POLLUTANT DISPERSION EVALUATION FROM OIL SPILLAGE

A CASE STUDY OF NIGER- DELTA

BY

ASUNMO ADEKUNLE ADESINA

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FEDERAL UNIVERSITY OF TECHNOLOGY MINNA
NIGER STATE

PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING [B.ENG] DEGREE IN THE DEPARTMENTOF CHEMICAL ENGINEERING.

OCTOBER 2003

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NIGER-STATE

OCTOBER 2003

DECLARATION

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

....	20/10/2003 ....
ASUNMO A. ADESINA	**DATE**

CERTIFICATION

This is to certify that this project titled "Pollutant dispersion evaluation from oil spillage" was carried out by ASUNMO ADEKUNLE ADESINA under the supervision of ENG'R ABDULKAREEM S.A. 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.

.... 20/10/2003

PROJECT SUPERVISOR **DATE**

ENG'R. ABDULKAREEM S. A.

....

HEAD OF DEPARTMENT **DATE**

DR. ABERUAGBA

....

EXTERNAL SUPERVISIOR **DATE**

DEDICATION

This Project is dedicated to my lovely Paternal Grandma; **MADAM AMINAT ABEKE ASUNMO** and my parent **Mr. ABDULRASHEED OMOBORIOWO ASUNMO and Mrs. AFUSAT ADUNNI ASUNMO.**

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ABSTRACT

The dispersion of pollutants as a result of oil spillage in Niger –Delta area of Nigeria has led to strain in the relationship between oil exploring and host communities. Analysis of experimental result of pollutant dispersion due to the oil spillage in Niger-Delta has been carried out. Attempt at modeling of pollutant dispersion evaluation from oil spillage was explored using Q-basic program. Simulation result of the developed model show that increased in volume of oil spill leads to increase in effective dispersion of pollutants. Also the porosity of the soil in Niger-delta area contributed greatly in such away that the smaller the porosity the higher the horizontal dispersion of pollutant. Experimental results reveal that the area investigated are not in conformity with the FEPA limit and that continuous spillage of the quantity in the immediate environment will in the long run lead to change in the physico-chemical properties of soil.

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CHARTER ONE

1.0 INTRODUCTION

1.10 GENERAL INTRODUCTION

The most significant pollution from the petroleum industry is oil that arises from accidental oil spills. This is because the effects of oil spill are very visible and sometimes devastating. Petroleum and its component which have been released into the environment are eventually degraded into simple compound of their constituent element by physio-chemical or biological agencies, with or without human assistance and becomes innocuous; but in the process, they may cause serious damage to plant and environmental and this impede human exploitation of natural resources {Achem 1998}.

Oil spill whether or not they are petroleum based, have the ability to kill and injure a wide array of plant, animal and microorganism as well as disrupt subtle ecosystem process {BRETT1998}. Spill can also cause severe surface and ground water pollution. Oil spills posing an immediate threat to the environment require quick and throughout responses when an oil spill or release occurs on land or inland water and shorelines it is responsibility the Environmental protection Agency EPA to respond {Brett 1998}. To be able to deal with the threat of an oil spill quickly, the EPA created the EPA oil spill program (OSP) run under the supervision of the EPA's emergency response program of the superfund (Brett, 1998). The OSP has been able to reduce the number of spills to less than 1% of the total volume of handled each year (OSP overview 1997). However, the need for continued oil spill prevention can be seen in the fact nearly half of all reported hazardous waste spills that occurred in EPA region

5 (Illinois, India, Michigan, Minnesota, Ohio and Wisconsin) involved some form of oil Rittenhouse, 1996). The ability of government and people to quantify the effect of the resultant pollution on the environment cum ineffective monitoring of the companies by the appropriate organs have exposed the people in the Niger-Delta area to a lot of health hazard. It is therefore, on this note that a mathematical model that can determine the concentration of pollutant from the oil spill as it disperses from the source is developed.

Mathematical modeling is a simplified image of processes taking place in a system. This could include heat propagation, concentration of dispersion of gases from combustion and generation of heat and propagation etc. Model retains the most essential properties of the actual processes but represent them in mathematical forms. According to (Luyben 1995), "Mathematical Modeling is very much an art. It takes experienced practice and brain power to be good mathematical modelers". Mathematical Models of a system must be sufficiently simple easy to grasp and give a clear idea about all the qualitative of the phenomenon of interest. On the other hand, it must be sufficient accurate in bringing the qualitative aspect of the process [Abdulkareem, 200]

Simulation represents the application of modeling techniques to real system. This enabling information on plant characteristic to be gained without either constructing or operating the full-scale plants or system under consideration. Simulation methods come into two type viz Digital simulation and Analogue simulation of these two, Digital simulation which involve the use of codes and programs are more in use since they can be implemented on modern computer with exceptional speed [William, 1995]

1.20 **AIMS AND OBJECTIVES**.

The aims of this project are to predict the extent of pollution of soil in the Niger- Delta area of Nigeria due to oil spillage from the oil companies. This could be achieved via the realization of the following objectives;

1 Developed a predictive model that will determine concentration of pollutant from the oil as it dispersed from the sources.

2 Simulate the developed model equation by computer programme.

3 Find the interaction between the various parameter that govern pollutant dispersion in soil i.e. volume of oil spill, soil porosity, hydrological parameter e.t.c

4 Determine safe distance for farming and living from the processing industries.

SCOPE OF STUDY

The project focuses on predictive model for pollutant from oil spillage in the soil in Niger-Delta area of Nigeria

JUSTIFICATION.

The advancement being made in science and technology and indeed chemical engineering contributed immensely to continue global industrial growth and development. Series of research have been carried out on oil spillage. Oil pollution of 1990[OPA 90] established the thirteen-member interagency coordinating committee on oil pollution research. The committee is charged with coordinating a comprehensive program of research, technology development, and demonstration among federal agencies in cooperation with industries, universities, and research institution e.t.c. Their responsibility includes preparation of an oil pollution research and technology plan. The committee submitted their report to congress in April 1992. Also Saskatchewan petroleum /Government Environment committee Guideline No.3 January 1, 1999 worked on restoration of spill site on Saskatchewan Agriculture and pasture lands. The committee worked on the effect of crude oil on the soil and reclamation of crude oil contaminated soil.

In Nigeria Achem Monday 1998 studied Environmental impact assessment of oil spillage a case study of ubeji soil after spillage, okopi Solomon studied impact of oil spillage in Nigeria a case study of oshika oil spillage.

It could be observed that much work has been done on oil spillage but little has been carried out on modeling and simulation of pollutant dispersion from oil spillage.

This project seeks to develop a model that will assist in knowing the concentration of pollutant from sources to the other part of the soil. This project is therefore a contribution to the advancement in science and technology, considering the effect of oil spillage on Agriculture and economic.

CHAPTER TWO

LITERATURE REVIEW

OVERVIEW OF POLLUTION.

Pollution is caused when a change in physical chemical, or biological condition in the environment harmfully affect the quality of human life. Including effect on other animal and plant [The new encyclopedia Britannica volume 14]. Most pollution may be characterized as a production excess resulting from manufacturing or growing more than is to be consumed or as a result of discarding products after use. Though pollution is generally attributed to material substances [gases and particulate matter from smokestacks, chemical in water or solid wastes, paper, glass, used automobiles], pollution may also be non-material, such as an excess of noise and light [The new encyclopedia Britannica volume 14]. There are three types of pollution; air pollution, water pollution and land pollution. Pollutants in air or land, washed or leached out by rain, contribute to water pollution, and substances in water settle out in sediment and end up as pollution of the land. [The new encyclopedia Britannica volume 14]

The quality of our environment is of major concern in today's world. Many effort are being made to prevent damage to the environment by petroleum and its product. Damage can occur in numerous ways. For example, in the early day of petroleum industry, oil well blow out were common. Natural gas escaping from a well was burned off rather than saved [The new book of knowledge volume 15]. Often pollution is accidental, for example, the breaking up of a giant tanker as a result of a storm or a collision, can release thousand of oil into the ocean or land. The oil befouls the seawater damages beaches, and kills fish, other marine animals and birds. Sometimes pollution is even deliberate, for example some tankers, in spite of laws making it illegal, discharge oil residues into the ocean, rather than unloading this waste at the next port. Considering the expansion and diversification into other areas such as petrochemical and gas, there is needed to control the contamination and pollution of general environment against petroleum operation. Crude oil exploration, production and distribution in Nigeria have resulted in the degradation and pollution of the environment.

In this regard pollution will be defined as the addition to any segment of the environment of any material, which has detrimental effect. In view of complete nature of petroleum industry pollution problem are a matter of fact very complex indeed. The various effect of pollution depends on the pollutant. In the case of oil spills, there would be serious damage to the marine life and vast destruction of the environment..

SOURCES OF POLLUTION FROM OIL

Operational activities within the petroleum industry could result in the discharge of pollution into the general environment. Presently in Nigeria known sources of pollutions are;

1 Onshore and offshore exploration and production operation.
2 Transportation operations.
3 Petroleum refining operation activities.

OIL SPILLAGE.

With the increase in activities of oil exploration and exploitation in Niger- Delta area, there is an increase in the like hood of oil spill occurring. Spill can be harmful to the environment especially to the soil. Oil spillage is the uncontrolled discharge of hydrocarbon- liquid, solid or gaseous into the environment. It could be spilled on the land or water. Oil spill are classified according to volume so that a clear indication of response competence level required for each tier is mapped out or as described by Department of petroleum Resources [DPR]. It is estimated that between 1976 and 1991, 2,976 oil spills have occurred with about 2.1 million barrels of oil lost during the period. This represents on enormous cost to the country both economically and environment [susu et-al, 1995].

CLASSIFICATION OF OIL SPILL.

TIER-1 OR MINOR SPILL.

This refers to a spill or any discharge of oil less than 25 barrels on land, offshore or coastal water that does nit pose a threat to the public health or welfare.

TIER-2 OR MEDIUM SPILL.

This refers to a spill or discharge of oil over 25 to 250 barrels into inland water or 250 to 2,500 barrels on land, offshore and coastal water.

TIER 3 OR MAJOR SPILL.

This refers to a spill or any discharge of oil over 250 barrels into inland water or over 2500 barrels on land, offshore and coastal water. A spill of lesser volume that poses a threat to the public, health, or welfare may classified as medium or major spill depending upon its degree impact.

CAUSES OF OIL SPILLAGE

A Good understanding of the causes of spills important for the determination of effective containment recovery and counter measures. From the numerous investigations of oil spill incident in Nigeria the causes of oil spillage are many and various. These may be broadly classified into oil well blowout, accidental operational sabotage and natural causes

2.5.1 OIL WELL BLOWOUT

Oil well blowout is as the result of in balanced between the hydrostatic mud head and the formation pressure. It occurs when the formation fluid enters the well bore during the drilling operation due to the fact that the formation pressure is higher than that5 of the hydrostatic mud head resulting into disastrous oil well blowout. This could be due to improper well mounting, lack of adequately rated and open table well control equipment and strict vigilance of the drilling screw

2.5.2 ACCIDENTAL DISCHARGES

Accidentals causes may be due to equipment failure or human error. Equipment failure could be due to malfunctioning, age, overloading(as when there is excessive pressure causing a break-out),corrosion or abrasion of part of facilities, and equipment mal function(achem,19 98).Human error results when a worker fails to do what he/she is expected to do .For a example a valve could be left open while is being pumped or pressure is allowed to build up beyond the designed capacity of the equipment or facility.

2. 5.3 OPERATIONAL DISCHARGES

Operational discharges of oil are very common. By its nature, some oil is expected to escape in small quantities during oil operation, example when changing connection or transferring oil from one container to another. At industrial site, such little drops could build up to a substantial quantity which then poses a problem of disposal (Achem, 1998).

2.5.4 SABOTAGE

Sabotage cases refers to deliberate intervention of a normal operation of an oil facility either for the purpose of venting their anger or to get some monetary compensation from the oil company concerned.

2.5.5 NATURAL CAUSES

Another causes of oil spill is natural causes such as wind hurricane, cyclone, storm, flood etc.

2.6.0 EFFECT OF OIL SPILL

2.6.1 EFFECT OF OIL SPILL ON SOIL

After the crude or petroleum product is spilled, it migrates down ward under the force of gravity. The mobility of the oil in the soil depends on its viscosity, quantity of the oil spilled and the permeability of the soil. During its movement through the unsaturated zone, there is absorption and reaction between the oil and the 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 aquifers, when oil i8s not immobilized in unsaturated zone, the spill will reach the water table, the oil is forced to spread literally in form of a thin pancake due to it lower specific gravity. Soluble component will dissolve bin the water and vapours will be released which may collect forming potential five or explosion hazards. The pollution plume of crude oil and dissolved phases will move in the direction ground water flow in the aquiter (Achem, 1998)

2.6.2 EFFECT OF OIL SPILL ON CROP PERFORMANCE

The first noticeable effect of oil spill across the surface the land in many quantities is likely to be upon vegetations. Plants exchange the gases involved in respiration and photosynthesis through small pores, mostly on their underside of their leaves, some specialist plant of water logged, anaerobic soil also transport air from this pores to their roots, improving the soil condition locally(Jackson,1958).The pores may readily be penetrated by thin oil, a process which is usually demonstrated by a darkening of the leaf as it air-spaces become filled with the oil; heaver fraction may block them up, while a coating of dark oil exclude or filter the sunlight necessary to the functioning of all the green plant(Jackson,1958).Once it has received a significant covering of an active oil, an individual leaf invariably dies. Oil percolating into the soil around the root may interfere with their uptake of water or causes the release of substances to the plant. From the study carried out on the effect of crude oil on microbial process in marine sediment, it is revealed that process like nitrification, denitrification, nitrogen fixation, sulphate reduction, phosphate uptake and photosynthesis did not occur at sufficient levels compared to the control site (Achem, 1998). Since the actual impact of micro-organism in the environment is a function of their activity rather than their numbers, it could be logical to inferred that the activities of this micro-organism is affected by crude oil. Through the extent of this impact is a function of the crude oil spilled to the environment.

2.70 PREVENTING AND LIMITING SPILLS.

Effective oil spill prevention is the best method for reducing the problem of oil spills. Through training programs properly maintained equipment, adequate alarm systems, strict adherence to industry and government codes and regulation adequate company community relationship all make essential contribution to the prevention of spills. if despite these preventive measure a spill does occur, it follow that the less oil spilled, the easier the clean up, the lesser the effect on the environment and the better for all. In most cases, the action necessary to limit the spill is obvious, close the valve that has been accidentally opened, cease pumping through the erupted oil line or repair the leak. If petroleum is escaping from a shore side facility, use sand bags or throw up a temporary dike to prevent damage into the water. In the case of a grounded tanker or barge transfer the oil into another vessel. One of the best ways to prevent or limit spills is to anticipate them by through training of crew and personnel. Workers who are keenly aware of the danger of spill are most likely to be prepared to take immediate and` effective action. Anticipating action should include the installation where possible, of equipment to control and stop the flow of oil.

The primary responsibility for handling spills should be delegated to one man or to a special committee such responsibility should include analysis of potential spill location, the preparation of plan for cleaning with emergencies, processing evaluating and making readily available the necessary equipment and materials and conducting training serious and drills in clean up procedures.

Alert, informed and responsible personel, through training and good equipment are a good recipe for preventing and limiting spills. Advantages are the cost of such precautions will be more than repaid by a reduction in lost oil and lower clean up costs. More important however, in the protection of our environment from pollution through the following

1 **OIL SPILL CONTEGENCY PLANNING**: because of the difficult decision that will be required during an oil spill in order to mitigate damage and to resolve conflicts of interest, much can be done at the contingency planning stage to identify sensitive areas and to determine priorities for protection.

Detailed consolidation should be given to the likely impact a spill would have on habit or activity, taking into account any seasonal variability. Attention should then be given to identifying areas to be protected and their order of priority. This will never be easy since the value of each resource to the community at large will depend upon weight given to environment, recreational economic and political considerations. This may require wide range of data to be gathered and evaluation.

2 maintenance of comprehensive records of oil spills: Establishing of a data bank or the impact of the petroleum industry on the environment.

3 Government should make a policy that will hold for reaching implication for oil operations in the country. Such policy should be designed to raise liability limits, create a national funds to help cover costs of catastrophic spills and other related petroleum production crisis, in effect, oil should be treated more like a hazardous substance similar to toxic chemical as liquefied natural gas [LNG].

2 .7.1 OIL SPILL CLEAN UP

2 .7 .1 .1 STANDARD CLEAN UP PROCESS

The basic environmental protection agency (EPA) clean up procedure for an individual site begins with a survey of site characteristics (i.e. location, surroundings, amount and type of waste.) it also include the drafting of a clean up (restoration) plan after which approval is obtained and clean up can proceed. After a hazardous waste site is discovered it must first undergo an evaluation in the forms of a preliminary site assessment and a site inspection. The preliminary assessment is a review of all information collected by field investigators for an individual site to evaluate the source and nature of the pollutant and whether a responsible party can be identified (superfund clean up process, 1998). The site inspection is generally conducted to examine potential pathways that the contaminant could use to affect human health. This usually involves different types of sampling, monitoring, reconnaissance, and other field activities. From this information a report is drifted that is the types of spillage, evaluate the impact on the surrounding area, and proposes a safety plan [superfund remedial response programme (RRP), 1983]. To base on the data gathered during the evaluation of sites, those that are deemed potentially hazardous are ranked using a mathematical model known as the Hazard Ranking system (HRS) and then placed on the National priorities list (NPL) for long term remedial action (Brett, 1998). Criteria that are taken into account are the possible risks to the population, the hazard potential of the substances, the potential to contaminate drinking water or otherwise adversely affect public health, and the potential to harm sensitive ecosystem. With this knowledge, the EPA decides what, if any, course of action to take. Possible response could be removal of the pollutant and subsequent clean up of the site or to do nothing and end the superfund's association with the site. The more severely polluted the site or the greater the danger imposed, the high the priority for remediation. If remedial action is decided upon, the EPA must make a rapid, consistent, and rational decision on how to proceed. The objective is to determine the least expensive and most feasible, as well as reliable, method that reduces the danger and protects society and environment (Brett, 1998). The planning process consist of initial [planning, a remedial investigation a visible study, remedy selection, and remedial design and construction. Initial planning includes initial remedial action, which consist of the removal and control of the pollution sources. If these initial actions are not sufficient then off site actions need to be taken. These can include providing permanent alternative water supply, removing contaminated soil and sediment, and even relocatingsome population (superfund's, RRP, 1983). A study of hydrologic and geology condition, soil, sediment, ground and surface water, and air quality are conducted (superfund'sRRP, 1983). With this data the appropriate remedial technologies are identified. The feasibility study looks at all the appropriate technologies and recommends and develops a plan for the most promising. The final step is the remedial design and constructing of the remedy.

2.7.1.2 COMMON CEAN UP METHODS.

After almost two decades of mandatory hazardous site reclamation it is no surprise the EPA has developed a variety of innovative clean up technologies, many are still in the experimental stage, but some preferred methods have been especially effective in restoring sites degraded by oil pollution (Brett1998). A few of the more common methods for dealing with oil pollution include in-situ bioremediation, natural attenuation, pump and, excavation and incineration, and soil washing.

In-situ bioremediation is becoming the preferred method for treating soil and ground water affect by oil pollution (Brett 1998). It is a process that uses micro- organism to transform harmful organic compound, like oil, into nontoxic and less dangerous compound. Microorganisms require nutrient and organic carbon to fuel continued growth and respiration. These microbes break down carbon- containing organic compounds into form that are not nearly as harmful to human health pr the environment, with oil usually carbon dioxide and water (Sims et al, 1992). The most favourable aspect of in- situ bioremediation, aside from affordability, is that the clean up can take place directly on the site where there is pollution without having to severely disturb any land with the exception of some possible aeration. The bioremediation of petroleum product and hydrocarbon can occur naturally if there sufficient amount of nutrients available in the polluted area. However, additional amendments of microorganisms and / or nutrients van be added to the site to stimulate degradation, but this should be based on current concentration that are already present (venosa, 1996). Other factor that may slow bioremediation are; concentration of contaminants are so high they are toxic to microbes, an un favourable PH for microbes (too high or low), unfavourable moisture or temperature, and a lack of oxygen (common clean up methods, 1994). Altering environment condition, adding nutrient and additional microbes, and stimulating microorganism with electric charges can increase microbe's activity and bioremediation.

Natural attenuation is a non-invasive method that uses natural process to reduce concentration of oil and other chemicals. The major aspect of this method is that it requires intensive monitoring (this sound very much like bioremediation, which happen to be one aspect of natural attenuation, but also uses dilution or dispersion or adsorption (A citizen's Guide, 1996)).

Unlike bioremediation, the apparent goal of natural attenuation is not to transform compounds into less harmful ones, but to reduce toxic concentration of harmful substances. Natural attenuation does not rely fully on the activity of soil microbes. The process also includes the effect of dilution and dispersion, as well as adsorption. When introduced to the environment oil will disperse within the soil and even more so in water. As the original spill is dispersed over more area the concentration of oil are diluted and decrease. In water, oil molecules are repelled by water and take any opportunity to attach themselves to an available particle of clay or organic matter, thus being adsorbed. Unlike bioremediation these process do not destroy oil compound, but reduce the concentration of contaminant in order to reduce potential risks (A citizen's Guide, 1996).

More traditional method still used today includes the pumping and treatment of oil polluted aquifers, the excavation and subsequent disposal or incineration of hazardous wastes, and soil washing. In the pump and treat method polluted water can be treated after capturing it with the use of well or drains. The water can then be treated using a carbon adsorption system, microorganism, high intensity light and chemical, or air stripping which is the use of high powered air stream that removes volatile organic carbons (VOC'S) as it moves across the surface (common clean up methods, 1994). When oil severely pollutes soil it may be necessary to excavate a site, using heavy machine, and remove the polluted soil. The excavated materials can then be incinerated at temperature between 1600f to 2500f. After incineration the waste product must be disposed of at a Resource conservation and Recovery act (RCRA) permitted facility. Incineration cannot destroy all organic compound, but is required and able to remove at 99.9%(common clean up methods, 1994)

✓ Soil washing is a little more complex than its name, but not much. The process begins by using a soil washing machine, usually using water and some detergent, to treat sorted soil and shoreline material. The contaminated material is first sorted to remove large debris and is then placed in the washer. After being washed the material has been further sorted and drained of contaminants, so the material can then be used as back fill. If the treated soil is still contaminated the soil is reprocessed until clean. The finer silt and clay particle that are filtered and drained from coarser materials have adsorbed the oils compounds. This concentrated volume of polluted soil particles can then be treated further using incineration or some other treatment (common clean up method, 1994)

2.80 MATHEMATICAL MODELLING AND SIMULATION

Model is a simplified representation of a system intended to enhance our ability to understand, explain, change, preserve, predict and possibly control the behaviour of a system (NAELAMKAVIL 1987). Modeling is thus, the process of establishing, interrelationship between important entities of a system. Models are represented in term of goals, performance criteria and constraints (Jamen and Donald). Mathematical model of a system only represent the mathematical aspect of a process or system of interest. It gives the description of the process, both the physical and chemical phenomena taking place their in. a model retain the physical properties of the system, it is therefore aimed at providing the simplest possible description of a system which is an exact scaled down replica of the prototype and at the same times retain it physical character (William, 1990)

2.81 PRINCIPLES OF MODEL FORMATION.

The principle of model formulation involve are stated below;

2.82 BASIS.

The basis for mathematical model is fundamental physical and chemical laws, such as the law of energy and momentum conservation stated in their time derivative forms. Others include parameter such as mass transfer coefficient, diffusivity constant, reaction rate, which are either obtained experimentally or from process operating databank.

2.83 ASSUMPTION.

There is the need to make simplifying but reasonable assumption about the system while modeling. The outcome of the model is dependent on the assumption as they impose limitation on the model. A simple model needs many assumption and yield an approximate result quickly, whereas a more complicated model of the same system need fewer assumptions and yield a more accurate answer by more advanced mathematical techniques. Thus the assumption must be carefully considered when evaluating results

2.84 MATHEMATICAL CONSISTENCY OF MODEL.

Care must be taken not to under specify or over specify the numbers of variable or equation describing the system because in order to obtain a solution, the numbers of variable must equal number of equation i.e the "degree of freedom" of the system must be zero.(William, 1990). These must also be a consistency in the unit of term of the equations. Consistency checks are essential as they save many hours of frustration, confusion and wasted compute time.

2.85 SOLUTION OF THE MODEL EQUATION.

Available solution techniques are tools that must be kept in mind as the model is being developed. In the search for a method of solution, possible approximation for the defining equations, boundary and initial condition and an acceptable find solution are considered.

2.86 VERIFICATION.

The need to prove the validity of a model is an important part of mathematical modeling. Because of the complex nature of verifying the model, it is often neglected. However, one way of achieving this objective is by comparing average experimental result, for similar operation condition to the computer results.

2.90 SIMULATION.

Martin shubik defines simulation of a system as the operation of a model, which is a representation of the system, the model being amenable to manipulation, which would be impossible, too expensive or impracticable to perform on the system it portrays.

Simulation is used for two principal reasons;

1 To give greater understanding and insight into the behaviour of the physical system and the principle upon which its design is based.

2 To provide a convenient, inexpensive and time saving means of gaining this understanding and insight under a variety of operation condition.

2.91 SIMULATION PROCESS.

Simulation process could be described as a three-step process;

1 A mathematical model is first created to describe the behaviour of the system being studied.

2 The mathematical model is manipulated wherever possible and practicable to give the desired information concerning the system.

3 Whenever conventional mathematical manipulation is impractical the analog /digital computer may be used to stimulate the mathematical model.

2.92 SIMULATION PROCEDURE.

The procedure for carrying out the manipulations stated below is as follows;

1. Data collection
2. Problem analysis
3. Simulation model specification
4. Model programming
5. Model verification
6. Simulation experimentation
7. Evaluation and interpretation of simulation results
8. Report generation

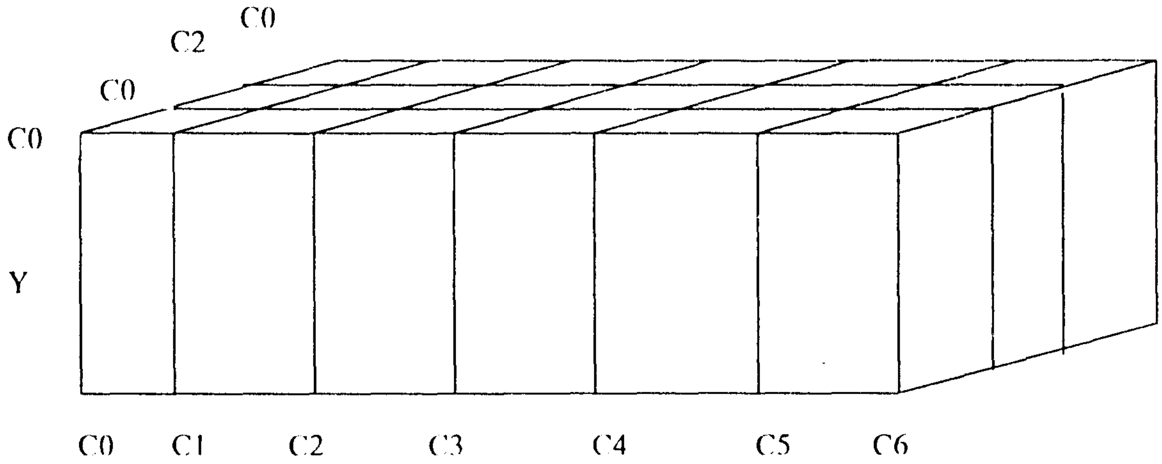
CHAPTER THREE

3.0 CONCEPTUALIZATION OF MODELING TECHNIQUE.

3.1 MATHEMATICAL MODELING OF POLLUTANT DISPERSION FROM OIL SPILLAGE

Oil spill in oil producing area has contributed to occurrence of catastrophic in that area. Due to the dispersion of this spill from sources of spill to the other near-by villages, the soil has been contaminated and it affects the farming and ground water of the area.

THE BLOCK DIAGRAM OF OIL SPILL DISPERSION ALONG XAND Y.



The diagram above showed the dispersion of oil from the spill site (co) to the various distance along x and y Cartesian coordinate.

ASSUMPTIONS.

The following assumptions were made for the purpose of modeling and simulating the pollutant dispersion in the soil.

1. The equilibrium-controlled linear or non- linear sorption and first order irreversible rate reaction are involved in chemical reaction.
2. The velocity of dispersion of oil is the same as the velocity of groundwater.

3 The movement of oil along the x and y Cartesian coordinate are uniform.

4 The hydrodynamic coefficient are the same

FUNDAMENTAL OF THE TRANSPORT MODEL.

GOVERNING EQUATIONS

The partial differential equation describing transport of contaminant in soil can be written as follows (javandel et.l, 1984).

$\partial c/\partial t = \partial/\partial xi\ (Dij\partial c/\partial xj) -= \partial/\partial xj\ (VtC)+qs/\ \Phi\ Cs\ +\sum Rk$ ----------------------------- 3.1

Where

C is the concentration of contaminant dissolved in soil groundwater, ML^{-3};

Xi is the distance along the respective Cartesian coordinate axis, l;

T is the time, T;

Dij is the hydrodynamic dispersion coefficient, L^2T^{-1};

qs is volumetric flux of water per unit volume acquifer representing sources (positive) and sinks negative, T^{-1};

Cs is the concentration of the sources or sink, LT^{-1};

Vt is the seepage or linear pore water velocity, LT^{-1};

Φ is porosity of the porous medium dimensionless;

$\sum Rk$ is a chemical reaction term, $ML^{-3}T^{-1}$.

Assuming that only equilibrium –controlled linear or non-linear sorption and first order irreversible rate reaction are involved in the chemical reaction term in equation (3.1) can be expressed as (Groove and Stollenwerk, 1984);

$\sum Rk=Pь\partial\sum/\phi\partial t-\ \lambda\ (C+\ Pь\ \sum/\phi)$ ---------------------------------- 3.2

Where

Pь is the bulk density of the porous medium, ML^{-3};

∂ is the concentration of contaminant sorbed on the porous medium, MM^{-1}

λ is the rate constant of the first order reaction, T^{-1}.

By rewriting $P_b\partial\sum/\phi\partial$ term as;

$P_b\partial\sum/\phi\partial t = P_b\partial\sum\partial c /\partial c\, \phi\partial t$ --3.3

And substituting equation (3.2) and (3.3) into equation (3.1) to obtained

$\partial c/\partial t = \partial/\partial x_i (D_{ij}\partial c/\partial x_j) -= \partial/\partial x_j (V_tC)+q_s C_s / \Phi + P_b\partial\sum\partial c / \phi\partial t\partial c - \lambda (C+ P_b \sum/\phi)$-----

3.4

Moving the fourth term on the right hand side of the equation (3.4) to the left hand side equation (3.4) becomes

$R\partial c/\partial t = \partial/\partial x_i (D_{ij}\partial c/\partial x_j) -= \partial/\partial x_j (V_tC)+q_s C_s / \Phi-- \lambda (C+ P_b \sum/\phi)$--------3.5

Where

$R= 1+ P_b\partial\sum\partial c\, \phi$ ---------------------------------------3.6

Equation (3.5) is the governing equation for transport model.

From equation (3.5) above the first, second and third terms are dispersion, advection, sources or sinks term respectively on the right hand side of the equation

DISPERSION

DISPERSION MECHANISM.

Dispersion in porous media refers to the spreading of contaminant (oil) over a greater region than would be predicted solely from the groundwater velocity vectors. As described by Anderson 1984, dispersion is caused by mechanical dispersion, a result of deviation of actual velocity on a micro scale from the average soil water velocity, and molecular diffusion, a result of concentration variation. The molecular diffusion effect is generally secondary and negligible compared to the mechanical dispersion effect, and only becomes important when soil water velocity is very low. The sum of the mechanical dispersion and the molecular diffusion is termed hydrodynamic dispersion.

The dispersion term in equation (3.5) $\partial/\partial x_i (D_{ij}\partial c/\partial x_j)$ represent a pragmatic approach through which realistic transport calculation can be made without full describing the heterogeneous velocity field, which of course is impossible to do in practice. While many different approaches and theories have been developed to represent the dispersion process, equation (3.5) is still the basis for most practical simulations.

Dispersion coefficient.

The hydrodynamic dispersion tensor for isotopic porous media is defined, according to Bear (1979), in the following component forms,

$Dxx = \alpha L = Vx^2/|V| + \alpha r Vy^2/|V| + D^*$-------------------- 3.7a

$Dyy = \alpha L\ Vy^2|V| + \alpha r\ Vx^2/|V| + D^*$-------------------- 3.7b

$Dxy = Dyx = (\alpha L - \alpha r)\ VxVy/|V| + D^*$---------------------3.7c

Where

L is the longitudinal dispersivity, L;

R is the effective molecular diffusion coefficient LT^{-1}

VxVy are component of the velocity vector along x and y axes LT^{-1}

$|V| = (Vx^2 + Vy^2)$ is magnitude of the velocity LT^{-1}

ADVECTION

The second term on the right hand side of equation (3.5) $\partial/\partial xj\ (VtC)$ is referred to as the advection term. The advection term describes the transport of miscible contaminant at the same velocity as the groundwater. For many practical problems concerning contaminant transport in soil water, the advection term dominates. To measure the degree of advection domination, a dimensionless peclet number is usually used. The peclet number is defined as;

$Pe = |V|\ L/D$ ------------------------------3.8

Where

$|V|$ is the magnitude of the seepage velocity vector, LT^{-1};

L is a characteristic length, commonly taken as the grid cell width L;

D is the dispersion coefficient, L^2T^{-1}

In addition dominated problems, also referred to as sharp front problem, the peclet number has a large value. For pure advection problem, the peclet number becomes infinite.

SINKS AND SOURCES

The third term in the governing equation qsCs/ф is the sink or source term, which represent solute mass dissolved in oil entering the simulated domain through sources, or solute mass dissolved in oil leaving the simulated domain through sinks.

Sinks or sources may be classified as readily distributed or point sinks or sources. The areally distributed sinks or sources include recharge and evapotranspiration. The point sinks or sources include well, drains. Constant-head and generally head dependent boundaries in the flow model are also treated as point sink or sources because they function in exactly the same way as wells, drains in the transport model.

CHEMICAL REACTIONS.

The chemical reaction include in the transport model are equilibrium controlled linear or non- linear sorption and first order irreversible rate reaction most commonly, radioactive decay or biodegradation. More sophisticated chemical reaction can be added to the model when necessary without modifying the existing program.

LINEAR OR NON-LINEAR SORPTION.

Sorption refers to the mass process between the contaminant dissolved in ground water (solution phase) and the contaminant sorbed on the porous medium (solid phase). It us generally assumed that equilibrium condition exist between the solution phase and solid phase concentration and that the sorption reaction is test enough relative to ground water velocity so that it can be treated as instantaneous. The functional is called the sorption isotherm. Sorption isotherm is generally incorporated into the transport model through the use of the retardation factor (e.g. Goode and

Konikow). Three type of sorption isotherm are considered in the transport model; linear freundlich and Langmuir.

The linear sorption assumed that the sorbed concentration (∑ is directly proportional to the dissolved concentration.

(∑=Kdc ---3.81

Where Kd is called distribution coefficient, L^{2}M^{-1}.

The retardation factor is defined as

R= 1+ Pь∂∑∂c ф =1+ Pьkd/ ф --3.82

The freundlich isotherm is anon-linear isotherm expressed in the following form

(∑=KfC^a -- 3.83

Where

Kf is the freundlich constant, L^{3}M^{-1};

A is the freundlich exponent, dimensionless.

Both Kf and a are empirical coefficient. When a is equal to 1, the freundlich isotherm is equivalent to the linear isotherm. The retardation factor for the freundlich isotherm is defined accordingly as

R= 1+ Pь∂∑∂c ф =1+ Pь a Kf C^{a-1} / ф ----------------------------3.84

Another non- linear sorption isotherm is the Langmuir isotherm described by

(∑ =Kt%$_o$c /1+KtC -- 3.85

Where

Kt is the Langmuir constant L^{3}M^{-1}

%$_o$is the total concentration of sorption site available MM6-1

The retardation factor defined for the Langmuir isotherm is then

R= 1+ Pь∂∑∂c ф = 1+ Pь/ ф [Kt %$_o$/ (1+KtC)^2] ---------------------------------3.86

RADIOACTIVE DECAY OR BIODEGRADATION.

The first irreversible rate reaction term include in the governing equation -- $\lambda (C+ P_b \sum/ \phi))$ represent the mass loss of both the dissolved phase (c) and the sorbed phase ($\sum$ with the same rate constant rate(λ). The rate constant is usually given in term of the half-life

$\lambda = Ln2/ t_{1/2}$--------------------------------------3.87

Where

$t_{1/2}$ is the half –life of radioactive or biodegrable material, or the time require for the concentration to decrease to tone – half of the original value.

EULERIAN- LAGRANGIAN SOLUTION

EULERIAN- LAGRANGIAN EQUATION.

According to the chain rule, the advection term in governing equation (3.5) can be expanded to

$\partial/\partial xi\, (VtC)= Vt\, \partial c / \partial xi + C\partial Vt/ \partial x$------------------------------------ 3.88

$= Vt\, \partial c / \partial xi + qs/ \phi$ --3.89

Substituting equation (3.89) into equation (3.5) and dividing both sides by the retardation factor, the governing equation becomes

$\partial c/\partial t = 1/R\, \partial/\partial xi\, (Dij\partial c/\partial xj) - Vx\, \partial c / \partial xi - qs\, [C- Cs]/ R\, \phi - \lambda/R[C+ P_b \sum \phi]$----------3.90

Where

Vx= Vt/R, representing the retarded velocity of a contaminant particle

Equation (3.90) is an Eularian expression of a contaminant derivatives,($\partial c/\partial t$) indicate the rate of change in solute concentration (C) at a fixed point in space. Equation (3.90) can also be expressed in the largranigian form as

$DC/Dt = 1/R\ \partial/\partial x_i\ (D_{ij}\partial c/\partial x_j) - V_x\ \partial c/\partial x_i - q_s\ [C - C_s]/R\ \phi - \lambda/R[C + P_b \sum \phi]$-----3.91

Where the substantial derivatives $DC/Dt = \partial c/\partial t + V_x \partial c/\partial x$,

Indicate the rate of change in solute concentration (c) along the path line of a contaminant.

The concentration change due to dispersion alone can be written as

$DC/Dt = 1/R\ \partial/\partial x_i\ (D_{ij}\partial c/\partial x_j) = 1/R[\partial/\partial x(D_{xx}\partial c/\partial x) + \partial/\partial x(D_{xy}\partial c/\partial y) + \partial/\partial y(D_{yx}\partial c/\partial x) + \partial/\partial y(D_{yy}\partial c/\partial y)$

$= 1/R\ [D_{xx}\partial^2 c/\partial x^2 + D_{xy}\partial^2 c/\partial x\partial y + D_{xy}\partial^2 c/\partial x\partial y + D_{yy}\partial^2 c/\partial x^2$----------------3.92

The hydrodynamic coefficient along x and y are the same. Therefore $D_{xx}=D_{xy}=D_{yy}$.

The equation (3.92) becomes;

$1/R\ D_{xx}\ [\partial^2 c/\partial x^2 + \partial^2 c/\partial y^2]$---3.93

Substituting equation (3.93) into equation (3.91) to obtain

$$\underline{DC/Dt = 1/R\ D_{xx}\ [\partial^2 c/\partial x^2 + \partial^2 c/\partial y^2] - q_s\ [C - C_s]/R\ \phi - \lambda/R[C + P_b \sum \phi]\text{-----}3.94}$$

Equation (3.94) is the model equation for pollutant dispersion in soil.

CHAPTER FOUR.

4.0 EXPERIMENTAL METHODOLOGY.

4.1 ANALYTICAL AND EXPERIMENTAL PROCEDURE.

The presence of the component to be analyzed and contamination of the of the land by petroleum crude was tested using the oil detector pan below.

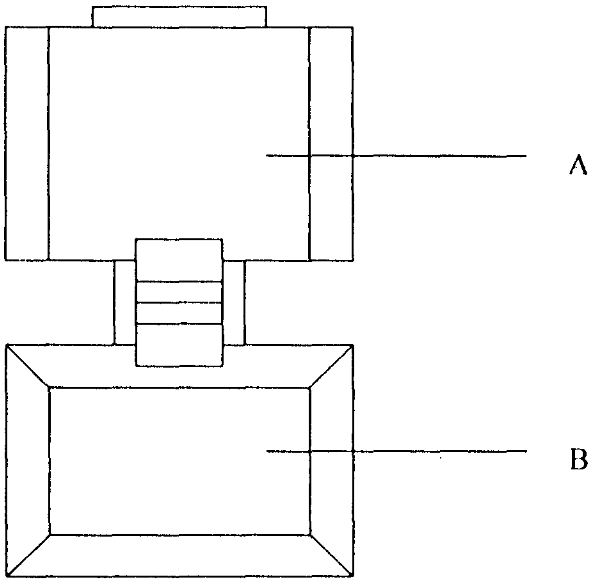


FIG: 4.1

0.51 liter of water was poured into both pans A and B and 200gm of the suspected contaminated soil mixture was added into the water in the pan A. The soil sample were mixed up together using a small stick or iron steal rod. After mixing the mixture was left for 1-3minutes. Then the water in pan a was allowed to flow to pan B. Much attention was paid to colour changes and behavior of the floating layer Thick floating layer was observed, observation with anti-reflection plate makes the layer thinner coming out with a blue colour, which signifies diesel or fuel oil. The pan was then washed and rinsed for next use. Three tests was carried in the spill area to confirm the presence of fuel oil in it.(Jackson, 1958). Starting again from the incident point, 15m were measured vertically into the earth crust and the sample collected. From the already measured point 15m was further measured downward and another sample was collected. This was continued for another two point.

All sample were air dried, sieved and analyzed for PH, electric conductivity, organic nitrate, TPH, BOD, NO_2, CO_3, and particulate organic phosphate.

4.2 DETERMINATION OF BIOLOGICAL OXYGEN DEMAND (BOD)

This is the amount of oxygen required by the bacteria to reduce some of the organic matter in a waste under standard condition. The BOD serves as the useful measure of the quality of the biodegrade matter which serves as food for bacteria.

This is defined as the difference in value of the dissolved oxygen at day 1 and day 5 of the same sample.

4.2.1 PROCEDURE FOR BOD DETERMINATION.

10gof soil sample was collected at site; it was placed in an ambered (dark room) glass bottle with screwed cap. The sample was then filled to the brim in the glass bottle and taken to the laboratory. Sample from each site was duplicated.

The dissolved oxygen (D O) meter probe, after due calibration was inserted into each bottle containing the impacted soil sample; the reading observed was recorded as DO_1. The sample in DO_1 after reading was immediately transported to an incubator and left for five days to incubate at a temperature of 36.4°c. The repetition of the DO meter probe after five days on the same sample gives a reading of DO_5 (Jackson, 1958).

Calculation

BOD in ml/g= $DO_1 - DO_5 / p$

Where

$DO_1$is dissolved oxygen (O_2) after sample preparation in mg/l

DO_5 is dissolved oxygen (O_2) of dilute after 5 days of incubation at 20°c.

P is decimal volumetric fraction of sample used.

4.3 DETERMINATION OF PH.

The PH values usually serve as measure of acidity or alkalinity of a substance and it is the used measured or means of expression of the hydrogen ion concentration of a substance.

4.3.1PROCEDURE FOR PH DETERMINATION.

10g of air-dried soil sample were collected and weighed accurately into two beakers. 250ml of distilled water were added and stirred for a period of time with the aid of magnetic stirrer. This was then allowed to settled for 5-10 minutes, the meter was calibrated prior standard of the of4, 7,sample were analyzed by dipping of the probe of meter into soil and water suspension of 1:1 ratio.

4.4. DETERMINATION OF ELECTRICAL CONDUCTIVITY.

This is the numerical expression of the ability of an aqueous solution to conduct an electric current in the system. This ability depends on the presence of ion, their total concentration, valency and relative concentration and as well as temperature of measurement. Solution of relatively good conductor while molecule of organic compound that do not dissolve in aqueous solution conduct current very poorly. The electric conductivity determination serves a very useful purpose in chemical analysis and in the estimation of total solids.

4.5 DETERMINATION OF TOTAL PETROLEUMHYDROCARBON (TPH).

4.5.1 PROCEDURE.

5g of impacted wet soil sample was weighed and placed in a glass vial of 40ml capacity of screwed cap. 5g of sodium sulphate (anhydrous) were added to it and it was mixed thoroughly until the mixture becomes dry.10ml of tetrachloroethylene solvent was added to the sample and placed in a sonicator to digest for 7hrs.

The sample was then filtered into a 50ml volumetric flask through filter paper containing 2g of sodium sulphate (anhydrous), then 1g of deactivated "florisol" was added to remove polar compound and make to mark with tetrachloroethylene.

The filtrate was then analyzed with Fourier transform infrared spectrophotometer (FTIR). Genesis series and the signal was determined using stored calibration graph in the WINFIRST software of the computer. The reading obtained was calculated taking into cognizance the following;

Wet weight of sample taken

Volume of extract

Moisture content of the soil. (Jackson, 1997)

4.6 DETERMINATION OF NITRATE / NITRITE (NO_3 &NO_2)

4.6.1PROCEDURE

These are determined calorimetrically in accordance with the water operational guide 1987, using unican ultra-violet/ visible spectrometer. Soil sample were extracted with sodium acetate while extract for NO^3 were analyzed using brucine (2.5%) in the presence of concentrated sulphuric acid at 470nm. Meanwhile, NO^2 was analyzed using sulphuric acid dissolved 30% acetic acid with alpha- napthylamine in acetic acid solution at 520nm. (Silverstein and Perth, 1950).

4.7 DETERMINATION OF PHOSPHATE

4.7.1PROCEDURE.

Phosphate was determined in accordance with stannous chloride. Reduction method as described in American public Health Association (APHA), 42AE using unican ultra violet/ visible spectrophotometer. Soil samples are extracted with 25% acetic acid and the extract was run on the ultra violet at a wavelength of 700nm (SILVERSTEIN &PERTHEL, 1950).

4.8 DETERMINATION OF CARBONATE

4.8.1 PROCEDURE AND REAGENTS

0.05m sodium hydroxide (NaoH).

2cm^3 concentration Hcl – dilute to 100cm^3 volumetric flask.

10g of the sample were dissolved in 30cm^3 of distilled water. Filter paper was used to filtrate the sample, to separate the solute from the soil sample.

25cm^3 of sample was pipetted into conical flask and two drops of methyl red indicator was added. The sample was then titrated with an acid i.e. Hcl. The volume of the acid used was noted and the average determined (Jackson, 1957)

CHAPTER FIVE

5.0 RESULT.

5.1EXPERIMENTAL RESULT.

5.2 TABLE OF RESULT

TABLE 5.2.1: SITE A 0M FROM SPILT (HORIZONTALY)

S/NO	Depth (cm)	Matrix	PH	E/cond (ms/cm)	Org.NO_3 Mg/kg	Org.po_4 Mg/kg	TPH Mg/kg	NO_2 Mg/kg	CO_3 Mg/kg	BOD Mg/kg
1	0-15	Soil	5.82	2.35	0.32	12.35	82.88	0.12	0.56	0.15
2	15-30	Soil	6.40	1.20	0.22	2.15	44.50	0.08	0.32	0.12
3	30-45	Soil	6.95	0.97	0.13	0.88	25.00	0.05	0.14	0.09
4	45-60	Soil	7.02	0.68	0.08	0.37	14.87	0.01	0.17	0.05

TABLE 5.2.2: SITE A 0mFROM SPILT SITE (VERTICAL)

S/NO	Depth (cm)	Matrix	PH	E/cond (ms/cm)	Org.NO_3 Mg/kg	Org.po_4 Mg/kg	TPH Mg/kg	NO_2 Mg/kg	CO_3 Mg/kg	BOD Mg/kg
1	0-15	Soil	5.53	1.12	0.32	10.10	34.33	0.09	0.42	0.75
2	15-30	Soil	6.42	1.00	0.10	2.0	20.03	0.08	0.19	0.30
3	30-45	Soil	6.98	0.88	0.67	0.98	12.08	0.06	0.07	0.21
4	45-60	Soil	7.00	0.57	0.32	0.34	0.45	0.05	0.01	0.10

TABLE 5.2.3: SITE B 1m FROM SPILT SITE (HORIZONTAL)

S/NO	Depth (cm)	Matrix	PH	E/cond (ms/cm)	Org.NO_3 Mg/kg	Org.po_4 Mg/kg	TPH Mg/kg	NO_2 Mg/kg	CO_3 Mg/kg	BOD Mg/kg
1	0-15	Soil	5.03	0.52	0.21	2.62	13.02	0.08	0.24	3.50
2	15-30	Soil	5.92	0.40	0.14	2.05	5.17	0.08	0.15	1.80
3	30-45	Soil	6.23	0.31	0.09	1.76	1.98	0.7	0.76	032
4	45-60	Soil	6.75	0.19	0.02	1.21	0.46	0.5	0.10	0.09

TABLE 5.24: SITE B 1m FROM SPILT SITE (VERTICAL)

S/NO	Depth (cm)	Matrix	PH	E/cond (ms/cm)	Org.NO_3 Mg/kg	Org.po_4 Mg/kg	TPH Mg/kg	NO_2 Mg/kg	CO_3 Mg/kg	BOD Mg/kg
1	0-15	Soil	4.23	0.34	0.18	0.15	5.20	0.06	0.12	10.00
2	15-30	Soil	5.40	0.30	0.20	0.10	3.14	0.03	0.09	8.30
3	30-45	Soil	6.32	0.27	0.26	0.06	1.98	0.02	0.07	6.00
4	45-60	Soil	7.12	0.12	0.30	0.02	1.00	0.01	0.03	4.97

5.3 SIMULATION RESULT

Simulation of the model means the use of computer codes to show the operation and behaviour of the system. The model equation was simulated using Q-Basic programme. The result at various distance and time are shown in table 5.3.1 to 5.3.10

Table 5.3.1: Computed concentration [g/m^3] of total hydrocarbon for 100 barrel of oil spill.

Distance 2m

Time [day]	Conc. along axis x [Cx]	Conc. along y axis [Cy]
1	6.488037	6.488037
2	10.30349	10.30379
3	14.11903	14.11947
4	17.93584	17.93492
5	21.7255	21.72362
6	25.56424	25.56276
7	29.37789	29.30032
8	33.19643	33.1932
9	37.01689	37.01085
10	40.82394	40.82368

Table 5.3.2: Computed concentration [g/m^{3}] of total hydrocarbon for 150 barrel

Distance 2m

Time [day]	Conc. Along x axis [Cx]	Conc. Along y axis [Cy]
1	9.584145	9.584145
2	15.45412	15.45441
3	21.1773	21.17774
4	26.90175	26.90082
5	32.62351	32.62179
6	38.34543	38.34394
7	44.066729	44.06915
8	49.7929	49.78967
9	55.7929	55.51495
10	61.23569	61.23542

Table 5.3.3: Computed concentration [g/m3] of total hydrocarbon for 100 barrel

Distance 4m

Time [day]	Conc. Along x axis [Cx]	Conc. along y axis [Cy]
1	6.488429	6.488429
2	10.3043	10.3041
3	14.12162	14.12122
4	17.93994	17.93683
5	21.75981	21.75205
6	25.57238	25.5673
7	29.38085	29.38052
8	33.1983	33.1952
9	37.01331	37.01031
10	40.82617	40.82577

Table 5.3.4: Computed concentration [g/m^3] of total hydrocarbon for 150 barrel

Distance 4m

Time [day]	Conc. Along x axis [Cx]	Conc. Along y axis [Cy]
1	9.731417	9.731417
2	15.45493	15.45473
3	21.17989	21.17949
4	26.90582	26.90274
5	32.63179	32.6256
6	38.35375	38.34849
7	44.06968	44.06935
8	49.79484	55.51442
9	55.51742	55.51442
10	61.23792	61.23752

Table 5.3.5: Computed concentration [g/m^3] of total hydrocarbon for 100 barrel

Distance 6m

Time [day]	Conc. Along x axis [Cx]	Conc. Along y axis [Cy]
1	6.48866	6.488466
2	10.30427	10.30405
3	14.12199	14.12154
4	17.94047	17.93723
5	21.75981	21.75981
6	25.57557	25.5692
7	29.38573	29.38424
8	33.20589	33.19905
9	37.01174	37.01254
10	40.83171	40.82735

Table 5.3.6: Computed concentration [g/m^{3}] of total hydrocarbon for 150 barrel

Distance 6m

Time [day]	Conc. Along x axis [Cx]	Conc. Along y axis [Cy]
1	9.731454	9.731454
2	15.4549	15.45468
3	21.18026	21.17981
4	26.90637	26.90314
5	32.63336	32.62726
6	38.35676	38.35038
7	44.07456	44.07306
8	49.80235	49.79596
9	55.51585	55.51665
10	61.24346	61.2391

Table 5.3.7: Computed concentration [g/m^{3]} of total hydrocarbon for 100 barrel

Distance 8m

Time [day]	Conc. Along x axis [Cx]	Conc. Along y axis [Cy]
1	6.488464	6.488464
2	10.310419	10.30399
3	14.122	14.1216
4	17.94042	17.93726
5	21.7601	21.75424
6	25.5619	25.56981
7	29.38865	29.38577
8	33.20885	33.20118
9	37.01629	37.01563
10	40.8309	40.83081

Table 5.3.8: Computed concentration [g/m^3] of total hydrocarbon for 150 barrel

Distance 8m

Time [day]	Conc. Along x axis [Cx]	Conc. Along y axis [Cy]
1	9.731452	9.731452
2	15.45482	15.45462
3	21.18027	21.17987
4	26.90633	26.90317
5	32.63364	32.62779
6	38.35738	38.351
7	44.07748	44.07459
8	49.80532	49.79765
9	55.5204	55.51974
10	61.24982	61.24982

Table 5.3.9: Computed concentration [g/m^{3}] of total hydrocarbon for 100 barrel

Distance 10m

Time [day]	Conc. Along x axis [Cx]	Conc. Along y axis [Cy]
1	6.488456	6.488456
2	10.30411	10.30394
3	14.12195	14.11386
4	17.94028	17.93722
5	21.76012	21.75444
6	25.57635	25.57005
7	29.39016	29.38651
8	33.21016	33.20197
9	37.01902	37.0172
10	40.84131	40.83252

Table 5.3.10: Computed concentration [g/m^3] of total hydrocarbon for 150 barrel

Distance 10m

Time [day]	Conc. Along x axis [Cx[	Conc. Along y axis [Cy]
1	9.731444	9.731444
2	15.45474	25.45457
3	21.18022	21.17987
4	26.90619	26.90312
5	32.63367	32.62798
6	38.35754	38.35124
7	44.07899	44.07533
8	49.80663	49.79844
9	55.52312	55.5213
10	61.25306	61.24427

5.4 DISCUSSION OF RESULT.

From literature review, oil spill, whether or not they are petroleum based, have the ability to kill and injure a wide array of plants, animals and microorganism, as well as disrupt the ecosystem process. Spills cause severe surface and groundwater pollution. When soil is contaminated with crude oil, the rate of water infiltration into the soil is drastically reduced due to the oil coating the surface of soil particles. Also, in turn, water and soluble nutrient are unavailable to the plant roots and beneficial soil microorganism. The members of microorganism in the contaminated soil decrease due to the lack of oxygen and lack of nutrient carried with water.

On the basis of available experiment data of oil spillage at various distance and that of simulated values, it could be observed that the most dangerous zone is the site near the spillage because the nearer the site of spill the faster is the dispersion as shown in fig.3. However the effect of oil spilt felt within range of one to two days, depending on the volume of oil spill. From the experimental values shown in table 5.2.1 to 5.24 the concentration of oil pollutant in soil varies from distance to distance. These values are resultant of the volume of oil spill. The simulated results are p resented in table 5.3.1to 5.3.10. It could be seen from the table that concentration of pollutant in soil varies as the volume of oil spill change and with distance from oil spill site. The concentration is measured either as the volume of oil pollutant, or as pollutant units in unit volume of the oil spill. From simulated result, the values of pollutant in the soil in vertical and horizontal axis are increased with time but decrease with distance.

The PH of soil under investigation is observed to be in the range of 5085 to 7.12

And FEPA recommended limit be within the range of 6.5 to 8.5. Data of the study indicates that the people in the Niger- Delta area are exposed to danger due to the continuous pollution of soil due to oil spillage. The variation between experimental and modeling simulation result could be attributed to some of assumption made at the initial stage of modeling and the fact that experimental values are a measure of soil pollution because of the possibility of accumulation while the simulation results is an instantaneous values i.e. it measured the possible amount of total hydrocarbon that could dispersed at a given time.

5.5 CONCLUSION.

From this project, the following conclusion can be deduced;

- It was observed that the result of simulation of model developed based on the modified pollutant transport principle showed conformity with the experimental results.
- The dispersion partern of oil showed that the extent of spread is dependent in volume of oil spill, soil porosity, and time and soil retardation.
- The quality of the soil with respect to its physico-chemical parameters such as PH is unacceptable when compared to Federal Environmental Protection Agency set limit.

5.6 RECOMMENDATION

- Government should find a mean of attach monitor to the pipeline that would be monitored the transportation of oil from top stream field to down stream process.
- Government should provide social amenities for the people of Niger-Delta area because of poor farming and fishing due to contaminated of soil and rivers by oil.
- Oil Company should include oil collection facilities to all new and installation of pipe network that will link the oil station to process industries.

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APPENDIX

```
5 REM "PROGRAM FOR TWO DIMENSIONAL TRANSPORT DISPERSION OF OIL ALONG X AND Y DIRECTION"
10 DIM c(10, 10), cn(10, 10), ai(10), bi(10), ci(10), fi(10), aj(10), bj(10), cj(10),
fj(10), a(10), b(10), co(10), f(10), x(10), at(10), bt(10), ft(10), ct(10)
20 READ dt, dx, u, v, k, im, jm, nm, ip, jp
30 DATA 1,10,.1,.98,.5,4,4,6,2,2
LET r = .2
PRINT " retardation factor"; r
LET g = .8569
PRINT "bulk density"; g
LET w = .2
PRINT "porosity"; w
LET s = .3
PRINT "conc of contaminant"; s
LET T = 82.88
PRINT " conc from source"; T
LET I = 2.6741E-07
PRINT "half life "; l
LET h = .31
PRINT ; "conc sorbed"; h
INPUT "volumetric flux"; q
40 a0 = 1 / dt + (2 * k / dx ^ 2)
a1 = -(v / 2 / dx) + (k / 2 / dx ^ 2)
a2 = (v / 2 / dx) + (k / 2 / dx ^ 2)
a3 = (1 / dt) - (2 * k / dx ^ 2)
a4 = (k / dx ^ 2) - (u / 2 / dx)
a5 = (k / dx ^ 2) + (u / 2 / dx)
a6 = -(u / 2 / dx) + (k / 2 / dx ^ 2)
a7 = (u / 2 / dx) + (k / 2 / dx ^ 2)
a8 = -(v / 2 / dx) + (k / dx ^ 2)
a9 = (v / 2 / dx) + (k / dx ^ 2)
a10 = (k / 2 / dx ^ 2)
42 FOR j = 2 TO jm - 1
aj(j) = -a1 - a10
bj(j) = a0
cj(j) = -a2 - a10
NEXT j
bj(2) = bj(2) + 2 * cj(2)
aj(2) = aj(2) - cj(2)
bj(jm - 1) = bj(jm - 1) + 2 * aj * (jm - 1)
cj(jm - 1) = cj(jm - 1) - aj(jm - 1)
44 FOR I = 2 TO im - 1
ai(I) = -a6 - a10
bi(I) = a0
ci(I) = -a7 - a10
NEXT I
bi(2) = bi(2) + 2 * ci(2)
a1(2) = ai(2) - ci(2)
bi(im - 1) = bi(im - 1) + 2 * ai(im - 1)
ci(im - 1) = ci(im - 1) - ai(im - 1)
50 T = 0
n = 0
60 T = T + dt
n = n + 1
70 IF n / 2 = INT(n / 2) THEN GOTO 80 ELSE GOTO 200
80 FOR I = 2 TO im - 1
```

```
90 FOR j = 2 TO jm - 1
fj(j) = c(I, j) * a3 + c(I + 1, j) * a4 + c(I - 1, j) * a3
NEXT j
100 FOR j = 2 TO jm - 1
a(j) = aj(j)
b(j) = bj(j)
co(j) = cj(j)
f(j) = fj(j)
NEXT j
km = jm - 1
110 GOSUB 1000
120 FOR j = 2 TO jm - 1
cn(I, j) = x(j)
NEXT j
cn(I, 1) = cn(I, 2) * 2 - cn(I, 3)
cn(I, jm) = cn(I, jm - 1) * 2 - cn(I, jm - 2)
180 NEXT I
190 FOR j = 1 TO jm
cn(1, j) = 2 * cn(2, j) - cn(3, jn)
cn(im, j) = 2 * cn(im - 1, j) - cn(im - 2, j)
NEXT j
195 GOTO 305
200 FOR j = 2 TO jm - 1
210 FOR I = 2 TO im - 1
fi(I) = c(I, j) * a3 + c(I, j + 1) * a8 + c(I, j - 1) * a9
NEXT I
220 FOR I = 2 TO im - 1
a(I) = ai(I)
b(I) = bi(I)
co(I) = ci(I)
f(I) = fi(I)
NEXT I
km = im - 1
230 GOSUB 1000
240 FOR I = 2 TO im - 1
cn(I, j) = x(I)
NEXT I
cn(1, j) = cn(2, j) * 2 - cn(3, j)
cn(im, j) = cn(im - 1, j) * 2 - cn(im - 2, j)
250 NEXT j
300 FOR I = 1 TO im
cn(I, 1) = 2 * cn(I, 2) - cn(I, 3)
cn(I, jm) = 2 * cn(I, jm - 1) - cn(I, jm - 2)
NEXT I
305 cn(ip, jp) = 1
310 FOR I = 1 TO im
FOR j = 1 TO jm
c(I, j) = cn(I, j)
NEXT j
NEXT I
320 PRINT
IF T = 1 GOTO 330
PRINT "conc @"; T - 1
PRINT
FOR I = jm TO 1 STEP -1
FOR j = 1 TO im
LET c(I, j) = ABS(c(I, j))
```

```
LET ct = (.00024) * ((1 / r) * (c(I, j)) - ((q / r * w) * (s - T)) - (1
/ r) * (s * (g * h / w)))
PRINT ct
NEXT j
NEXT I
330 IF n < nm THEN GOTO 60
340 END
1000 bt(2) = b(2)
at(2) = a(2)
ft(2) = f(2)
1010 FOR k = 3 TO km
bt(k) = b(k) * bt(k - 1) - at(k - 1) * co(k)
at(k) = a(k) * bt(k - 1)
ft(k) = f(k) * bt(k - 1) - ft(k - 1) * co(k)
NEXT k
1020 x(km) = ft(km) / bt(km)
FOR k = km - 1 TO 2 STEP -1
x(k) = (ft(k) - at(k) * x(k + 1)) / bt(k)
NEXT k
1030 RETURN
```