0
Day7	19.2	23.3	23.6	25.7	27.4
Day8	19.5	23.7	24.0	26.0	27.8
Day9	19.8	24.0	25.0	27.3	29.5
Day10	20.6	24.4	25.5	27.7	30.2
Day11 3rd Layer	21.5	25.0	25.9	28.0	30.5
Day12	21.8	25.5	26.3	28.4	30.8
Day13	22.0	25.8	26.8	28.8	31.2
Day14	22.4	26.3	27.0	30.0	31.5
Day15	22.7	26.4	27.4	30.3	31.8
Day16	23.0	26.5	27.8	30.7	32.2

Day17	23.2	26.8	28.0	31.2	32.6
Day18	23.4	27.2	28.3	31.5	33.0
Day19	23.5	27.6	28.6	31.8	33.4
Day20 4th Layer	23.6	28.0	29.0	32.2	33.7
Day21	23.7	28.4	29.3	32.6	34.0
Day22	23.8	28.8	29.6	32.9	34.4
Day23	23.9	29.2	30.0	33.3	34.7
Day24 5th Layer	24.0	29.6	30.4	33.7	35.0

TABLE 4.2 REGRESSION RESULT

Volume(ml)	90ml	110ml	130ml	150ml	170ml
	Length(Depth) of soil Profile(cm)				
Time(Days)					
Day 1	15.03	16.52	18.03	19.53	21.03
Day 2	16.78	18.46	20.13	21.81	23.48
Day 3	17.90	19.68	21.47	23.26	25.04
Day 4	18.74	20.61	22.48	24.35	26.22
Day 5	19.41	21.35	23.29	25.23	27.16
Day 6	19.98	21.98	23.97	25.97	27.96
Day 7	20.48	22.52	24.57	26.61	28.66
Day 8	20.92	23.01	25.09	27.18	29.27
Day 9	21.31	23.44	25.57	27.70	29.82
Day 10	21.67	23.84	26.00	28.16	30.33

Day 11	22.01	24.20	26.40	28.59	30.79
Day 12	22.31	24.54	26.77	28.99	31.22
Day 13	22.60	24.85	27.11	29.36	31.62
Day 14	22.87	25.15	27.43	29.71	31.99
Day 15	23.12	25.43	27.73	30.04	32.35
Day 16	23.36	25.69	28.02	30.35	32.68
Day 17	23.58	25.94	28.29	30.64	33.00
Day 18	23.80	26.10	28.55	30.92	33.30
Day 19	24.00	26.40	28.80	31.19	33.59
Day 20	24.20	26.62	29.03	31.45	33.86
Day 21	24.39	26.82	29.26	31.69	34.12
Day 22	24.57	27.02	29.47	31.93	34.38
Day 23	24.74	27.21	29.68	32.15	34.62
Day 24	24.91	27.40	29.88	32.37	34.86

TABLE 4.3 PARTICLE SIZE ANALYSIS

LABEL	% SAND	% SILT	% CLAY	TEXTURAL CLASS
1	72.9	13.5	13.6	SANDY LOAM
2	77.0	4.8	18.2	LOAMY SAND
3	75.5	9.3	15.2	SANDY LOAM
4	72.1	4.0	23.9	SANDY CLAY LOAM
5	75.6	7.5	16.9	SANDY LOAM

CHAPTER FIVE

5.0 DISCUSSION OF RESULT

Chemical industries and other allied processes are the major cases of soil and water pollutions. Pollution constitutes a major socio-economic problem to the development of any nation. Crude oil is liquid and is made up of mixtures of various substances, the separation of which are some times difficult. They are principally compounds comprising of carbon and hydrogen, otherwise referred to as hydrocarbon. Sulphur, oxygen and nitrogen are also present in crude oil.

The experimental result and regression result obtained indicates that the absorption (dissolution) rate increases with increase in volume and also increase with time as shown in table4.1 and table 4.2. In terms of volume, if higher volume is used the unabsorbed crude oil exact higher weight due to gravity on the oil layer at the soil surface than lower volume and hence higher rate of absorption of crude oil. Therefore, the higher the volume of crude oil, the higher the weight, then the higher rate of absorption. In terms of density of crude oil, the higher the density of crude oil, the higher the rate of absorption of crude oil in to the soil, this is because the weight of crude oil is directly proportional to the density (weight= $v\rho g$) where v=volume, ρ= density and g = acceleration due to gravity. Therefore, the higher the weight, the higher the rate of absorption. In terms of surlphur content, among factors that affect the rate of absorption is the amount of sulphur in the oil spill. The higher sulphur content, the slower rate of absorption as shown in table 4.1 and 4.2, this because sulphur settled to the ground or top of soil and cover the soil air spaces, there by obstructing the flow of crude oil in the soil.

The absorption rate of crude oil was very fast at the first layer which covers the depth of 14.5cm within first and second day for 90ml of crude oil used as shown in table 4.1; while in the second and third layers absorption rate was very slow and covers depth of 20.6cm and 23.5cm within 9 days and 8 days respectively and in the fourth layer it takes just three days for absorption rate to reached fifth layer as shown in table 4.1 and this was due to porosity of different soil layers.

Regression analysis was carried out using experimental result and simulated results obtained as presented in the table 4.2. The simulated equation of the form $y = ax^n$ or $D = aT^b$, where D = depth\length (cm), T=time (days) was used and the regression equation gotten was equal to $D=(8.28 + 0.075V)T^{0.159}$.

5.1 CONCLUSION

From experimental and regression result it reveals that the absorption rate increases with increase in volume and also increase with time. It can be concluded that the higher the volume of crude oil, the higher the weight,. Then the higher rate of absorption. The higher the density of crude oil, the higher the rate of absorption in to the soil. this is because the weight of crude oil is directly proportional to the density. Also, it can be concluded that the higher the sulphur content, the slower the rate of absorption.

Moreso, it can be concluded that when there is crude oil spillage in a particular area, it takes more than three (3) weeks before the crude oil can penetrates/gets to the inner parts of the soil/land as confirmed from the experimental analysis carried out.

5.2 RECOMMENDATION

This type of study can be used to validate field Environmental impact Assessment (EIA) samples and predict vertical dissolution/distribution of crude oil in Niger-Delta where there is an oil spillage. This implies that this type of study, we can suggest indirectly the most appropriate environmental pollution remedial method in Niger-Delta.

In addition, this type of study can also be used to predict the extent or rate of crude oil absorption in future occurrence of crude oil spillage in Niger-Delta.

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APPENDIX

Using regression analysis of graphs of the form $y=ax^n$ where a and n are constant.

Linearised to log y= nlogx+loga

$y = mx + c$

where m = n,

c = log a,   a = antilog c

$D = aT^b$

Log D = blogT + loga

$y = mx + c$

where, D = depth/length (cm)

T = time (days) and

a and b are constant

x = time (days), y = length/depth (cm)

$an + b\Sigma x = \Sigma y$----------------------------(i)

$a\Sigma x + b\Sigma x^2 = \Sigma xy$-----------------------(ii)

Volume of the Crude Oil Used 90ml

log D = y	logT = x	X^2	xy
1.161	0.000	0.000	0.000
1.230	0.301	0.091	0.370
1.255	0.477	0.228	0.599
1.262	0.602	0.362	0.760
1.272	0.699	0.489	0.889

log D = y	logT = x	X^2	xy
1.279	0.778	0.605	0.995
1.283	0.845	0.714	1.084
1.290	0.903	0.815	1.165
1.297	0.954	0.910	1.237
1.314	1.000	1.000	1.314
1.322	1.041	1.084	1.387
1.338	1.079	1.164	1.444
1.342	1.114	1.241	1.495
1.350	1.146	1.313	1.547
1.356	1.176	1.383	1.595
1.362	1.204	1.450	1.640
1.365	1.230	1.513	1.679
1.369	1.255	1.575	1.718
1.371	1.279	1.636	1.754
1.373	1.301	1.693	1.786
1.375	1.322	1.748	1.818
1.377	1.342	1.801	1.848
1.378	1.362	1.855	1.877
1.380	1.380	1.904	1.904
Σ31.711	23.79	26.574	31.905

Using equation i and ii above, where n = numbers of variables, we have:

$24a + 23.79b = 31.711$----------------------------(i)

$23.79a + 26.574b = 31.905$-----------------------(ii)

$a + 0.991b = 1.321$-----------------------------------(iii)

$a + 1.117b = 1.341$-----------------------------------(iv)

$0.126b = 0.002$

$b = 0.159$

Substitute b in equation (iv) above we have,

$a + 1.117b = 1.341$

$a + 1.117(0.159) = 1.341$

$a + 0.178 = 1.341$

$a = 1.163$

but $c = \log a$

$a = \text{antilog } c$

$a = \text{antilog } 1.163$

$a = 14.56$

Volume of the Crude Oil Used 110ml

log D = y	logT = x	x^2	xy
1.215	0.000	0.000	0.000
1.301	0.301	0.091	0.392
1.342	0.477	0.228	0.640
1.346	0.602	0.362	0.810
1.352	0.699	0.489	0.945
1.362	0.778	0.605	1.060
1.367	0.845	0.714	1.155
1.375	0.903	0.815	1.242
1.380	0.954	0.910	1.317
1.387	1.000	1.000	1.387
1.398	1.041	1.084	1.455
1.407	1.079	1.164	1.518
1.412	1.114	1.241	1.573
1.420	1.146	1.313	1.627
1.422	1.176	1.383	1.672
1.423	1.204	1.450	1.713
1.428	1.230	1.513	1.756
1.435	1.255	1.575	1.801
1.411	1.279	1.636	1.843
1.477	1.301	1.693	1.883
1.453	1.322	1.748	1.921

	1.459	1.342	1.801	1.958
	1.465	1.362	1.855	1.995
	1.471	1.380	1.904	2.030
Σ	33.508	23.79	26.574	33.693

Using equation (i) and (ii) above we have:

24a + 23.79b = 33.508------------------------------(i)

23.79a + 26 574b = 33.693--------------------------(ii)

a +0.991b = 1.396---------------------------------------(iii)

_(a + 1.117b) = 1.416-----------------------------------(iv)

0.126b = 0.02

b = 0.159

substitute b in equation (iv) above we have,

a +1.117b = 1.416

a + 1.117(0.159) = 1.416

a + 0.178 = 1.1416

a = 1.238

since c = log a

log a = c

a = antilog 1.238

a = 17.30

Volume of the Crude Oil Used 130ml

log D = y	logT = x	x^2	xy
1.262	0.000	0.000	0.000
1.342	0.301	0.091	0.404
1.348	0.477	0.228	0.643
1.354	0.602	0.362	0.815
1.360	0.699	0.489	0.951
1.365	0.778	0.605	1.062
1.373	0.845	0.714	1.160
1.380	0.903	0.815	1.246
1.398	0.954	0.910	1.334
1.407	1.000	1.000	1.407
1.413	1.041	1.084	1.471
1.420	1.079	1.164	1.532
1.428	1.114	1.241	1.591
1.431	1.146	1.313	1.640
1.438	1.176	1.383	1.691
1.444	1.204	1.450	1.739
1.447	1.230	1.513	1.780
1.452	1.255	1.575	1.822
1.456	1.279	1.636	1.862
1.462	1.301	1.693	1.902
1.467	1.322	1.748	1.939

1.471	1.342	1.801	1.974
1.477	1.362	1.855	2.012
1.483	1.380	1.904	2.047
Σ 33.878	23.79	26.574	34.024

Using equation (i) and above we have:

24a + 23.79b = 33.878---------------------------------(i)

23.79a + 26 574b = 34.024------------------------------(ii)

a + 0.911b = 1.412--(iii)

_(a + 1.117b) = 1.430---------------------------------------(iv)

0.126b = 0.02

b = 0.159

substitute bin equation (iv) above we have:

a + 1.117b = 1.430

a + 1.117(0.159) = 1.430

a + 0.178 = 1.430

a = 1.252

since c = log a

a = antilog c

a = antilog 1.252

a = 17.86

Volume of the Crude Oil Used 150ml

log D = y	logT = x	x^2	xy
1.305	0.000	0.000	0.000
1.380	0.301	0.091	0.415
1.384	0.477	0.228	0.660
1.389	0.602	0.362	0.836
1.396	0.699	0.489	0.976
1.403	0.778	0.605	1.092
1.410	0.845	0.714	1.191
1.415	0.903	0.815	1.278
1.436	0.954	0.910	1.370
1.442	1.000	1.000	1.442
1.447	1.041	1.084	1.506
1.453	1.079	1.164	1.568
1.459	1.114	1.241	1.625
1.477	1.146	1.313	1.693
1.481	1.176	1.383	1.742
1.487	1.204	1.450	1.790
1.494	1.230	1.513	1.838
1.498	1.255	1.575	1.880
1.502	1.279	1.636	1.921

	1.508	1.301	1.693	1.962
	1.513	1.322	1.748	2.000
	1.517	1.342	1.801	2.036
	1.522	1.362	1.855	2.073
	1.528	1.380	1.904	2.109
Σ	34.846	23.79	26.574	35.003

Using equation (i) and above we have:

24a + 23.79b = 34.846---------------------------------(i)

23.79a + 26 574b = 35.003-----------------------------(ii)

a + 0.911b = 1.452---------------------------------------(iii)

_(a + 1.117b) = 1.471--(iv)

0.126b = 0.02

b = 0.159

substitute b in equation (iv) above we have:

a + 1.117b = 1.471

a + 1.117(0.159) = 1.471

a + 0.178 = 1.471

a = 1.293

since c = log a

a = antilog c

a = antilog 1.293

a = 19.63

Volume of the Crude Oil Used 170ml

log D = y	log T = x	x^2	xy
1.342	0.000	0.000	0.000
1.413	0.301	0.091	0.425
1.415	0.477	0.228	0.675
1.420	0.602	0.362	0.855
1.427	0.699	0.489	0.997
1.431	0.778	0.605	1.113
1.438	0.845	0.714	1.215
1.444	0.903	0.851	1.304
1.470	0.954	0.910	1.402
1.480	1.000	1.000	1.480
1.484	1.041	1.084	1.545
1.489	1.079	1.164	1.607
1.494	1.114	1.241	1.664
1.498	1.146	1.313	1.717
1.502	1.176	1.383	1.766
1.508	1.204	1.450	1.816
1.513	1.230	1.513	1.861
1.519	1.255	1.575	1.906
1.524	1.279	1.636	1.949
1.528	1.301	1.693	1.988
1.531	1.322	1.748	2.024

1.537	1.342	1.801	2.063
1.540	1.362	1.855	2.097
1.544	1.380	1.904	2.131
Σ 350491	23.79	26.574	35.60

Using equation (i) and above we have:

$24a + 23.79b = 35.491$---------------------------------(i)

$23.79a + 26\ 574b = 35.60$-----------------------------(ii)

$a + 0.911b = 1.479$--(iii)

$\_(a + 1.117b) = 1.496$--(iv)

$0.126b = 0.02$

$b = 0.159$

substitute b in equation (iv) above we have:

$a + 1.117b = 1.496$

$a + 1.117(0.159) = 1.496$

$a + 0.178 = 1.496$

$a = 1.318$

since $c = \log a$

$a = \text{antilog } c$

$a = \text{antilog } 1.318$

$a = 20.80$

since b is constant throughout irrespective of volume, we have

$cn + f\Sigma x = \Sigma y$--------------(1)

$c\Sigma x + f\Sigma x^2 = \Sigma xy$-----------(2)

$y = ax^n$

$D = aT^{-b}$

$D = aT^{-0.159}$-------------------(j)

a	volume
14.56	90
17.30	110
17.86	130
19.63	150
20.80	170

X	**Y**	**X^2**	**XY**
90.00	14.56	8100.0	1310.4
110.0	17.30	12100.0	1903.0
130.0	17.86	16900.0	2321.8
150.0	19.63	22500.0	2944.5
170.0	20.80	28900.0	3536.0
Σ650.0	90.15	88500.00	12015.7

Using equation (1) and (2) above we have :

5c+650f = 90.15---------(1)

650+88500f = 12015.7-------(2)

c+130f = 18.03---------------(3)

$-(c+136.15f) = 18.49$----------(4)

$6.15f = 0.46$

$f = 0.075$

substitutes f in equation 3 above we have:

$c+130f = 18.03$

$c+130(0.075) = 18.03$

$c+9.75 = 18.03$

$c = 8.28$

Forming another equation with a we have:

$a = c+fv$

$a = 8.28+0.075V$

substitute a into equation j above we have:

$D = (8.28+0.075v)T^{0.159}$