EFFECT OF OIL SPILLAGE ON AMONYE, ISHIAGU L.G.A. OF EBONYI STATE

BY

ALA AYODEJI ADEBISI
(98/6860EH)

A PROJECT SUBMITTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF B. ENG(CHEMICAL)
NOVEMBER, 2004

DECLARATION

I, Ala Ayodeji Adebisi (Reg. No 98/6860), declare that this project work is my original work and has never to my knowledge been submitted else where before now.

Signature

28-11-2004
Date

CERTIFICATION

This is to certify that this project was supervised, moderated and approved by the following underlisted persons on behalf of the chemical Engineering Department, School of Engineering and Engineering Technology, Federal University of Technology, Minna.

--------------------------- 22nd/11/04

Project supervisor
Engr.E.J Eterigho(Mrs) Date

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Head of Department
Engr (Dr.) Aberuagba Date

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External Supervisor Date

DEDICATION

This project is dedicated to Almighty God, for the grace I enjoy in his son Jesus Chirst. Also to my father and to the loving memory of my departed mother. May God grant her Eternal Rest (Amen).

ACKNOWLEDGEMENT

This work will never have gone into completion but for the grace of God. I am most grateful to him for his guidance, care and divine provision. I also express my gratitude to High Chief A.Adeleye ,Olori .B.M Adeleye and Prof Ojerinde for their care and support all through. The same applies to my two brothers and sisters who have have contributed immensely to the succes of this work..

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ABSTRACT

Environmental degradation is a subject of concern in both the developed and the developing nations of the world. Oil spillage on surface water as an undoubteable effect on the flora and fauna, hydrology, and the aquatic eco-system. This necessitated the study of the effect of oil spillage on surface water in Amonye, Isiagu local government of Ebonyi state two years after the spill of dual purpose kerosene into the environment. Water samples were obtained from different locations around the impacted area and from a distant location to serve as control.

Quantitative analysis were carried out on these samples to analyse such parameters as pH, conductivity, total dissolve solid, total suspended solid, conductivity, alkalinity, hardness, chloride ions, sulphate nitrate, phosphate, chemical oxygen demand, turbidity, and petroleum hydrocarbon (oil and grease). The comparison of the result with the DPR and FEPA limit show that only total dissolve solid and hardness exceeded the recommended FEPA limit in three of the four samples and the control sample.

A mathematical model was also developed to show the trend of variation in the pH with respect to such parameters as alkalinity, temperature, and turbidity at a given spot(distance).

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NOMENCLATURE

$AgNO_3$	-	Silver Nitrate
APHA	-	America Public Health Association
BOD	-	Biochemical Oxygen Demand
^{o}C	-	Degree Centigrade
Ca	-	Calcium
Cm	-	Centimeters
Cu	-	Copper
COD	-	Chemical Oxygen Demand
DPK	-	Dual Purpose Kerosene
DPR	-	Department of Petroleum Resources
EPIA	-	Environment post Impact Assessment
EC	-	Electrical Conductivity
Fe	-	Iron
FEPA	-	Federal Environmental Protection Agency
K	-	Potassium
LTD	-	Limited
Mg	-	Magnesium
Mn	-	Manganese
Ml	-	Milliliters
Mg/l	-	Milligram per Liter
NH_4	-	Ammonium
NO_X	-	Oxide of Nitrogen
Na	-	Sodium
NTU	-	Turbidity unit
Nm	-	Nanometer
NIG.	-	Nigeria
N	-	Nitrogen
NNPC	-	Nigerian National Petroleum Corporation
Pb	-	Lead
PO_4	-	Phosphate
P^H	-	Hydrogen ion Concentration
PPL	-	Pipeline
PPMC	-	Pipeline Product Marketing Company
PPM	-	Part per Million

SO_X	-	Oxide of Sulphhur
SPM	-	Suspended Particulate Matter
THC	-	Total Hydrocarbon Content
TDS	-	Total Dissolved Solid
TSS	-	Total Suspended Solid
TS	-	Total Solids
USEPA	-	United State Environmental Protection Agency

CHAPTER ONE

1.0 INTRODUCTION

The mineral Survey Company began mineralogical studies in Nigeria in 1903. By 1907 organized marketing and distribution of petroleum product had began. In 1956, the first commercial oil field was discovered by shell in oloibini in former River State. This discovery mark the beginning of a new era, The success of shell in Niger delta attracted other companies including Mobil, Texaco, Gulf (now chevron), Agip, Esso and Safrap (now Elf) into the country. In 1963 the first off-shore finds were made by Gulf (Okan1), Mobil (Ata-1) and Texaco (Kulama-1), since then, the Nigeria oil industry has gone through rapid expansion not withstanding the disruptive effects of the civil war between 1967 and 1970.

The full-scale exploration of petroleum in the Niger Delta started about six decades ago. Before this era, the environment was healthy and supportive to the human inhabitant and other living organisms. The freshwater river and swamps were an unimaginable source of all sorts of seafood while the landmass was fertile and aeriable due to the consistent alluvial deposit on the creeks over the years.

These years of oil exploration and production activities have resulted in a severely degraded environment in this region. Oil Spillage - the uncontrolled discharge of oil (crude or it's refined product) or and its by-products including chemicals and emulsions, and other activities such as gas flaring, oil well drilling, dredging, sand filling, pipe laying, road construction, land clearing, land reclamation, construction of plant building, e.t.c. by oil multinationals have been identified as some of the causes of environmental damage in the region over time.

As far as oil and gas are concerned, agitators for revenue from their proceeds forget to discuss environmental problems emanating from exploration and other associated activities. In the Nigeria oil rich region, oil spillage had been identified as the leading cause of most environmental mis-haps. These effect of oil spillage abound affecting water, soil, surrounding vegetation, ecology, and the socio-economic activities as well as the health of the inhabitant of the affected area.(Ifode .D 2002)

Recording of baseline data for environmental impact assessment studies of oil spills particularly in the Niger Delta, a complex tropical ecosystem, which includes vast areas of farmland, freshwater swamps and mangrove, swamps.

Involves quantitative measurements using standard techniques and indicators for ground water, plant and animal life (aquatic and terrestrial), air, and soil (River State University of Technology 2002)

1.1 Aim and Objective

To assess the impact of oil spillage on Amonye in Ishiagu L.G.A. of Ebonyi state. The study looks at the overall effect on the immediate environment as a whole with emphasis on the phhysio chemical paramet phhysio chemical parameters of the aquatic habitat.

1.2 Scope of Work

This research work basically deal with the discussion and evaluation of analytic data of the direct impact of oil spillage in the affected area in Nigeria by comparing with the limitation set by FEPA and DPR, couple with modeling of the physio-chemical parameters obtain from the water body.

1.3 Methodology

Samples were collected from different locations around Amonye in Ishiagu L.G.A. of Ebonyi state for analysis. Water sample was collected from the creek proximal to the spill on-ward These samples were analyzed quantitatively for such parameters such as the pH, Alkalinity, Hardness, Nitrates, Sulphate, Biological Oxygen Demand, Chemical Oxygen Demand, Total Dissolved Solid and other physical parameters like colour, odour and turbidity of the sampled water.

CHAPTER TWO

2.0 LITERATURE REVIEW

Environmental pollution is the discharge of material or energy into water, land, or air that causes and may cause acute or chronic detriment to the earth ecological balance or lower the quality of life. These damages vary from those on short-term basis with identifiable impact on the environment or long-term perturbation in the delicate balance of the biological food web. The Oil Spill Intelligence Report in its annual International Oil Spill Statistics report for 1999, reported that in that year about 32 million gallons of oil spilled into water and land, in 257 incidents. Of those incidents, only 11 were spills from tankers, accounting for about 6.6 million gallons, or about one-fifth of the total volume of oil spilled. Twenty-five of the 257 spills were from barges and other kinds of vessels, such as freighters (totaling 1.5 million gallons). Eighteen spills were from trucks or railroad trains (totaling about half a million gallons). The largest number of spills and the largest volume of oil spilled were from accidents involving pipelines or fixed facilities (131 pipeline spills, totaling about 18.8 million gallons; 66 spills from facilities, totaling about 4.7 million gallons). (Ardea M.2003)

Oil discharges from shipping vessels, offshore/onshore extraction of oil, and transport of oil in pipelines are as a result of either accidents or deliberate operational discharges. Accidental discharges occur when vessels collide, become distress at sea (engine breakdown, fire, explosion) and break open, or run aground close to the shore, or when there is a blow out of an offshore/onshore oil well, or when a oil pipeline ruptures. Much can be done to avoid accidents, but there will always be unfortunate circumstances and situations that will cause accidents. Operational discharges, on the other hand, are mostly deliberate and "routine", and can to a very large extent be effectively controlled and avoided. It is much a question combining available technical solutions with information, education and a change of attitude among ship-owners, mariners, and offshore platform and pipeline operators.

There is no clear relationship between the amount of oil in the marine environment and the likely impact on wildlife. A smaller spill at an unfavourable season or in a sensitive environment may prove much more harmful than a larger spill at another time of the year in another or even the same environment. Even small spills can have very large effects. Therefore, one should not merely compare figures — the size of an oil spill is certainly not the only factor of importance in terms of what environmental damage can be caused by the oil.

In 1976, a spill estimated to have been less than 10 tonnes killed more than 60,000 long-tailed ducks wintering in the Baltic Sea and attracted to the seemingly calm water surface created by the oil slick. This could be compared to the effects on seabirds in Alaskan waters from the approximately 40,000 tonnes large Exxon Valdez oil spill in 1989, when an estimated 30,000 birds were oiled. (Ardea .M 2003)

The negative effects of on oil spill may eventually fade away, but in many cases it will be matter of years, even decades, before an area or ecosystem will be fully recovered from a spill that caused extensive damages. Every situation is unique and depending on the particular conditions and circumstances in that area, and on the characteristics of the spill. The recovery of an ecosystem will depend on the share of important populations being killed off or affected by acute poisoning and how effective the clean-up exercise.

The recovery of the affected habitats and species following an oil spill will to a large extent depend on the type of ecosystem, the vulnerability of the species and not least the climate of the region where the oil spill occurs. Generally, recovery will proceed faster in warmer climates and on rocky shores compared to cold climates and, for example, marshes. The long-term effects on deeper bottoms (i.e., if oil sinks and is absorbed in bottom sediments) is also a matter of concern.

2.1 Previous Occurrence

Oil spills happen all around the world. According to the Oil Spill Intelligence Report, spills in the size range of at least 34 tonnes have occurred in the waters of 112 nations since 1960. However, oil spills happen more frequently in certain parts of the world. They identified the following 'hot spots' for oil spills from vessels: the Gulf of Mexico (267 spills); the northeastern U.S. (140 spills); the Mediterranean Sea (127 spills); the Persian Gulf (108 spills); the North Sea (75 spills); Japan (60 spills); the Baltic Sea (52 spills); the United Kingdom and English Channel (49 spills); Malaysia and Singapore (39 spills); the west coast of

France and north and west coasts of Spain (33 spills); and Korea (32 spills)". ('Ardea ,M 2003)

In Nigeria quite substantial amount of crude oil is spilled annually, For example, Nwankwo (1989) reported 2,000 oil spillage in Nigeria between 1976 and 1988. During this period about 2 x 106 barrels of crude oil were discharged in the environment. In the Niger Delta. Nigeria National Petroleum Corporation (NNPC) statistics on oil pipeline accidents shows that in 1999 there was 524 cases of oil pipeline rupture, 27 was due to natural causes namely (wear and tear) while the rest 497 were due to vandalization. In the first six months of year 2000, 400 oil pipelines rupture occurred, 382 of which were due to willful vandalisation. (Gill. L.S et'al).

2.2 Law and Policies in Nigeria

Nigeria has enacted several oil-related laws. Review of this legislation indicates a number of provisions that generally authorize regulatory control, including control for environmental protection. In particular, the principal legislation for environmental control is the petroleum act 1969 with the petroleum (drilling and production) Regulation of 1969.

Indeed all license holders for exploration, prospecting, exploitation, transportation, etc. of petroleum are required to take/adapt practical precautions and/or all steps practicable to prevent pollution, cause as little damage as possible to the area of operation, avoid interference with works of public utility etc. Exiting oil-related legislation includes regulation of pipelines, drilling and production, refining, and storage activities. Authorities exist within current decrees to promulgate regulations, issue licensing requirements, and establish guidelines and procedures for environmental control.

At the technical level, the department of petroleum resources (DPR) of the ministry of petroleum resources and energy is the specialized agency responsible for the daily administration of petroleum matters impacting the environment. The growing concern for environmental impact and damages from oil pollution make the (DPR) to issue guidelines for handling, treatment and disposal by oil companies of spills, effluents, chemicals, and other waste products. DPR has developed recommended test procedures for assessing chemical dispersants used in oil spills. (EPIA of Amonye-Ishiagu oil spillage)

2.2.1 Petroleum (drilling and production) regulation 1969

Amended in 1973, regulates exploration, prospecting and exploitation of petroleum resources. This requires license holders to take "all practicable precautions" including provision of up-to-date equipment approved by the appropriate authority to prevent pollution of inland waters, rivers, water courses, the territorial waters of Nigeria or the high seas by oil or other fluids or substances capable of polluting the water, banks and shoreline or of harming or destroying fresh water or marine life, and where any such pollution occurs or has occurred, to take prompt steps to control, and if possible, end it (sect 25). Section 36 requires that apparatus be maintained and operated so as to prevent escape of petroleum into any water body and to minimize damage to the surface, tree, or crops of the area of operations.

2.3 Causes of Oil Spillage

All the possible causes of oil spillage can be categorize into either accidental discharge, operational discharge.

2.3.1 Operational Discharges

Naturally some oil escape in small quantity to the environment during oil companies operation. This is due to the age long problem of ineffective treatment of emulsion form by the mixture of oil and formation water coming from the various oil wells.

The department of petroleum resources have a standard of 10mg/l in the onshore and 40mg/l oil and grease in the offshore platform which is expected to be met by the companies, but most times this is exceeded resulting in environmental hazard due to accumulation of such in areas of shallow waters and swamps.

Ship-related operational discharges of oil include the discharge of bilge water from machinery spaces, fuel oil sludge, and oily ballast water from fuel tanks. Also other commercial vessels than tankers contribute operational discharges of oil from machinery spaces to the sea. Cargo-related operational discharges from tankers include the discharge of tank-washing residues and oily ballast water. Before international regulations were introduced to prevent oil pollution from ships, the normal practice for oil tankers was to wash out the cargo tanks with water and then pump the resulting mixture of oil and water into the sea.(Ardea .M 2003).

2.3.2 *Accidental Discharges*

This may be due equipment failure, as a result of overloading, age, malfunctioning, or corrosion. Human error too contributes to such accident. Likewise hose failure during loading of oil shipping vessels and shipwreck. Other causes such as vanderlization of oil pipelines and installation and natural disasters can still be categorize as accidental discharge.

2.3.3 Vandalization and sabotage

These are deliberate human interruption of normal operation of oil companies. This is on the rise in the Niger-Delta nowadays where the youth vanderlize oil facilities either to vent their anger or to get some monetary compensation from the Oil Company concerned.

2.3.4 Natural causes

Forces of nature such as earthquake, hurricane, cyclone, storm, flood etc are possible causes of oil spillage. It is important to note that man have no power over such.

2.4 Effect of Oil Spillage

Oil spillage has both Short and long term effects. The immediate effect are those due to the inconvienecies it causes the human population in the affected area and the displacement and death of other living things in the affected ecosystem. The long-term effect is as a result of the fact that it degrades the environment, which in turn upset the ecosystem of the area concerned. The effect of oil spillage is multi-facetted affecting the water, soil, air, vegetation, ecology of the impacted area and also the socio-economic and the health of the inhabitant of the affected area.(Patric .N 1999)

Oil spillage alters the physical appearance as well as the chemical composition of the area of spill. It effects in these cases depend on some factors such as

- *Amount of oil*

- *Physiography*
- *Type of oil*
- *Weather*

2.4.1 Water

A good percentage of oil spills is on water globally. When oil spill on water, it immediately spread out on the water surface because it is less dense than water (specific gravity of approx. 0.86). It therefore prevents oxygen and sunlight from reaching the water. The water quality deteriorates sharply during this post spill period. The contamination lead to scarcity of portable water in some cases. The green algae cannot photosynthesize while eggs, larvae and crabs die. Oil spillage alters the pH of the water body, it's colour, odour and many more. A quantitative analysis of a spill can be carried out by taking samples of the affected water for analysis.

2.4.2 Air

The evaporated components of the crude and the dead organisms cause unpleasant odour reducing the air quality.

2.4.3 Soil

As in the case of the water body oil spillage have devastating effect on the soil. Oil spillage destroys the topsoil. It also changes the soil chemistry and takes away the life supporting abilities of the soil.

2.4.4 Ecology

When the vegetation is stained with oil, reducing its life support capabilities. The small floating species such as periwinkles, crabs, fingerlings etc die or terribly bartered. The big ones migrate before they die. Birds are also poisoned one way or the other as a result of the spill.

2.5 Control of Oil Spillage

The effective control of oil spillage can only be achieve after having a good understanding of the causes. The control mechanism to be employed may be in form of corrective, preventive or predictive. Corrective measures involve the clean up process, which is very strenuous and or low effectiveness. Preventive and predictive measures involve mechanism to prevent the spill before it occurs at all. These processes include adequate monitoring and maintenance of facilities, investment in manpower and treatment of the pipelines with anticorrosion chemicals.

The actual cause of spillage and volume of oil spilled are important in determining the best control measure to be employed. The actual cause of a spill can be analyzed using several hazard analysis techniques such as checklist, fault tree, event three etc.

The check list is the oldest and simplest method for failure analysis. All possible causes are listed and then put together in a detached form. Omission from check list could be very dangerous. The list could be in the form of top-down or bottom-up according to weather we proceed from the undesired event to the contributory causes or follow the initial minor fault to the undesired top event. (Safety, loss and pollution prevention in chemical processes (Odigure 1998)

2.6 Contingency Plan

These are the preparation made in readiness for any possible accidental discharge into the environment. The purpose of such is to establish specific plan of action to be followed in the event of an operational emergency. To bring under control all incidents that may arise as a result of the operational emergency. And also to evaluate the extent of the impact arising from the emergency on the installation and overall environment and to specify clean-up, disposal and rehabilitation measures that may be carried out. (PPMC contingency plan 2003)

2.7 Oil spillage Emergency response Action.

These are immediate and necessary actions designed to contain the emergencies and it minimize the dangers to life, property and the environment.(PPMC contingency plan 2003)

The procedures for management and clean-up of oil spill are as follows

2.7.1 Land location (tank farm)

- Stop the source of spill where possible. Or reduce the rate of outflow.
- Stop all operational activities, loading, reception, pumping etc
- Close appropriate oil/water drain valve(s) located within the bundwalls so as to contain the spill within the area.
- Close appropriate oil/water drain valve at the depot's effluent discharge.
- Cut off all power supply to the tank farm and stop all workshop activities so as to minimize the risk of ignition.

- If the source of spill is a ruptured or failed tank, start evacuation of product to other tanks .
- Deploy all safety/ pollution control personnel and equipment to strategic position
- Commence evacuation of the spill using diesel driven portable pumps
- Contain spill in depot effluent discharge using booms deployed in selected locations
- Sand barriers
- Sorbent, chips or sawdust

2.7.2 Loading Gantry and Loading Area

- This area is usually paved with concrete. Any oily water will flow through the oily water drain to the separator. However , the surface water drain may be contaminated.
- Stop the source of leakage where possible or reduce the rate of outflow.
- Stop all loading operation and cordon off the area.
- Close the sluice gate at the depot effluent discharge
- Deploy all safety/ pollution control personnel and equipment to strategic position
- Start fire water booster pumps and using a jet spray systematically clean the area of oil spill.
- Prevent the spread of oil to municipal drains by deploying booms, sorbents and chips strategically.
- Follow the alerting procedure
- Follow all safety procedures and prevent fire outbreak at all costs.

2.7..3 Pump house

- Spills in this area are absorbed into the ground.
- Stop the source of leakage where possible or reduce the rate of flow.
- Close all sluice gates
- Start the fire pump and clean the pump house with a jet spray.
- Avoid flow into surface water , seepage into underground water and contamination of municipal sewers by

1. Deploy all safety/ pollution control personnel and equipment to strategic position
2. Deploying booms to selected positions
3. Using sand barriers
4. Using excavated and lined interceptor trenches

5. Sorbent, chips or saw dust

- Follow the alerting procedure
- Follow all safety procedures and prevent fire out break at all costs.

2.7.4 Pipe rupture

- Close the upstream and down stream valve on the pipe.
- Ensure safety and pollution control equipment and personnel have been moved to site and strategically deployed.
- Excavate trenches and line with high density polythene sheets to contain oil.
- Using portable suction pumps to pump out oil from trenches/ditches.
- Commence repair of pipeline using suitable cold cutters and continuos use of coolant.
- Ensure that farm lands, fish ponds, and adjacent streams. community, water supply sources and other sensitive areas are protected by using diverting booms skimmers and sorbents
- Follow the alerting procedure
- Follow all safety procedures and prevent fire outbreak at all costs.

2.7.5 Offshore location

- Where possible stop the spill or reduce the rate of flow.
- Promptly prevent oil spread using appropriate booms(river or ocean type depending on the size of spill, water current and wind velocity.
- Deploy skimmers into the water and commence recovery of oil into storage tanks
- Protect shore lines, beaches, mangrove, estuaries, and other sensitive areas using diverting booms skimmers and sorbents to minimize impact on adjourning banks.
- When the source has been stopped and further removal of the oil from the water is no longer practicable. Apply disdersant after due approval from the department of petroleum resources(DPR).
- Follow the alerting procedure
- Follow all safety procedures and prevent fire outbreak at all costs.

2.7.6 Marine vessels

The crew on board shall initially handle any oil spill on any vessel. Crew members are therefore required to have primary training in emergency situation response. Sufficient equipment and material shall be stored on board to ensure incident control capability before external assistance arrives. As a precautionary measure against fire out-break, there should be no loading/off loading of any vessel, land or marine, during threatening weather, thunder or rainstorm.

2.8 Common Clean-up Methods

The Clean-up procedure for an individual site have it's own peculiarity base on site characteristics (location, surrounding, amount and type of waste).

Site inspection is generally conducted to examine potential pathway that the contaminant could use to affect human health. This usually involves different types of sampling, monitoring, reconnaissance, and other field activities. Criteria that are taken into account are the possible risk 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.

Clean up is usually a very stressful exercise aimed at recovery of considerable quantity and to reduce the adverse effect of the oil spilled into the environment. In must cases clean-up operation is usually contracted out because it is physically demanding. Various equipment/tools are use to ease the clean-up stress such as absorbents skimmers oil/water pump, rakes, shovels forks, spades, wheelbarrow, dispersant etc.

There are various innovative clean up technologies many of which are still in the experimental stage, but some preferred methods have been especially effective in restoring sites degrade by oil pollution (brett1998). Some common methods for dealing with oil pollution include

- In-situ bioremediation
- Natural attenuation
- Pumping
- Excavation and incineration
- Soil washing.

i ***In-situ Bioremediation***: This is a process that uses microorganisms to transform harmful organic compound like crude oil and refined petroleum product into non-toxic and less dangerous substance. Microorganism requires nutrient and organic carbon for growth and metabolism. These microbes break down carbon containing organic compound while feeding on it and as a result releasing their waste which are not as harmful as the original contaminant.

ii ***Natural attenuation***: This use natural processes to reduce concentration of oil and other chemicals. Though this method is similar to bio-remediation but it does rely fully on the activity of soil microbes.

iii ***Pumping***: The polluted water can be treated after capturing it with a pump into a container. The water can then be treated using a carbon absorption system, microorganism, hydrocyclone and chemicals.

iv ***Excavation and Incineration***: When soil is severely bartered by oil it may be necessary to excavate the top soil and then incinerate. After incineration the waste must be dispose off at resource conservation and recovery act permitted facility. Incineration cannot destroy all organic compound but is able to remove 99.9% (common clean up method1994).

v ***Soil washing:*** The process uses a soil washing machine. Water and some detergent are use to wash the gathered soil affected by spillage. The washed soil is then use to sand fill the area. The finer silt and clay particle are filtered and drained from the coarser materials because they have absorbed the oil compound.

2.9 Disposal Methods

The disposal of oil debris and recovered spilled oil are important factor in post spill emergency/spill environment management. Debris may be composed of seawater, wood, sorbents, sand, gravel, dirt etc.
The disposal methods proposed depend on the situation under consideration. (PPMC contingency plan 2003)

2.9.1 Burial

Oil stained debris, liquid waste, and sludge from tanks shall be disposed of by burial in suitably sized, and specially prepared pits excavated at a safe distance from farmland, and natural water bodies. Applying the latest geomembrane technology, such pits shall be lined with high density polyethylene(HDPE)sheets. Alternatively, the pits could be lined with polyvinyl chloride(PVC) sheets. After depositing the oily waste into the pit and using part of the excavated soil along with nitrogen fertilizer as intermediate mix material, in the ratio of 1.5 the pit shall be covered with another HDPE or PVC lining before final coverage with the remaining excavated soil Open ended pipes shall be positioned on the pit as a vent for dangerous vapours. Under no circumstances shall sludge or only waste be buried within the bundwalls. Caution signs must be strategically placed at the burial sites

2.9.2 Burning at Site

A controlled burning at site as a means of disposal may be effected. A team of well trained fire fighter must be on site to supervise the burning exercise. Although, this type of burning may result in air pollution, It is believed that the volume of atmospheric air will effectively lower the concentration of the burnt residue to a safe level. Moreover, this method of disposal shall be resorted to once in a while and will mainly be for selected combustible materials like oil soaked sorbents or booms for instance.

2.9.3 Incineration

Oily waste shall also be disposed of by controlled burning in specially designed incinerators where available. Incinerators reduce the volume of waste and can produce steam as a by-product. The capital cost of installing an incinerator however is high but this method of disposal is fast and efficient.

2.9.4 Others

In the disposal of oil and water recovered by skimming operations the following disposal method are recommended. If the oil-water mix consist of refined products, it is discharged into a separator and later into slop tanks. If the oil-water mix consist of unweathered crude oil, it is returned to the refinery for processing or re-injection into the crude pipeline.

2.10 Pipelines

Pipelines are the safest way to transport oil from oilfield, terminals and depots. The most likely cause of pipeline failure and spillage of oil are damages resulting from the impact of large anchors, corrosion and sabotage. Major pipeline break can be detected fairly rapidly because any leakage in the in the pipeline is easily noted as a result of the corresponding hydrostatic pressure drop at the upstream terminal. In practice, any leak is unlikely to exceed 1000 tones

Measures taken to prevent spillage and to ameliorate environmental impact include choosing a stable route, and taking into account the interest of the fishermen and farmers when selecting a route. Other measures include the constant injection of anticorrosion chemicals into the streamline as well as cathodic protection of the pipeline. Onshore pipelines are extremely safe, pollution incidents are rare except when there are incessant vanderlization of the pipelines.

2.10.1 Nigeria Pipeline Network

Nigeria national petroleum corperation(NNPC) published in 2000 that, Nigeria has a total network of 5001km of oil pipeline consisting of 4315km of multi-product pipeline and 666km of crude oil pipeline. These pipeline criss-cross the country and interlink the 22 petroleum storage depot scattered across the nation, the refineries at Port-Harcourt, Kaduna and Warri, the off shore terminals at Escarvos and Bonny, and the jetti at Okrika, Atlas-cove, Warri and Calabar.
For reason of safety and security these pipelines are buried about one meter beneath the surface. Also a combination of NNPC, community, polices and indigenes provide surveillance for its safety. Inspite of these security measures, statistics on oil pipeline vandalization shows that in 1999 there was 524 cases of oil rupture, 27 was due to natural causes namely(wear and tear) while the rest 497 were due to vandalization. In the first six months of year 2000, 400 oil pipelines rupture occurred,382 of which were due to willful vandalisation. (Joel & kola et'al). It was also reported in punch newspaper(on 19th of Sept. 2000) that shell petroleum corporation reported 1136 cases of vandalization in six years.

2.11 Amonyi, Ishiagu oil spillage

Oil spill/ pollution occurred through an NNPC-PPMC pipeline rupture in July 1999 in Amonye community of Ishiaju. There was corrosion on the 2E pipeline system at kilometer 145. The 2E pipeline runs from Port-Harcourt to Enugu carrying petroleum products. At the time of rupture, dual purpose kerosene (DPK) was being pumped from Port-Harcourt to Enugu depot. The spill occurred at the height of the raining season when the right of way and adjoining farmland were flooded. The DPK spread on the floodwaters and driven by wind spread quickly into adjoining farmlands and streams in the area.

2.11.1 The Study Area

The co-ordinate of the study area is as follows:

Latitude $5^0$55'00"N

Longitude $7^0$3'00"E

The area under study is located in the hot tropical equatorial zone with mean temperature of 27.37^{0}C and average annual rainfall of 1580mm. The primitive vegetation has largely has been lost due to farming and other anthropogenic activities. The soil is loamy in nature and highly fertile. The study area is undulating with seasonal streams criss-crossing the area and they empty the major river Ivo. The Amonye Community consists of five harmlets ana a population of approximately 1,148 people. (EPIA of Amonye-Ishiagu oil spillage)

2.12 Behaviour of Oil on Water

When oil is spilled on water or reaches water via a leak on land, it is immediately subjected to a variety of simultaneous physical and chemical processes, which govern distribution and fate within the environment. After a short while of lag, biological processes also begin to act and gradually assume more importance. These individual processes differ in each type of environment. (EPIA of Amonye-Ishiagu oil spillage)

The following are the processes that may be involved.

1. Spreading
2. Evaporation
3. Horizontal transport by wind/currents
4. Emulsification
5. Solution in water (water soluble fraction)
6. Chemical degradation, photo induced oxidation
7. Absorption onto sediment particle
8. Sedimentation, settlement and re-suspension
9. Microbiological degradation
10. Uptake by larger organism
11. Weathering

2.12.1 Spreading

Once Oil is released on water, the process of spreading takes place immediately. This process stands to be the most significant. The rate of spreading of oil spill depend largely on speed of the water on which the spill occur and the pressure(pipe) under which the spill occur, and the subsequent effects are more on ponds or calm water than fast moving rivers and high seas. Some forces influence the lateral spreading of oil on even calm water.

These include gravitational force which brings about decreasing film thickness, surface tension and inertial forces, the force of gravity is found to be proportional to the film thickness, the gradient thickness and the density difference between the oil and water. The surface tension gives co-efficient of spreading which is the difference between air/oil and oil/water surface tensions.

This force that is independent of the film thick.ess is the dominant process gotten in the final phase of spreading.

The inertia of the oil body and the oil/water friction cause retardation on the surface tension. The inertia of a specific oil slick, which is a function of the density and thickness, readily diminishes alongside spreading. Another factor that affects spreading slightly is water temperature.(Akpofure et'al 2002)

2.12.2 Evaporation

The type of oil determines the rate of evaporation which varies from almost zero with a residential crude to almost 100% with low boiling point refined products.

2.12.3 Emulsification

This actually is a change of state from oil-in-water dispersion (oil-in-water slick) to water-in-oil emulsion with a resulting thick, sticky mixture containing up to 80% water, and termed chocolate mouse. With oil-in-water dispersion or emulsions such parameters as water, temperature, salinity, pH, presence of surface active agents and suspended particles predominate, as against water-in-oil emulsions.

2.12.4 Photo Chemical Oxidation

When petroleum or crude oil floats on water surface, it is invariably exposed to attack by atmospheric oxygen, solar radiation, the result of which is degradation to large molecular weight components, which subsequently degenerate into water soluble ones. The weight of this attack depends on the weight of oil slick.

2.12.5 Microbiological Degradation

Petroleum as well as it's refined products is a complex mixture of a wide range of hydrocarbon fractions with sulphur, oxygen and nitrogen compounds. These fractions which include straight or short-branched alkanes, cyclo-alkanes, aromatic hydrocarbons and heterocyclic compounds form a potential carbon and energy sources for microbial activities and hence biodegradable. The micro organisms including bacterial, yeast and fungi make use of oil in the soil on energy source with such additional nutrients as nitrogen, phosphorus, potassium and an adequate supply of oxygen.

This microbial activity causes crude oil disappearance from the soil after a considerable time. Accumulation of Carbondioxde, water, ammonia and some other intermediates are unavoidable, and the formation of waxy solids by unknown biosynthetic processes are all hazardous, and significantly long lasting.

2.12.6 Solution in water

The solubility of petroleum hydrocarbons varies with their molecular weight, in general those of low molecular weight are more soluble than those of higher molecular weight .Aromatic compounds tend to be more soluble than saturated compounds.

2.13 Mathematical Model and Simulation

A model is a simplified representation of a system intended to enhance our ability to understand, explain, predict and possibly control the behaviour of the system.(Nae Lamkav 1987).Modelling is thus the process of establishing inter-relationship between important entities of a system. Mathematical model is a model created using concept such as functions and equation or the use of various symbol usually algebraic to represent the variables or inter-relationship of the system. When we create mathematical models we move from the real world into the abstract world of mathematical concept, which is where the model is built. We then manipulate using mathematical techniques or computer aided numerical computation.

2.13.1 Simulation

Simulation of a model is defined as the operation of the model (Martin shobik). The implementation and validation of a model is the simulation. Simulation represent the application of modelling techniques to real systems, thus enabling information on the system to be gained without either construction or operating the full-scale system in consideration. Simulation can be used to predict the effect of changing condition, to optimise operation quickly and safely. It can also be use to provide indepth knowledge about a complete system behaviour.

2.13.2 Uses of Mathematical Model

Mathematical model can be used to explore the effect of changes in a system. It can result in an increase in the fundamental knowledge about a system since it usually involves a considerable analysis of the system. Other uses include the following

- To design a control stategy for a new process
- To select controller settings
- To design the control law
- To optimise process operating condition

CHAPTER THREE

EXPERIMENTAL

3.0 Experimental Methods

Five water samples were collected around the study area. The stations included areas impacted by the oil spill/pollution. One control site was establish farther away from the impacted area. The parameters analysed for in the various water samples include pH, conductivity, Turbidity, colour, Odour, Temperature and the concentration of suspended solid, Total dissolved solid, Alkalinity, Hardness, phosphate, sulphate, ammonium nitrate, chloride and oil in water

3.1 Sampling

Water samples were collected from the streams and river by grab method using stainless steel bailers and composites. All containers were sterilized in the laboratory and in field were rinsed at least three times with water being sampled before sample collection. The samples were then presented to 4^0C in coolers before transported to the laboratory for analysis.

3.2 Water Quality Parameters Analysis Procedures

There involves the analysis of the physical, chemical as well as the biological characteristics of the water. Parameters Such as turbidity, pH, conductivity, colour, taste, odour temperature, total dissolved solid, total susperded solid, chemical oxygen demand, oil and grease as well as the exchaneable anions

Parameters such as temprature conductivity, and pH were measured directly at the sampling location with the aid of thermometer, conductivity meter, pH meter respectively while the taste, colour and odour were just observed literaly during sampling.

3.2.1 Suspended solids

A Crucible and filter pad were kept in a dry oven and cooled. The dry mass is determined. Then a measured volume of water sample is drained through the filter pad contain in a porous bottom crucible . The crucible and filter pad are placed in a drying oven at 104^oC and dried to a constant mass. The difference in the mass of the apparatus before and after drying divided by the volume of water used gives the total suspended solid in mg/l.

3.2.2 Turbidity

The turbidity of water was measure with the aid of a turbid meter in which a standardized electrical bulb produces a light that is then directed through a small vial. In the adsorption mode a photometer measures the light intensity at a right angle from the light source. Turbidity is measured in NTU units.

3.2.3 Hardness

Analysis of the alkalinity of the water sample was carried in the laboratory using a spectrophotometric technique.

3.2.4 Total Dissolved Solid

The total dissolved solids were determined gravimetrically. Water samples (100ml) were filtered through a membrane filters. The filtrate were evaporated and dried in oven at 103^0C to 105^0C to constant weight.

3.2.5 Phosphate

Phosphate was determined by the stannous chloride method. Phosphate in water reacted with ammonium molybdate in acidic medium to form molybodophosphoric acid, which was reduced to molybdenum blue complex by stannous chloride. The intensity of colour was measured at 690mm using spectronic 20.

3.2.6 Sulphate

Sulphate was determined by the tubidimetric method. The sulphate was reacted with barium ion in the presence of sodium chloride-hydrochloric acid solution containing glycerol and ethyl alcohol. This resulted in the formation of collodial barium sulphate. The collodial barium sulphate was measured at 420nm

3.2.7 Total alkalinity

Total alkalinity was determined by titrating water samples(100ml) with 0.02N sulfuric acid solution using methyl orange as the indicator.

3.2.8 Ammonium Nitrate

This was determined using phenol and hypochlorite method. Alkaline phenol and hypochlorite catalyzed by sodium nitropruside, reacted with ammonia to form indophenol blue complex. The intensity of the colour was measured using unican SP 500 spectrophotometer at 630nm

3.2.9 Chloride

Chloride was measured titrimetrically (Argentometric method) in slightly alkaline solution with silver nitrate($AgNO_3$), Excess silver ions together with potassium chromate as indicator form a reddish brown complete compound of silver chromate. The reagents and chemicals used for this experiment were 0.01m silver nitrate, 0.01 nitric acid and 10% patassium chromate or phenolphthlein.

3.2.10 Oil in Water Oil in water was measured, after pre-extracting 100ml with 10ml carbon tetrachloride, using a horiba oil content analyzer (OCMA –200, range (0-100ppm) Biological Oxygen demand

3.2.11 Biological Oxygen Demand(BOD)

The dilution method was used. The dissolved oxygen content in the water sample was determined before incubating for five days and then repeated after the incubation period.The diffrence between the two values give the oxygen demand within the incubation period.

3.2.12.1 The Chemical Oxygen Demand

This was obtained by measuring 10ml of each sample into a conical flask and dilutting with 100ml of distilled water. 2ml of 8% NaOH solution was added and boiled continuously for 15minutes. 10ml of Oxalic acid was added immediately and the solution was back titrated immediately while hot.

3.3 Modelling for pH

The pH of water(degree of acidity or alkalinity) is a function of it's dissolve constituents. The pH of surface water is a function of its constituents at a particular distance and temperature. Therefore for a set conditions the pH of the surface water is a function of total alkalinity, distance, temperature and turbidity. Assuming pH to be constant (K), depending on the influencing parameters.

And that the operation parameters(temperature, total alkaiinity, distance and turbidity) has an independent and cumulative effect on the constant(K)

3.4 Assumptions

The modeling method is semi-empirical, semi analytical. The pH increase in this case is strictly based on its numerical value.This and other assuptions were made for simplicity and to yield the appropriate result quickly

3.4.1 Influence of Temperature

Henderson Hasselbalch Equation State that

$$pH = pKa + Log \frac{[A]}{[HA]}$$

But acid dissociation

$$Ka = \frac{[H^+] + [A^-]}{[HA]}$$

Ka = dissociation constant

But Ka is related to gibbs energy

$\Delta G = RTln\ Ka$

$\Delta G = -2.303RTlog\ Ka$

$pKa = -logKa$

$\Delta G = 2.303RTpKa$

$\Delta G = \Delta H - T\Delta S$

$$pH = \frac{\Delta H}{2.303RT} - \frac{\Delta S}{2.303R} + \frac{log[A^-]}{[HA]}$$

$$pH = \frac{K_1}{T}$$

$$pH = \frac{K_1}{Temperature} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

3.4.2 Influence of total alkalinity

Alkalinity in water is due to the presence of hydroxide, carbonate and bicarbonate of metals of which calcium ions and magnessium are most common. The higher the concentration of bicarbonate and carbonate salt in a water sample, the higher the possibility of having the bicarbonate salt of calcium and magnessium. This implies that the higher the alkalinity and the hardness of the water. A numerical increase in pH denote an increase in alkalinity therefore,

$pH \ \alpha Total\ alkalinity$

$pH=K_2\ XTotal\ alkalinity$……………………………………………….2

3.4.3 *Influence of distance*

When there is a spill on stagnant surface water, assuming that spreading occur unidirectionally(on one axis) . Though It takes some time before the oil start to weather but the effect of such oil if felt more at the point of spill then at a distance afar of. The effect in this case is quantified in term of the pH. The water is expected to be more acidic at the environ of spill, therefore the pH increase in numerical value(alkalinity) at a distant location.

pH α Distance

pH = K_3 Xdistance..3

3.4.4 Influence of Turbidity

Turbidity of water is the degree of transparency of the water. The basic factor that reduces turbidity of water is the dissolution of substance The surface water is brownish(turbid) and normally harbor more aquatic life. Therefore it is assume that the dissolve substance causing the turbidity are not harmful to the aquatic life. Therefore it is assume that the dissolves substances causing the turbidity are not harmful to the aquatic life(not acidic). The numerical value of pH increases (alkalinity) with the turbidity.

pH α Turbidity

pH = K_4 Xturbidity..4

3.4.5 PROPOSED MODEL

This model will only give the relationship between the pH the parameters being considered only. Combining the assumptions(equations1, 2, 3 and 4) give the equation below

$$pH = \frac{K_1}{Temperature} + K_2 X \text{ Total alkalinity} + K_3 X\text{distance} + K_4 X \text{ Turbidity}...5$$

3.5 Mathematical Model for pH

The model is use to find the values of the canstants K_1, K_2, K_3, K_4 in the proposed model

Let

Te.	represent	Temperature.
Ta	,,	Total alkalinity
Di	,,	Distance
Tu	,,	Turbidity

pH = f(Temp, Tallk, DIs, Tur) 1

pH = f(K_1.Te + K_2.Ta + K_3 . Di + K_4 . Tu) 2

therefore equation 2 can be written as

pH = K_1.Te + K_2.Ta + K_3 . Di + K_4 . Tu 2a

Where pH is the dependent variable in the equation and K_1, K_2, K_3, and K_4 are the independent variables for the desired pH.

Let I represent the square of the error between the observed pH and its predicted value p, using the experimental data obtained.

For n experiments the square of error

To minimise the error we equate the partial differential with respect to K_1,K_2, K_3 and K_4 to zero

$$\text{As}\ \frac{\delta nI}{\delta K_1} = -2\sum_{1} \frac{1}{Tc}\cdot\left[\left[p - \left(\frac{K_1}{Tc} + K_2\cdot Ta + K_3\cdot Di + K_4\cdot Tu\right)\right]\right] = 0$$

$$\frac{\delta nI}{\delta K_2} = -2\cdot\sum_{1} Ta\cdot\left[\left[p - \left(\frac{K_1}{Te} + K_2\cdot Ta + K_3\cdot Di + K_4\cdot Tu\right)\right]\right] = 0$$

$$\frac{\delta nI}{\delta K_3} = -2\cdot\sum_{1} Di\cdot\left[\left[p - \left(\frac{K_1}{Te} + K_2\cdot Ta + K_3\cdot Di + K_4\cdot Tu\right)\right]\right] = 0$$

$$\frac{\delta nI}{\delta K_4} = -2\cdot\sum_{1} Tu\cdot\left[\left[p - \left(\frac{K_1}{Te} + K_2\cdot Ta + K_3\cdot Di + K_4\cdot Tu\right)\right]\right] = 0$$

$$\sum_{n=1}^{6}\frac{p}{T} := K_1\left(\sum_{n=1}^{6}\frac{1}{Te^2}\right) + K_2\left(\sum_{n=1}^{6}\frac{Ta}{Tc}\right) + K_3\left(\sum_{n=1}^{6}\frac{Di}{Tc}\right) + K_4\left(\sum_{n=1}^{6}\frac{Tu}{Tc}\right)$$

$$\sum_{n=1}^{6} Ta\cdot p := K_1\left(\sum_{n=1}^{6}\frac{Ta}{Te}\right) + K_2\left(\sum_{n=1}^{6} Ta^2\right) + K_3\left(\sum_{n=1}^{6} Ta\cdot Di\right) + K_4\left(\sum_{n=1}^{6} Ta\cdot Tu\right)$$

$$\sum_{n=1}^{6} Di\cdot p := K_1\left(\sum_{n=1}^{6}\frac{Di}{Tc}\right) + K_2\left(\sum_{n=1}^{6} Di\cdot Ta\right) + K_3\left(\sum_{n=1}^{6} Di\cdot Ta\right) + K_4\left(\sum_{n=1}^{6} Di\cdot Tu\right)$$

$$\sum_{n=1}^{6} Tu\cdot p := K_1\left(\sum_{n=1}^{6}\frac{Tu}{Te}\right) + K_2\left(\sum_{n=1}^{6} Tu\cdot Ta\right) + K_3\left(\sum_{n=1}^{6} Tu\cdot Di\right) + K_4\left(\sum_{n=1}^{6} Tu^2\right)$$

Table 3.1: Data for surface water from Nun River OF Samabri-Beseni FD area in Bayelsa State

Matrix	pH	Temperature(oC)	Total alkalinity(mg/l)	Distance(m)	Turbidity (NTU)
Water	7.23	29.5	80	0	3.5
Water	7.28	30	100	100	3.8
Water	7.25	29.5	100	200	3.5
Water	7.33	30	40	0	5
Water	7.16	30.5	40	100	5.5
Water	7.35	30	40	200	4.5

Summing the data on excel worksheet as shown in the appendix 1

The equations generated from the data surface water in table 3.1 are

$0.006707\ K_1 + 13.41317\ K_2 + 20.05835\ K_3 + 0.860949\ K_4 = 1.457602$......6

$13.41317\ K_1 + 31200\ K_2 + 42000\ K_3 + 1610\ K_4 = 2905$........................7

$20.05835\ K_1 + 42000\ K_2 + 100000\ K_3 + 2530\ K_4 = 4364$........................8

$0.860949\ K_1 + 1610\ K_2 + 2530\ K_3 + 114.44\ K_4 = 187.449$......................9

solving these equations (6, 7, 8, and 9) for K_1, K_2, K_3

and K_4 using Matcad tosolve the matrix generated from the coeficients

$$Ala := \begin{pmatrix} 0.006707 & 13.41317 & 20.05835 & 0.860949 \\ 13.41317 & 31200 & 42000 & 1610 \\ 20.05835 & 42000 & 100000 & 2530 \\ 0.860949 & 1610 & 2530 & 114.44 \end{pmatrix}$$

$$Deji := \begin{pmatrix} 1.457602 \\ 2905 \\ 4364 \\ 187.449 \end{pmatrix}$$

$$Water_S := lsolve(Ala, Deji)$$

$$Water_s = \begin{pmatrix} 206.97 \\ -3.302\times 10^{-4} \\ 2.26\times 10^{-4} \\ 0.081 \end{pmatrix}$$

$K_1 := 206.97$

$K_2 := -3.302\times 10^{-4}$

$K_3 := 2.26\times 10^{-4}$

$K_4 := 0.081$

Therefore

$$pH = \frac{206.97}{Te} - 3.302X10^{-4}\ X\ Ta + 2.26X10^{-4}\ X\ Dis + 0.081\ X\ Tur$$

Substituting back into the proposed model give

$$pH = \frac{206.97}{Temperature} - 3.302X10^{-4}XTotal\ Alkalinity + 2.26X10^{-4}XDistance + 0.081X\ Turbidity \quad ......10$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results of Experimental Analysis

The results for the physico-chemical analysis of water samples are presented in the tables below. As earlier stated the samples were taken from five spots for the various analyses- the Okuiyi ROW Station, T_3.3, Ivo river Station, T_4.4, and a control spot C_5

Table 4.1: Water sample one (Okuiyi ROW Station)

S/N	Parameter	Lab. Analysis result	DPR Limit	FEPA Limit	Unit
1	pH	7.48	6.5-8.5	6.5-8.5	
2	Conductivity	380.00	900		µS/cm
3	Alkalinity	85.00	500	500	mg/l
4	Hardness	107.50		100	mg/l
5	Chloride	64.50	600	600	mg/l
6	Turbidity	0.34	10		NTU
7	NO_3	2.14		10-30	mg/l
8	SO_4	2.50	200	400	mg/l
9	P	0.40		20	mg/l
10	TSS	<1.00	30	30	mg/l
11	TDS	195	2000	200	mg/l
12	COD	10.32	40		mg/l
13	Oil & grease	2.10	10	10	mg/l

Table 4.2

Water sample two ($T_3.3$)

S/N	Parameter	Lab. Analysis result	DPR Limit	FEPA Limit	Unit
1	pH	7.28	6.5-8.5	6.5-8.5	
2	Conductivity	460	900		µS/cm
3	Alkalinity	132.50	500	500	mg/l
4	Hardness	185.00		100	mg/l
5	Chloride	62.50	600	600	mg/l
6	Turbidity	0.50	10		NTU
7	NO_3	1.75		10-30	mg/l
8	SO_4	4.00	200	400	mg/l
9	P	0.30		20	mg/l
10	TSS	<1.00	30	30	mg/l
11	TDS	245	2000	200	mg/l
12	COD	16.144	40		mg/l
13	Oil & grease	5.50	10	10	mg/l

Table 4.3: Water sample Three (Ivo river Station)

S/N	Parameter	Lab. Analysis result	DPR Limit	FEPA Limit	Unit
1	pH	6.88	6.5-8.5	6.5-8.5	
2	Conductivity	40.00	900		µS/cm
3	Alkalinity	27.50	500	500	mg/l
4	Hardness	17.00		100	mg/l
5	Chloride	7.00	600	600	mg/l
6	Turbidity	0.21	10		NTU
7	NO_3	0.48		10-30	mg/l
8	SO_4	<1.00	200	400	mg/l
9	P	0.25		20	mg/l
10	TSS	<1.00	30	30	mg/l
11	TDS	22	2000	200	mg/l
12	COD	1.50	40		mg/l
13	Oil & grease	0.75	10	10	mg/l

Table 4.4: Water sample Four (T_4.4)

S/N	Parameter	Lab. Analysis result	DPR Limit	FEPA Limit	Unit
1	pH	7.0	6.5-8.	6.5-8.	
2	Conductivity	440.00	900		μS/cm
3	Alkalinity	105.00	500	500	mg/l
4	Hardness	130.00		100	mg/l
5	Chloride	69.50	600	600	mg/l
6	Turbidity	0.42	10		NTU
7	NO_3	0.50		10-30	mg/l
8	SO_4	3.50	200	400	mg/l
9	P	0.48		20	mg/l
10	TSS	<1.00	30	30	mg/l
11	TDS	230.00	2000	200	mg/l
12	COD	15.00	40		mg/l
13	Oil & grease	2.40	10	10	mg/l

Table 4.5: Water sample Five (control station C_5)

S/N	Parameter	Lab. Analysis result	DPR Limit	FEPA Limit	Unit
1	pH	8.14	6.5-8.5	6.5-8.5	
2	Conductivity	630.00	900		μS/cm
3	Alkalinity	222.50	500	500	mg/l
4	Hardness	275.00		100	mg/l
5	Chloride	23.00	600	600	mg/l
6	Turbidity	0.63	10		NTU
7	NO_3	1.25		10-30	mg/l
8	SO_4	5.50	200	400	mg/l
9	P	0.65		20	mg/l
10	TSS	<1.00	30	30	mg/l
11	TDS	320.00	2000	200	mg/l
12	COD	21.40	40		mg/l
13	Oil & grease	1.20	10	10	mg/l

4.2 Simulation Result.

The simulated result below were generated from the modelled equation (10)using parameters from tables 4.1 – 4. 5 respectively. The simulated results alongside the corresponding experimental results are shown in Table 4.6 below.

Table 4.6: Simulated/ Experimental Result

Experimental result of pH	Simulation result of pH
7.48	7.262
7.28	7.259
6.88	7.270
7.05	7.261
8.14	7.240

4.3 Discussion of Results

The result of the analysis of water samples from the various sampling spots were presented in tables 4.1, 4.2, 4.3, 4.4 and 4.5. Tabl 4.1 shows the result obtained from Okuiyi right of way station and presented alongside the comparison with the recommended FEPA and DPR limit. All the parameters were within the stipulated range except for hardness which was 107mg/l against 100mg/l recommended by FEPA. In table 2, hardness and total dissolve solid were the only parameters to exceed the stipulated limit. In table 3, all the parameters were within the recommended limit but the hardness and total dissolve solid were very low (hardness 17mg/l and total dissolve solid, 22mg/l) compared to other sample results. Table 4 also shows that the alkalinity exceeded the required limit slightly, 105mg/l, while that of total dissolve solid was 230mg/l compared to the FEPA limit but within the DPR limit of 2000mg/l. Analysis of the control sample show a similar result with the conductivity higher than that of others (630) while the total dissolve solid and hardness were still higher than the FEPA limit. The simulated result in table 4.6 give a value of the pH ranging from 7.24-7.270 which were within the stipualted DPR and FEPA limits also.

From the comparison made with sttipulated limits, the pH and other parameters in the result does not pose any problem to the receiving environment except for the water hardness and total dissolved solid which is expected to contribute to non acceptablilty of the water for domestic use, waste of soap in laundry and high cost of treatment of the water for both domestic and industrial use

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the result of theanalysis it can be deduced that the impact of the oil spillage was brief, and that the environment had almost been self restored before the time of this study. This may probably be due to the fact that the analysis was not caarried out immediately the spill occur and the fact that spilled oil is volatile (DPK) therefore evaporating quickly. The physico-chemical parameters analyzed fall within the limit specified by FEPA except for that of hardness and total dissolved solid(TDS) which were higher in three of the four samples taken in the impacted area as well as in the control sample.

A model equation for predicting the pH, a measure of the water quality was also developed which can be use to predict the pH in any post spill on water. This model was also use to simulate the experimental results in the studied area and the values of the pH evaluated also fell within the stipulated DPR and FEPA limit of surface water pH

5.2 Recommendation

1) There should be pits around pipelines to reduce the effect of any spill to the environment.

2) Pipelines should be replace after their life expectancy.

3) The pipelines and other oil processing equipment susceptible to corrosion should by properly treated constantly with anti-corrosion chemicals

4) There should be an environmental inventory of all water that is liable to be affected by oil spill.

5) Government should make it as a matter of necessity To provide amenities to communities that are likely to be affected by oil spillage.

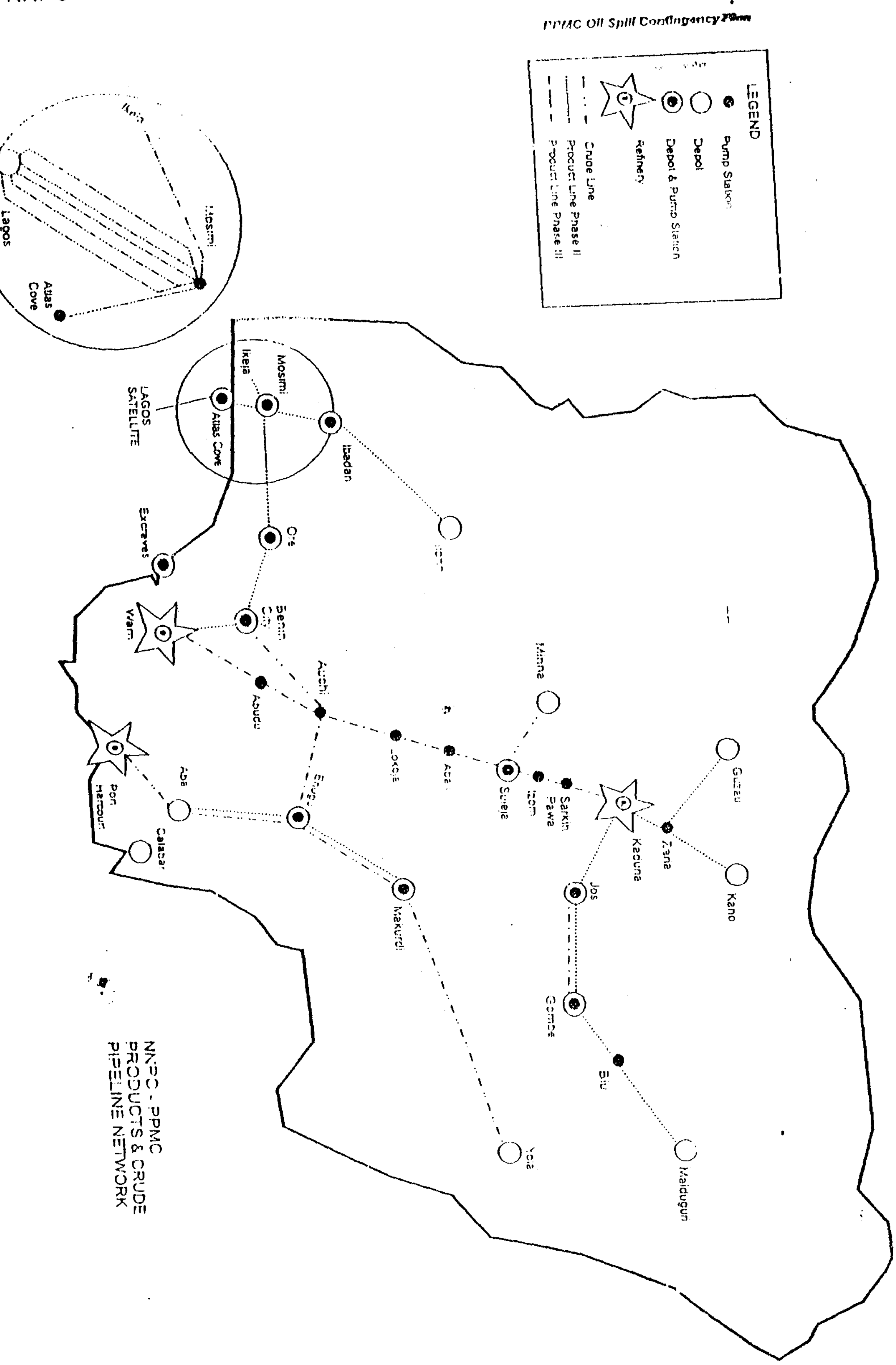
6) Compensation should be paid to any individual that is directly affected by oil spillage.

7) Contigency plans should be strictly followed.

APPENDIX

Appendix 1

NNPC-PPMC Products and Crude Pipeline Network



MAP X ON PAGE 16

Appendix 2

Computer Aided Summation On Excel Worksheet.

pH	Te	Ta	di	Tu	l/Temp^2	Ta/Te	Dis/Te	Tur/Te	pH/Temp
7.23	29.5	80	0	3.5	0.0011	2.7119	0	0.1186	0.2451
7.28	30	100	100	3.8	0.0011	3.3333	3.3333	0.1267	0.2427
7.25	29.5	100	200	3.5	0.0011	3.3898	6.7797	0.1186	0.2458
7.33	30	40	0	5	0.0011	1.3333	0	0.1667	0.2443
7.16	30.5	40	100	5.5	0.0011	1.3115	3.2787	0.1803	0.2348
7.35	30	40	200	4.5	0.0011	1.3333	6.6667	0.15	0.245
					Σ0.0067	Σ13.413	Σ20.058	Σ0.8609	Σ1.45

pH	Te	Ta	di	Tu	Ta/Te	Ta^2	Di.Ta	Tur.Ta	Ta.pH
7.23	29.5	80	0	3.5	2.7119	6400	0	280	578.4
7.28	30	100	100	3.8	3.3333	10000	10000	380	728
7.25	29.5	100	200	3.5	3.3898	10000	20000	350	725
7.33	30	40	0	5	1.3333	1600	0	200	293.2
7.16	30.5	40	100	5.5	1.3115	1600	4000	220	286.4
7.35	30	40	200	4.5	1.3333	1600	8000	180	294
					Σ13.413	Σ31200	Σ42000	Σ1610	Σ2905

pH	Te	Ta	di	Tu	Dis/Te	Dis.Ta	Dis^2	Dis.Tur	Dis.pH
7.23	29.5	80	0	3.5	0	0	0	0	0
7.28	30	100	100	3.8	3.3333	10000	10000	380	728
7.25	29.5	100	200	3.5	6.7797	20000	40000	700	1450
7.33	30	40	0	5	0	0	0	0	0
7.16	30.5	40	100	5.5	3.2787	4000	10000	550	716
7.35	30	40	200	4.5	6.6667	8000	40000	900	1470
					Σ20.058	Σ42000	Σ100000	Σ2530	Σ4364

pH	Te	Ta	di	Tu	Tur/Te	Tur.Ta	Tur.Dis	Tur^2	Tur.pH
7.23	29.5	80	0	3.5	0.1186	280	0	12.25	25.305
7.28	30	100	100	3.8	0.1267	380	380	14.44	27.664
7.25	29.5	100	200	3.5	0.1186	350	700	12.25	25.375
7.33	30	40	0	5	0.1667	200	0	25	36.65
7.16	30.5	40	100	5.5	0.1803	220	550	30.25	39.38
7.35	30	40	200	4.5	0.15	180	900	20.25	33.075
					Σ0.8609	Σ1610	Σ2530	Σ114.44	Σ187.45

Appendix 3
Simulation on Mathcad.

$K_1 := 206.97$ $K_2 := -3.302\times 10^{-4}$

$K_3 := 2.26\times 10^{-4}$ $K_4 := 0.081$

<u>Sample one</u>

$Te := 28.5$

$Ta := 85$

$Di := 0$

$Tu := 0.34$

$$pH := \frac{K_1}{Te} + K_2 \cdot Ta + K_3 \cdot Di + K_4 \cdot Tu$$

$pH = 7.262$

<u>Sample two</u>

$Te := 28.5$

$Ta := 132.5$

$Di := 0$

$Tu := 0.5$

$$pH := \frac{K_1}{Te} + K_2 \cdot Ta + K_3 \cdot Di + K_4 \cdot Tu$$

$pH = 7.259$

<u>Sample three</u>

$Te := 28.5$ $Ta := 27.5$

$Di := 0$ $Tu := 0.21$

$$pH := \frac{K_1}{Te} + K_2 \cdot Ta + K_3 \cdot Di + K_4 \cdot Tu$$

$pH = 7.27$

<u>Sample four</u>

$Te := 28.5$ $Ta := 105$

$Di := 0$ $Tu := 0.42$

$$pH := \frac{K_1}{Te} + K_2 \cdot Ta + K_3 \cdot Di + K_4 \cdot Tu$$

$pH = 7.261$

<u>Control sample</u>

$Te := 28.5$ $Ta := 222.5$

$Di := 0$ $Tu := 0.63$

$$pH := \frac{K_1}{Te} + K_2 \cdot Ta + K_3 \cdot Di + K_4 \cdot Tu$$

$pH = 7.24$

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