Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 9 ~ Issue 3 (2023) pp: 74-100
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

TITLE

ABSTRACT
An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially the marine ecosystem, due to human activity, and is a form of pollution. The term is usually given to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land. Although Nigeria has taken significant measures to create effective environmental safety strategies and guidelines, there have been numerous cases of Oil spillage in Nigeria which affects the quality of the environment. The aim of the study was to design an oil spill monitoring drone which will give a real time and accurate data of oil spillage which will help reduce the prevalence of oil spillage in the country. It involved the construction of a dynamic drone device for surveillance in Agricultural lands in Imo State and Rivers State. Experimental cross-sectional study design was used to design and estimate the data generated in the study. The dynamic drone device constructed in the study showed a real time oil spillage in different agricultural lands in Imo. The soil samples were gotten and tested to confirm the presence of oil spillage. The study therefore suggests the use of a dynamic drone device to monitor the increasing oil spillage occurring in Agricultural lands and offer ways to detect and amend it on time.

Received 13 Mar., 2023; Revised 27 Mar., 2023; Accepted 29 Mar., 2023

I. INTRODUCTION

This research deals with the development of a robotic device (drone) for oil spill surveillance on agricultural soil that is in this context the oil spill pollutes not only the river but the environment including the soil.

Consequentially, pollution is the introduction of harmful substances or products (contaminants) into the normal environment that cause adverse change.

In this study, it involves robotic engineering i.e., exploring the feasibility of utilizing mobile robotic drones for detecting ground oil leakage on agricultural soil. By the application of ground and air borne remote surveillance methods and visual inspections.

Forms of pollution
The major forms are

- Air pollution includes the release of particulates and chemical into the atmosphere. Such as carbon monoxide sulfur dioxide, chlorofluorocarbons (CFC) and nitrogen oxides produced by industry and motor vehicles. Photochemical ozone and among are created as nitrogen oxides and hydrocarbons react to sunlight.
- Noise pollution which includes roadway noise, aircraft noise, industrial noise as well as high-intensity sonar.
- Soil contamination which occurs when chemical is released by spill or underground leakage. The most significant soil contamination are hydrocarbon, heavy metals, MTBE herbicides, Pesticides, and chlorinated hydrocarbons
- Radioactive contamination which resulted from the 20th century activities in atomic physics such as nuclear power generation and nuclear weapon research manufacture and deployment.
- Water pollution by the discharge of waste water from commercial and industrial waste into surface waters discharges of untreated domestic sewage, and chemical contaminants such as chlorine from treated sewage release of waste and contaminants into surface runoff flowing to surface water.

Oil spill is the release of a liquid petroleum hydrocarbon into the environment especially marine areas due to human activity and in form of pollution. The term is usually applied to marine oil spill where oil is released into ocean coastal waters, but spills may also occur on land.

Oil spills may be due to releases of crude oil from tankers offshore platforms, drilling of wells as well as spills of refined petroleum products as such as gasoline, diesel and their by-product, heavier fuels used by large ships such

as bunker fuel or the spill of any oily refuse or waste oil. Many oil –producing communities in Nigeria especially Etche Rivers State in the Niger delta have been suffering from the aftereffects of oil spillage. The accidental discharge of petroleum product on soil or water surfaces is termed oil spill. Oil –spill pollution has been hazardous and problematic worldwide (Vincent, 1980). The Nigerian National Petroleum Corporation (NNPC) in 1986 reported that a total of about 5,000 barrel of crude oil was spilled from Nigerian Agip oil company (NAOC) pipeline near Oshika in rivers state in august 1983 (IPS, RUST,1986). Analysis of the oil sample from the affected environment showed that the organic content of the soil in polluted area was slightly higher and there was also slight increase in soil acidity. Recorded incidence of oil spill show that a lot of problem have arisen because of it. A lot is being spent by affected countries in the cleaning of spills. United States of America for example spends millions of dollars in the control and cleaning of oil spills (API 1975) lives have been lost because of disease caused by oil spill issues in Nigeria have been very contentious with local communities in needed for the sources, extent and responses to contamination in affected areas to be controlled.
Risk assessments have emerged because of worldwide interest in different aspects of hazards.
Asserts that involves the identification of hazards, estimating the threats may pose to humanity and the environment and the evaluation of such risk in a comparative perspective (Mitchell 1989).

1.2. STATEMENT OF PROBLEM

The widespread incidences of oil spills caused by the corrosion of pipes, tanks leakages infrastructures decay and sabotage in Niger delta areas that is Southeast and South South result in many instances of soil and water contamination. The disposal of organic and inorganic wastes on agricultural soils, wastewater and wastes from everyday operation at outlet has contributed to the pollution of water and soil.
In general, oil spills present problem that affects the economic activities, human health, conservation of natural resources, the ecology, and the aesthetic values of these areas.

1.3. OBJECTIVES

The main objective of this study is to develop an adaptive dynamic surveillance drone device to determine the presence and levels of total petroleum hydrocarbon content in soils during actual spillage affecting Agricultural productions.
The specific objectives are:

1. To determine oil spill and forms to establish affected agricultural land areas, facilitating remediation and recovery.
2. To determine impact of oil pollution on features of crops after its changes with time.
3. To determine the use of drone in post-spill impact mapping of an affected area.

1.4. Justification of Study

This study is timely because there is need for knowledge on the control of oil spills on soil agricultural and for a better understanding of the remedial and recovery measures that may be required after oil spillage. The justification of this study cannot be over overemphasized, especially in the face of increasing industrialization and urbanization in the environment.
Consequently, results from this study could serve as.

1. A guide to highlight the hazards or dangers associated with oil spill on Agricultural soil.
2. A means to draw government's attention to enforce legislation on oil spill guidelines as regards the Shell Petroleum Development Company (SPDC) and other companies.
3. A medium to provide relevant data to the companies as a basis for advising their management to install an effective, functional, and efficient oil spill remedial method in preference to the current management method used.
4. A medium to suggest a good way of protecting oil pipelines which could serve as a reference in improving the economy of the country.
5. A means to provide necessary information to government health workers in a bid to policing a sound and healthier environment for the people Nigeria.

1.5. Scope

The research focused on the Development of a Drone Device for Surveillance for Agricultural Lands to Detect Crude Oil Spill in FUTO.

II. Literature Review

The environment could be defined as the combination of external or extrinsic conditions that affect, either directly or indirectly, the growth and development of organisms and the wellbeing and activities of man (NNPC,1995).
Environment impacts of oil discharge may occur because of obstruction, debris discharges and physical interruption.
According to Sharma et.al. (1980) environmental pollution has adverse effects on plant growth, and these may range from morphological abbreviation, reduction in biomass to stomata abnormalities.

2.1. REVIEW OF PAST WORK

All over the world there has been a lot of effort to analyze the effect of oil spill in the environment where it occurs. Most of these studies were done during actual spill events while others were while monitoring studies on non-spill state of pollution of the environment. There has been quite a lot of impressive literature on oil spill, which would be cited.

According to Ejofodomi and Ofualagba (2017) exploring the feasibility of robotic pipeline surveillance for detecting crude oil spills by the application and utilizing small mobile robots for early detection of ground oil leakage. Using a method defined as Ground Robotic Oil Spill Surveillance (GROSS) which have the capacity to detect crude oil spills.

According to Vanitha Aenugu and Peng-Yung Woo (2012) did a work on using a mobile robot to determine a dynamic path planning for tracking randomly moving goal with avoidance of multiple randomly moving objects.

Roudabe Seif and Mohammadreza Asghari Oskoei (2015) stated that robot navigation is challenging for mobile robots' technology in environments with maps. Since finding an optimal path planning in robot navigation is an axial issue. They adopted a reasonable relation between parameters used in the path planning algorithm in a platform which a robot will be able to move from the start point in a dynamic environment with map and plan optimal path specified goal without collision with moving and static obstacles.

According to Eluwande and Ayo (2016) with pipeline infrastructures vastly distributed across Nigeria, to ensure continuous supply at the places needed, the monitoring of these pipelines for protection and operational safety is very important given the numerous cases of vandalization and crude-oil theft. This has proven to be a challenging task considering the numerous security infrastructures and agents required, hence expensive in nature. This concept paper shows a proposed solution using an unmanned aerial vehicle (UAV) technology for real-time monitoring and surveillance of the entire pipeline network. The overall aim was to build a drone (quadcopter) together with a pipeline monitoring system which acted as a surveillance system and reacted to attacks on above-ground oil pipelines, majorly for areas not easily accessible by security personnel.

Ahirwar et al (2019) stated that, the world population has increased day by day and projected to reach 9 billion people by 2050, so that the agricultural consumption will also increase. There is extreme need to fulfil the food demand of each person. Agriculture sector is the most promising sector, dealing with a lot of problems now a day's one of the main problems is labour unavailability for farming. Other problems or difficulties are extreme weather events, inadequate amount and inefficient application of fertilizer, infection, diseases, allergies, and other health problems due to chemical application (fungicide, pesticide, insecticide etc.) or insect/ animal bite. The use of advanced technologies such as drone in agriculture offer potential for facing several major or minor challenges. The major applications of drone in agriculture are irrigation, crop monitoring, and soil and field analysis and bird control.

2.2 Types of Drones and Their Uses

As an emerging technology for farmers, drone terminology may cause confusion. However, the practical use of drones and sensors is straightforward. The two acronyms for drones are unmanned aerial vehicles (UAV) and unmanned aerial systems (UAS). term UAV means a drone, while UAS includes drones and their associated tools (e.g., 32flight software or cameras). Both the UAV and UAS terms are typically used in technical and regulatory documents.
Most drones fall under the categories of rotary or fixed wing. A rotary style drone would be similar to a helicopter, while a fixed wing drone looks exactly like an airplane. A third type of drone is a hybrid, which has both rotary and fixed wings.
Rotary Drones
A rotary drone is often identified by the number of rotors (propellers). An example would be the quadcopter which has four rotors.
A rotary drone is an excellent scouting tool for field crop operations. A quadcopter can takeoff land vertically, so field lanes and parking spots become launching zones. Rotary drones are easy to maneuver across the field and can hover over problem areas.

Battery life is an issue with rotary drones since power is drained more quickly due to the powering of multiple propellers. Flight times for many quadcopters range from 10-20 minutes and can be less when flown during high wind speeds. As such, rotary drones are useful for smaller fields and scouting operations.

An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially the marine ecosystem, due to human activity, and is a form of pollution. The term is usually given to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land. (Ayuba, 2012). Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil (Adelana et al., 2011).

Oil spills penetrate into the structure of the plumage of birds and the fur of mammals, reducing its insulating ability, and making them more vulnerable to temperature fluctuations and much less buoyant in the water. Cleanup and recovery from an oil spill is difficult and depends upon many factors, including the type of oil spilled, the temperature of the water (affecting evaporation and biodegradation), and the types of shorelines and beaches involved. (Benka-Coker and Ekundayo, 2007). Spills may take weeks, months or even years to clean up. Oil spills can have disastrous consequences for society; economically, environmentally, and socially. As a result, oil spill accidents have initiated intense media attention and political uproar, bringing many together in a political struggle concerning government response to oil spills and what actions can best prevent them from happening (Kadafa, 2012).

Oil was first found in Nigeria in 1956, then a British protectorate, by a joint operation between Royal Dutch Shell and British Petroleum. The two begun production in 1958, and were soon joined by a host of other foreign oil companies in the 1960s after the country gained independence and, shortly after, fell into civil war. (Nwilo and Badejo, 2005). The rapidly expanding oil industry was dogged in controversy from early on, with criticism that its financial proceeds were being exported or lost in corruption rather than used to help the millions living on $1 a day in the Niger delta or reduce its impact on the local environment (Nwilo and Badejo, 2005).

A major 1970 oil spill in Ogoniland in the south-east of Nigeria led to thousands of gallons being spilt on farmland and rivers, ultimately leading to a £26m fine for Shell in Nigerian courts 30 years later. (Adelana et al., 2011). According to the Nigerian government, there were more than 7,000 spills between 1970 and 2000. In 1990, the government announced a new round of oil field licensing, the largest since the 1960s. Non-violent opposition to the oil companies by the Ogoni people in the early 1990s over the contamination of their land and lack of financial benefit from the oil revenues attracted international attention. Then, in 1995, Ogoni author and campaigner Ken Saro-Wiwa was charged with incitement to murder and executed by Nigeria's military government. (Adelana et al., 2011). In 2009, Shell agreed to pay £9.6m out of court, in a settlement of a legal action which accused it of collaborating in the execution of Saro-Wiwa and eight other tribal leaders. Hundreds of minor court cases are brought each year in Nigeria over oil spills and pollution. Last year, Shell admitted spilling 14,000 tonnes of crude oil in the creeks of the Niger delta in 2009, double the year before and quadruple that of 2007 (Benka-Coker and Ekundayo, 2007).

2.1.1 Crude oil Resources

More than any other natural resource, oils and natural gas have had a dramatic effect on the world's civilization (Ayuba, 2012). The lives of people and the economy round the world have been revolutionized by oils and gas resources, according to Plänitz & Kuzu (2015). In addition to keeping the industrialized countries' economies humming, oil exporters rely on it to fund their own national and economic advancement objectives. According to Kumar et al. (2013), oil and gas are often admired for their economic potential, with less attention on the environmental implications, particularly at the discovery stage. He goes on to say that badly managed oil and gas operations, both upstream and downstream, have serious negative effects on the environment. Social, biological, and physical components of the environment are all affected by it.

2.1.2 Crude oil Exploration Process

If hydrocarbons are found in a geological formation, exploratory drilling is carried out to see if the site is economically viable for further development (Devoid, 2013). During normal conditions, it will take between 90 and 120 days for the activity to be completed. Drilling rigs are used to carry out exploratory drilling in the field. Drilling bits of various diameters are commonly used in the drilling operation to create circular openings from the surface down into desired well height (Aketch, 2012).

*Corresponding Author: XXXX

According to Younes (2012), drilling fluids that are either oil-based, water-based, or synthetic are circulated to the drill bit in the drilling string. Wellbore stability, sealing permeable formation, lubrication of and support for the drill bit, and transfer of hydraulic energy to the drill bit and tools are all benefits of the drilling fluid structure. During the drilling mud preparation process, chemicals as well as mud additives are typically diluted to the necessary concentrations by water and then added. According to Fauzi et al. (2011), the diameter of every segment of a well is reduced as the depth grows. During well drilling, bentonite combined with water is frequently poured down the drill filament in order to propel drill cuttings up the annulus. The well's structural integrity is ensured by cementing a 30cm conductor in place. Afterward, the wellhead as well as other equipment are put in place, and drilling may begin.

According to Aketch (2012), drilling mud circulates through following well sections and cuttings are returned to the drilling rig for separation before they are discharged. This process is repeated for each new section of drilling. It is drilled and bonded into place as each piece of the well is excavated and then the next smaller diameter segment is dug. This solids control package is used to separate drilling fluid from the drill cuttings before they are returned to the drill.

Exploration for oil and gas includes tasks such as clearing vegetation to build an access route and location for the construction of well pads, says Ayuba (2012). After this, the perimeter is built. Drilling water reservoirs with a volume of 6,500 m per site are also being dug and coated with HDPE lining material as part of other preparation activities. Excavation of a conventional 16 m long x 9 m wide x 3 m deep drill cuttings pit with a bottom of 8 m x 13 m is performed on each site. According to Fauzi and colleagues (2015), the next step in well digging is to gather and put together the derrick or mast, as well as other necessary equipment, and erect it. Drilling methods include auger, cable-tool, rotary and compressed air techniques. Foam/polymer and foam/polymer drilling are also available. Rotary drilling is perhaps the most commonly used drilling technology in developing countries. Pumped through the oil well with water, bentonite, and synthetic stabilizers. Ports in the drill pipe allow drilling fluids to be poured into and out of the drill bit. Through the annulus, the drilling fluid extracts the drill bit cuttings and delivers them to the surface. Drill cuttings are sorted from drilling fluids in settling tanks after they reach the surface and are then pushed back down the hole. (Nwilo and Badejo, 2005).

Drilling fluids, natural gas, formation water, waste from the entire exploration process, as well as disruption of indigenous livelihoods owing to changes in land use and land cover, all have a significant impact on the plant cover and require a strong institutional and legal framework to assure long-term management of the fields' surroundings (Baffes, 2016).

2.1.3 The overall effects of crude oil exploration on the Biophysical Environment

The term "biophysical environment" refers to both the physical and biological environment. Biological elements include things like plants and animals, whereas the physical elements include things like water, soil, and air (Margaret et al., 1998). Surveying, clearing seismic lines, and huge dynamiting are all part of oil and gas drilling (Nnabuenyi, 2013). Additionally, the biophysical environment is influenced by things like the surface of the ground and its affects, the procurement of many acres of land for each well pad, brine pits, pipelines, tank batteries, and site clearance (Ayuba, 2012). Another major problem linked with soil and water contamination is the generation of waste from drilling activities (Mbithe, 2016).

Fig 1: Crude oil spill on water (Namuyondo, 2014).

Many changes have been reported in land usage in affected areas due to oil and gas drilling. Oil and gas development activities in the Niger Delta have resulted in serious conflicts of interest with the region's existing land use plans. The original recreational, educational, religious, and grazing properties have been converted into oil and gas exploration fields, which has drastically altered the community's aspirations (Mogborukor & Phil, 2014).

Oil and gas installations, according to Ogwu (2011), change the terrain from a countryside to an urban context. Furthermore, he argues that while these advancements had some positive socioeconomic impacts, they had a negative impact on Niger Delta ecosystem. Researchers found that burying pipelines in the Niger Delta disrupted delicate ecosystems like those found there, including as forests and mangroves, in a research by Mmom & Arokoyu (2010). Osei et al., (2006), reports that the construction of well pads as well as access roads necessitated substantial removal of land cover vegetation. They employed geospatial data processing and analysis to examine the changes in the Niger Delta forest area between 1985 and 2005. Oil and gas drilling has had a significant impact on the environment, according to a new study.

Waste products from oil and gas drilling may pose a threat to water and soil quality (Namuyondo, 2014). It is thought that the narcotic effects of dynamite explosions in aquatic habitats, as well as the death of fish as well as other fauna creatures, are real (Olujimi et al., 2011). As dynamite firing during seismic surveys destabilizes sedimentary strata, the water turbidity may also rise (Mogborukor & Phil, 2014). In the context involving oil and gas exploration, the principal source of water pollution is the waste materials produced (Ezekwe et al., 2014). Many waste products are generated during oil and gas prospecting during drilling. Drilling fluids tainted drill cuttings, formation water, spilled drilling fluids, and other related waste items may pollute water bodies and the soil if they are not adequately managed. (Mbithe, 2016).

A major source of waste in the oil and gas industry is drilling fluid pollution. Drilling mud today has a complex structure that can vary greatly not just from one location to the next but also from one depth to the next inside a single well (Shadizadeh & Zoveidavianpoor, 2010). According to Mbithe (2016), drilling fluids can be classified either as synthetic-based, oil-based, or water-based. According to Behnamanhar (2014), saltwater or fresh water can be utilized to make water-based fluids, which are commonly used. They're a little pricey, but they're mainly employed in the upper parts of the well-drilling process. Drilling in water-sensitive formations or at high temperatures, or to avoid drilling bit rust, calls for oil-based fluids (Katarina et al., 2006). Polynuclear aromatic hydrocarbons are absent from synthetic muds, making them safer, disintegrating faster, and bio accumulating less than oil-based muds (Neff et al., 2000). During exploration, cuttings are removed from the face of the drill, the drill bit is greased, and the hydrostatic pressure is maintained throughout (Gbedebo, 2010).

There are four main components of drilling fluids, according to Devold (2013). They're the oil- or water-based liquids, and the reactive solids that help with density and viscosity. Bentonite clay is a common type of reactive solid in systems like these. In order to keep the pressure in the well constant, inert particles are used as a weighing agent. The physical, chemical, and biological properties of the drilling fluids can be controlled by the application of additives. They contain lime and caustic soda to manage the PH as well as other conditioning reagents that include starches, emulsifiers, lubricants and organic polymers as well as surfactants, detergents and salts. (Mbithe, 2016). Drilling muds contain harmful compounds that must be properly managed to maintain the long-term sustainability of the environment (Eze et al., 2015). To put it another way: Drilling fluids are responsible for around 4 percent of all oil drilling waste.

Other byproducts of exploration drilling include drill cuttings. To put it another way, drill cuttings are made up of little pieces of rock that were generated when the drill bit sank into the rock and drilled farther into it. The texture, size, and shape of these small rock fragments can vary greatly depending on the type of drill bit used and the underlying rock material (Balgobin, 2012). Pumping out the produced cuttings from the well is made possible by drilling mud running down the drill pipe within the drill string (Vaughan, 2012). Through the holes in the drill bit, Devold (2013) states that drilling mud Is suspended in the annulus and is brought to the surface by gravity and subsequently sedimented in the buffer pit due to gravity. Drill cuttings make up the majority of drilling waste, and appropriate management is essential to ensuring a sustainable environmental management strategy" (Onwukwe & Nwakaudu, 2012). Drilling waste includes produced waters as well as other byproducts. A combination of drilling site saline water with radionuclides and benzene resulted in this water (Sumi, 2005). In order for crude oil and gas to be delivered via pipelines, water must be removed, according to Arthur et al (2005). Produced water accounts for the majority of waste water generated by oil and gas extraction. Waste chemicals from drilling operations, as well as any other items purposely introduced to the drilling fluids, are disposed of in the reserve pit (Al-haleem *et al.,* 2013).

Toxic metals, hydrocarbons, and salts make up the bulk of drilling waste, and their inadequate disposal on land or water can lead to environmental damage (Al-haleem et al., 2013). Toxic metals in drill wastes arise from naturally occurring deposits that fuse with waste during drilling, whereas others originate from additives (Mutua, 2016). Select heavy metals such as barium and chromium from chrome-lignosulfonate deflocculates have historically been the most commonly discovered (Zoveidavianpoor et al., 2012). It is often crushed into small symmetrical particles prior to its usage in the fluid as a weighing agent, according to Odari et al., (2015). In addition to the Barites, several metals will be present because of the contaminations. Zinc, Copper, Lead, and Nickel, concentrations in drill waste were found to be higher than those found in naturally occurring metals. Drilling fluid contaminated with heavy metals can be traced back to significant levels of contaminants in the drilling mud.

Chromium, a constituent of mud additives and primarily of Chrome-based deflocculates, is another important component of heavy metal pollution. Chromium hexavalent, employed as a gel thinner, high-temperature stabilizer, biocide, and corrosion inhibitor, is extremely hazardous (Mutua, 2016). Lower arsenic, Cadmium, mercury, and zinc levels in drilling muds have been found (Rourke & Connolly, 2003). Heavy metals, according to Conant & Fadem (2012), do not just stay in the drilling waste; they also leak into the groundwater and soil, which is a major concern. Because they can't be broken down into non-hazardous forms, their contamination in any given biome is a potential permanent threat, which causes a great deal of concern (Adesodun, 2007). For both animals and humans, the most toxic heavy metals are Lead (Cadmium), Mercury (Mercury), Cadmium (Arsenic), Copper (Zinc), and Chromium (Lead). According to a study by Mahurpawar (2015), chronic exposure to mercury can cause symptoms such as weariness, weakness, anorexia, and problems with the digestive system. There can be a variety of symptoms, such as tremors in the fingers, eyelids, lips, and even the entire body, which can lead to hallucinations at high exposures. Mercury can also cause damage to the neurological system, kidneys, and liver. Chronic exposure to Lead can trigger toxic reactions in the nervous, hematological and renal systems, resulting in brain damage and seizures. This can lead to death. Animals have been shown to develop cancer as a result of lead exposure. Nickel exposure can cause respiratory tract diseases and allergic reactions, as well as cases of cancer and neurological breakdowns, and eventually death if the exposure continues for an extended period of time.

Cadmium can cause anemia, kidney failure, pulmonary emphysema, fractured bones, renal stones, stunted growth, respiratory tract diseases, cancer, joints and back discomfort, if ingested in excessive amounts. Iron can cause heart problems and respiratory infections if it is inhaled over a lengthy period of time. Some cancer cases have been linked to long-term exposure to hexavalent chromium in the respiratory tract. Lung cancer as well as skin diseases can also result from long-term exposure to high levels. Arsenic can cause digestive issues, pneumonia, peripheral neuropathy, weakening of the skin and damage to the kidneys and the nerves if exposed for a long time. (Mbithe, 2016).

Salts are another unpleasant component of drilling waste when it comes time to dispose of it. In the words of Al-haleem et al. (2013), the discharge of trash containing high salt concentrations can have a devastating effect on aquatic ecosystems. High concentrations of Sodium Chloride might interfere with the development of embryos and fetuses and may result in fetal mortality. In addition, it can impair bone growth and irritate the eyes, skin, and respiratory system (Bakke et al., 2013). Plant and vegetation growth can be harmed by salts, according to Asche & Lead (2013), since they alter soil pH and other physical and chemical structures in the soil. In addition to hazardous trash, hydrocarbons are difficult to dispose of (Onwukwe, & Nwakaudu, 2012). A hydrocarbon-bearing deposit or pollution from oil-based drilling muds can lead to hydrocarbons in drilling waste, according to Devold (2012). The higher the concentration of hydrocarbons in the well, the deeper it is (Balgobin, 2012). Polyaromatics, Cycloparaffins, and Aromatics are some of the different types of hydrocarbon groups (Al-haleem et al., 2013). When hydrocarbons are inhaled, cutaneous contact, or ingested by humans, they have an adverse effect on their health, according to Abdel-Shafy & Mansour (2016). This effect is dependent on the method of exposure. This can cause tongue, throat and stomach irritation or possibly harm to the digestive systems in the short term. Abnormal cardiac rhythms, liver, kidney, or digestive system harm are all possible long-term effects of ingesting certain foods. Long-term exposure to benzenes can lead to serious blood diseases, whereas exposure to some PAHs can lead to skin cancer, lung problems, and other problems throughout the body with prolonged exposure (Sheehan & McDonagh, 2008). According to Okoro et al. (2006), inhaling hydrocarbons can cause throat, lungs and nose irritation, headaches, dizziness and muscle weakness, as well as liver and renal damage. Suffocating plants with air and interfering with their metabolic processes like photosynthesis, respiration and expulsion are known side effects of hydrocarbons (Rusin *et al.,* 2015).

Fig 2: Oil spill on Agricultural land (Eze et al., 2015)

2.1.4 Managing Waste from crude oil Drilling Operations

Activities related to waste management include those that ensure that waste does not harm humans or other organisms in general by ensuring that waste is properly handled and disposed of (Garcia, 2011). Due to the variety of activities that oil and gas operations typically entail, waste management is critical for the industry. These activities, which can include everything from exploration and drilling to construction and production to the availability of messing facilities and transportation and communication, generate a variety of types of waste that must be properly managed to avoid harmful environmental effects when released (Cirnat and Chirila, 2007).

The processes of Waste Management in crude oil Drilling Operation is typically managed in four distinct ways, each based on globally recognized rules and aimed at ensuring long-term sustainability. These waste management alternatives include: Recovery/reuse, Recycling/material recovering, Energy recovery/incineration and Disposition in land fields (land fillings). (Garcia, 2014)

2.1.5 Challenges of Managing Waste in crude oil Drilling Operations

The following are some of the difficulties associated with garbage management:

1. Waste management systems that do not meet international standards or industry standards (Fletcher & Hewett, 2014).
2. Ineffective waste removal or discharge processes planned (Fletcher & Hewett, 2014);
3. Laws, rules, and regulations addressing waste management that are not properly rooted (Byarugaba & Ssenyonjo, 2016).

2 1.6 Benefits of Managing Waste in crude oil Drilling Operations

For the health and well-being of humans, the environment and biodiversity, good waste management is essential in oil and gas production activities (Derefaka, 2014). In addition to reducing legal and financial responsibilities for both the government and the oil and gas industry, proper waste management reduces reputation concerns for oil and gas corporations (Derefaka, 2014). The resources that could otherwise be used to mitigate the consequences of poor waste management can instead be put to good use in the development of a nation's infrastructure. Effective waste management offers a plethora of advantages, necessitating the development of long-term solutions.

2.2 Nigerian crude oil industry and its Drilling Operations

Awodola (1997) listed environmental pollution as second only to economic depression as one of the world's most pressing issues, and this is because it has a devastating impact on people 's health and biodiversity. Tyonongo (2008) asserts that "environmental degradation is crucial since the ability of the environment to maintain and sustain life depends on the right natural balance of its components; soil, water, air, plants and animals."

Study after study has shown that the petroleum industry around the world is a third-party contributor to environmental deterioration. This is because oil extraction activities discharge toxic elements into the environment, such as greenhouse gases, toxic and carcinogenic compounds.

Gas flaring, which includes the burning of related gas as a byproduct of crude oil recovery from oil wells in the course of exploration, is one main source of environmental pollution in the Niger Delta. Due to the fact that associated gas is frequently deemed uneconomical to reclaim by oil firms, they flare or release it into the atmosphere, resulting in acid rain that harms the ecosystem and kills fish. Because of this, waterways have been contaminated, wildlife and plants have been decimated, soils and vegetation have been degraded, and the environment as a whole has suffered. Acid rain is also released resulting from the gas flaring activities in the region of the Niger Delta, causing the soil to become unsuitable for cultivation. Natural environment, humanity, and wildlife are all harmed by Niger Delta gas flaring, according to (Nenibarini, 2004), who claims that gas flaring contains over 250 pollutants.

Oil and gas extraction in the Niger – delta region has also resulted in water pollution. People consider water to have been polluted when it loses some or all of its usefulness as a result of man's activities in all or some of the ways it would have been useful in the natural form (Helmer, 1975). In addition to harming humans and animals, polluted water often alters the natural ecology, which has far-reaching consequences for the rest of the planet. Oil and gas extraction, development and refinement, tank washing, effluent discharge and transportation are among the activities of these companies. In the majority of situations, the garbage generated by these operations winds up in waterways. Water contamination in the Niger – delta region is mostly caused by oil spills and drilling fluids, since oil and water cannot be separated. A number of old oil platforms and installations, such as pipes, rupture, leaking oil into the neighboring area. Pipes and valves that leak and spill pollute streams, making them unsuitable for use in agriculture and other industries.

Besides oil drilling and handling, further oil exploration as well as exploiting dangers on the ecosystem are also created by the exhaust fumes emitted into the environment by the eventual users of the product of the industry or by its sheer unprotected presence. (Egwu, 2012). It is because oil exploration and exploitative activities in the Niger – delta has continued notwithstanding the presence of regulatory frameworks that Nigeria has been a central point in scholarly endeavors on how oil- and gas-related activities might lead to environmental deterioration. Several studies, such as Nwilo & Badejo, (2004) have argued in support of this position, pointing out that the Niger Delta is a hot topic when it comes to environmental degradation because of the region's history of crude oil exploration, exploitation, and related operations in Nigeria's Niger Delta. Examples of environmental destruction include polluting already-existing bodies of water, destroying natural vegetation and faunal ecosystems, endangering aquatic life, destroying agriculture and water bodies, causing property damage or even resulting in the death of people among others (NDES, 1997).

*Corresponding Author: XXXX

Degradation of the ecosystem in the Niger – delta region is a clear example of the harmful influence that human activities, such as petroleum extraction, have on the natural environment. Although Nigeria has environmental regulations, the problem persists despite the fact that the environment has been degraded. Egwu (2012) lays the burden for environmental degradation squarely on the shoulders of oil exploration and exploitation companies/multinational businesses present in the Niger Delta, arguing that these companies' unethical behavior cannot be separated from environmental deterioration. There is a severe degradation of the environment as the result of many of these practices not complying with environmental laws and principles and practices of environmental management. Scholarly interest in Nigeria's environmental laws has grown as a result of this. Environmental protections in Nigeria have long been criticized for their lack of effectiveness in preventing environmental degradation.

2.2.1 Current scenario of compliance procedures in managing waste in the Nigerian crude oil industry

Since the 1960s, Nigeria has implemented a variety of environmental rules and regulations that govern management of waste and the avoidance of dangerous industrial wastes from being released into the environment. In addition to safeguarding the environment against degradation caused by the discharge of hazardous wastes, such legal frameworks are also implemented to ban actions that exacerbate damage to the environment (Adamu, 2012). It has been shown that most waste management regulations are essentially useless. The same can be said for some aspects of these regulations, which can be difficult to identify as either preventative or precautionary. Lawmakers in Nigeria have fallen far short of their responsibilities when it comes to enforcing these rules and ensuring that they are followed (Adamu, 2012). As a result of this situation, Nigeria finds itself in a difficult position when it comes to enforcing protocols for achieving sustainability in waste management (Fagbohun, 2010).

2.2.2 Challenges facing the Country for Compliance

Although Nigeria has taken significant measures to create effective environmental safety strategies and guidelines, there have been numerous recorded cases of environmental violations in the course of oil and gas exploitation operations in the Niger-Delta, which represents nearly all of the oil and natural gas platforms as well as installations. Additionally, there is a lack of effective adherence on the part of the multinationals and enterprises engaged. The following are some of the most significant roadblocks to the country's environmental regulations. (Mbithe, 2016).

2.2.3 The Need for an Alternative Approach in detecting crude oil spillage

Nigerian Oil Spill Monitor (NOSM), an arm of the National Oil Spill Detection and Response Agency (NOSDRA) are in charge of detecting oil spillage in Nigeria. NOSDRA was established in 2006 as an institutional framework to co-ordinate the implementation of the National Oil Spill Contingency Plan (NOSCP) for Nigeria. All throughout the world, environmental destruction and pollution have received significant attention, with efficient waste management taking the lead. The oil and gas sector has received the most attention since it is claimed to be responsible for a large portion of the environmental damage caused by faulty waste management laws and policies. Internationally recognized requirements such as ISO 14001 EMS (environmental management standards) are typically advised to enable proper waste management that will allow for sustainable growth because waste management is a worldwide problem (Cheremisinoff, 2006).

There is need for alternative approach in crude oil spillage detection because the available methods are inefficient and not effective. The alternative approach such as the use of dynamic drone device will help determine the presence and levels of total petroleum hydrocarbon content in soils during actual spillage especially as it affects agricultural production.

Nigeria could benefit from an improved waste management system, such as one based on the internationally recognized ISO 14001 EMS (environmental management standards), which incorporates environmental best practices into operational processes. Oil and gas waste management standards have long been internationally acknowledged, especially in the absence of universally accepted regulatory guidelines for how oil and gas businesses should manage and control waste disposal. It is common knowledge that multinational corporations should adhere to these guidelines when running their businesses and disposing of their garbage. For the oil and gas business, ISO 14001 Environmental Management Standards are especially recommended since they include standards that promote best practices (Cheremisinoff, 2006).

*Corresponding Author: XXXX

Due to the oil and gas industry's global reputation as a major generator of trash, ensuring that multinational organizations and firms operating within it comply with environmental requirements has become imperative. Not effectively managing these wastes can have substantial negative impacts on the environment, especially on the health and well-being of the people who live near oil rigs and facilities. In Nigeria, there have been several instances of environmental damage caused by inappropriate trash disposal (Nenibarini, 2004). The Niger Delta's environment and biodiversity have been negatively affected by oil and gas waste despite several academic studies and recommendations on how to properly manage garbage (Adekola & Mitchell, 2011). A sustainable waste management strategy that adheres to internationally recognized norms and practices while emphasizing best practices is therefore imperative given the current state of waste management in the country (Cheremisinoff, 2006).

2.3 Oil spill monitoring system

To monitor oil spill, several technologies have been developed to do this. The inbuilt sensors or satellites help in proper detection and surveillance during crude oil monitoring

2.3.1 Sensors

Visual sensors

Despite many shortcomings, passive sensors that operate in the visible region of the light are still used in oil spill remote sensing. The effect of some environmental conditions such as sun glint and wind sheen would lead to a misinterpretation by creating a resemblance to oil sheens, which is considered a limitation of such sensors (Jha et al., 2008). Another drawback is that visual sensors cannot operate at night because they are using sunlight reflectance for operation. In addition, they require cloudless and clear weather requirements. Given the limitations of visual sensors for oil spill detection, and since they are not able to provide thickness information or oil classification, these sensors are not used alone for oil spill monitoring. However, this method cannot be fully automated and requires human intervention to set a proper threshold for feature extraction. Optical sensors are rather used to document the spill and to provide a frame of reference for other sensors (Fingas and Brown, 2017)

Infrared sensors

Infrared passive sensors are relatively cheap remote-sensing technologies that can be used to detect oil spills. The emissivity of the oil in the thermal infrared red region is lower than the emissivity of the water. This is how the thick oil could be distinguished from the background water by absorbing the infrared radiation from the sun and appearing as a hot spot compared with the cold background for the water (Jha et al., 2008). An opposite phenomenon is observed during the night when the heat loss from the oil layer is faster compared with the water. This is the reason why they appear cooler at night. However, false-positive results could be obtained by misinterpreting the thermal radiation from seaweeds. In addition, infrared sensors require the absence of cloud and heavy fog for good operation (Fingas, 2018). Infrared sensors can detect oil films with 10s–100 s um thickness. However, the brightness of the infrared sensing-based imagery does not vary with slick thicknesses in the mm range. Therefore, we cannot rely on infrared sensors to yield slick thickness measurements (Chih and Andrews, 2008)

Ultraviolet sensors

Very thin oil films have a strong reflectance in the ultraviolet region compared with seawater. This allows the use of ultraviolet sensors for oil spill detection when the thickness is not greater than 10 um. Also, look-alikes such as sun glints, wind slicks, and biogenic material challenge ultraviolet sensors for oil spill detection. Jha et al., (2008) proposed adaptive thresholding for chemical spill detection (not oil specifically) from ultraviolet images, which shows a distinction between the chemicals and the water background. They used ultraviolet range for remote detection of hydrocarbons such as benzene. Generally, fewer ultraviolet sensors are being used for oil spills in today's remote sensing because of the low relevance of thin slicks to oil spill clean-up (Fingas and Brown, 2017).

Passive microwave radiometer sensors

Compared with water, the oil emits stronger microwave radiation and appears brighter in the background. Passive microwave radiometers are used for both oil spill detection and thickness estimation. The need to acquire knowledge about weather conditions, the low spatial resolution of this sensor, and the a-priori knowledge required about the oil characteristics all influence the microwave brightness and decrease the effectiveness of microwave radiometers for oil spill monitoring (Jha et al., 2008). Furthermore, the main issue with this technology tends to be the cyclical relationship between the microwave brightness of the slick and its thickness. Currently, available models can only measure limited thickness ranges. Given the requirement of a dedicated aircraft to mount this sensor, in addition to their high cost, it is complicated to put them into operation. Currently, the microwave sensor is not being used for oil detection and slick imaging (Fingas and Brown, 2017).

Radar sensors

With the absence of oil slicks, a bright image is obtained by radar sensors for clean seawater. Once the oil is spilled into seawater, the ocean capillary waves are reduced, and radar reflections are decreasing. Dark spots are obtained in radar imaging. This allows for oil spill detection (Hollinger and Mennella, 2013). Synthetic aperture radar (SAR) and side-looking airborne radar (SLAR) are the two most common types of radar, which are used for oil spill remote sensing. Imaging SAR systems are off-nadir instruments whose backscattering over the ocean is primarily due to Bragg scattering at relevant incident angles. (Hollinger and Mennella, 2013). The synthetic aperture radar technique is highly prone to false targets, however, and is limited to a narrow range of wind speeds when small ocean waves do not yield a difference between the oiled area and the sea. SAR techniques are not used for oil thickness estimations nor for oil classification. Being widely mounted on space-borne platforms, the radar is a very useful active sensor for a synoptic view of the oil spill over a wide scene (Jha et al., 2008).

2.3.2 Platforms: Satellites to complementary drones

Most recent techniques using one sensor, or a combination of sensors, are done remotely using satellites systems. Radar satellites provide a selection of resolutions and polarizations. Serious efforts have been made to replace airborne remote sensing with satellite remote sensing. However, satellites face the limitations of overpass frequency and low spatial resolution, and the long time required for processing the dataset, potentially disrupting oil spill contingency planning (Xu et al., 2016). This limitation has been improved using satellite constellations.

A combination of satellite and airborne sensors is used in many countries in northern Europe for oil spill surveillance. The strategic planning is based on satellite imagery that provides a synoptic view of the oil spill, whereas airborne sensors are used for short-term or tactical responses. Contrarily to visible and radar sensors, due to the high atmospheric absorption and scattering, many sensors including the infrared and the fluoro-sensors are not suitable to be operated on a space-borne platform (Fingas and Brown, 2017).

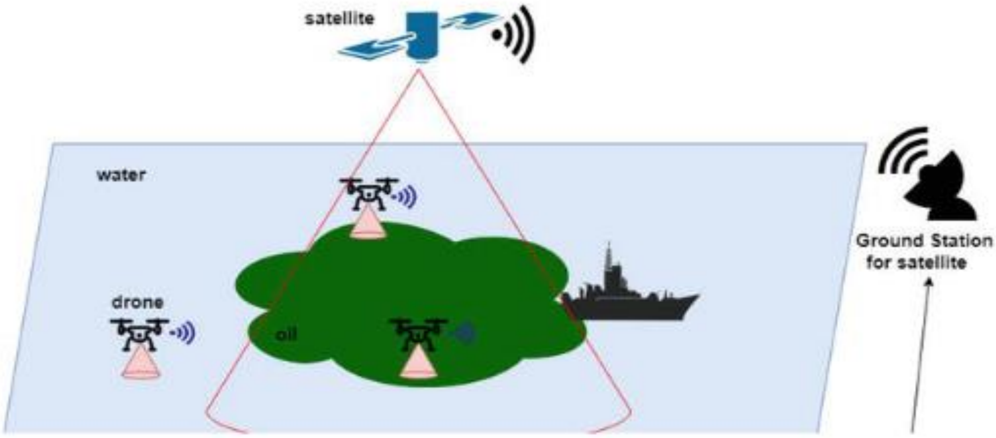

Fig 3: Satellite based drone (Xu et al., 2016).

Despite all the effort done using space-borne platforms, only 25% of the pollution cases are detected by satellite systems. For a quick response and rapid intervention, the European Maritime Safety Agency (EMSA) has proposed using drones as complementary systems in satellite maritime surveillance. Aerial surveillance could be improved significantly through the introduction of drones because it is a quick assessment tool for oil spill accidents. In addition, drone-based tools will be particularly valuable as it provides high spectral resolution, at a relatively low cost (Barenboim et al., 2015).

2.4 Features for good monitoring

Once a spill occurs, the oil will spread quickly on the water surface to form oil layers such as slicks, films, and sheens. To alleviate the severity of oil spills and promptly react to such incidents, it is crucial to have oil-spill monitoring systems that enable an effective contingency plan. A rapid response time and a quick intervention allow dictating the best actions to deal with oil spills. Therefore, monitoring systems must perform several functionalities and provide valuable information to contain the damage. (Saleem et al., 2021). According to Saleem et al., (2021), in crude oil detection, the following processes are paramount:

Oil-spill detection

The most important part during oil spills is to detect oil slicks. It is important to locate them and to determine how large the spread is. This necessary information allows oil spill mapping for both tactical and strategic countermeasures.

Oil-thickness estimation

The thickness distribution of spilled oil is another critical information for spill containment. Using the knowledge about the oil thickness, an estimation of the total volume spilled can be performed so that adequate tools are used in clean-up operations.

Oil classification

Classifying the oil type is also important during spill containment. Based on this information, the authorities estimate the environmental damage in the short- and long term to take appropriate response activities.

Oil-spill tracking

Since the spill can spread quickly within a few hours, an effective contingency plan demands the ability to track the spill over time. Tracking provides timely and valuable information to anticipate possible damage scenarios, predict the trajectory using additional input from weather forecasts, and assist in clean-up operations. This allows for selecting properly the sensor and the platform. In addition, suitable and effective algorithms could be developed.

However, the following features are important qualities of a good monitoring device according to Jha et al., (2008).

Spatial resolution: it is an important characteristic of the sensor that affects the accuracy in mapping oil slicks with accurate thickness measurements.

Quick response: oil spill surveillance requires an acceptable time frame for collecting and processing the data, which stresses the need for real-time data availability.

Day-time conditions: the operation of the sensor at any time during the day and night is essential for an effective surveillance system.

weather conditions: it is important to limit the effects of weather conditions including rain and fog.

Large-scale view: the sensor that captures a synoptic view of the area allows monitoring over a large spill spread.

Cost and size: the acceptable size and cost of the sensor are critical to decreasing the overall cost of the system.

2.5 A review of Dynamic drone device

A dynamic drone is a flying robot that can be remotely controlled or fly autonomously using software-controlled flight plans in its embedded systems. UAV drones are equipped with different state of the art technology such as infrared cameras, GPS and laser. (Daou et al., 2021). These features are good at surveillance and can help detect oil spillage. Using drones for in Agriculture can increase the accuracy of field data and save time as well. Drones not only send 2D view of earth but also can collect point clouds for 3D for physical and man-made objects easily and rapidly. (Huo et al., 2017). Obtaining precise and appropriate data on land and water bodies are a pre-requisite for making effective and timely economic and strategic plans in a densely populated country such as Nigeria. Therefore, use of Drones, now has become an important part of national planning and development schemes for the country. (Huo et al., 2017).

Fig 4: A dynamic drone device (Yadav et al., 2013).

2.5.1 Working Principle of Drone and Flow Pattern

The subject of Fluid dynamics plays a significant role in the design and development of aircraft and drones. This consists of the working principle of the aerodynamics of aircraft. A sufficient amount of upward force is required to lift the vehicle against gravity which is named Lift. A force created to move the vehicle or body in motion is called thrust. These forces can be studied using the kinematic laws of fluid flows. When air flows over an aerofoil and pressure, viscous and drag force act on the profiles (Yadav et al., 2013).

Force is directly proportional to the velocity of air at the inlet. The flow pattern around the cross-section of the aerofoil or propeller is shown below. High fluid pressure at the bottom and low pressure at the top of the propeller causes an upward force which is called a lift. This force is responsible for lifting the weight of an aero-plane or drone. (Huo et al., 2017). The amount of lift force depends on the angle of inclination of the aerofoil or propeller. Based on the principle of conservation of energy in fluid flow (Bernoulli's principle, the sum of all forms of energy in a fluid is constant along the streamline. (Jiang et al., 2021), When air flows over an aerofoil or wing, its velocity increases at the top portion. But the pressure of air decreases. In contrast, the air velocity decreases and pressure increase at the bottom side of the blade. The next pressure difference across the aerofoil results in an upward force which is called a lift (Huo et al., 2017).

2.5.2 Major Components of a dynamic Drone

According to Jiang et al., (2021), a dynamic drone is made up of different parts. These parts are important during the assembly stage in dynamic drone development. They include:

The Frame: It should have sufficient strength to hold the propeller momentum and additional weight for motors and cameras. It should be Sturdy and less aerodynamic resistance.

Propellers: The speed and load lifting ability of a drone depends on shape, size, and number of propellors**.** The long propellors create huge thrust to carry heavy loads at a low speed (RPM) and less sensitive to change the speed of rotation**.** Short propellors carry fewer loads. They change rotation speeds quickly and require a high speed for more thrust.

Motor: Both motors brushless and brushed type can be used for drones. A brushed motor is less expensive and useful for small-sized drones. Brushless type motors are powerful and energy very efficient. But they need Electronic Speed Controller (ESC) to control their speed. These brushless motors are widely used for racing freestyle drones, traffic surveys and aerial photography drones.

ESC (Electronic Speed Controller): ESC is used to connect the battery to the electric motor for the power supply**.** It converts the signal from the flight controller to the revolution per minted (RPM) of motor**.** ESC is provided to each y motor of the drone

Flight Controller (FC): It is the computer processor which manages balance and telecommunication controls using different transmitter**.** Sensors are located in this unit for the accelerometer, barometer, magnetometer, gyrometer and GPS. The distance measurement can be carried out by an ultrasound sensor.

Others such as the Radio Transmitter sends the radio signal to ESC to pilot to control motor speed, the Radio Receiver receives the signal from the pilot. This device is attached to the quadcopter and the Battery (High-power capacity, Lithium Polymer (LiPo)) is used for most dynamic drones.

Fig 5: Basic components of a drone device (Yadav et al., 2013).

2.5.3 Development of a Dynamic Drone

The working principle of drones is similar to the flying of aero-planes. The vertical lift force is created due to pressure difference across the rotating blades. The drag and gravity forces act against its vertical motions. By controlling the speed and directions of different rotors we can control the motion of the drone or UAV. Drone consist of mechanical, electrical, and electronic components all of which perform a strategic function on the drone. (Hensley et al., 2012)

The Payload of drone, Number and speed of propellors, Aerodynamics of propellors, spacing between the propellors, lift coefficient of drone, the thrust generated by the drone decide the aerodynamic design of the drone. CFD modeling will help to optimize the aerodynamics and applications of drone. (Laneve and Luciani, 2015)

Additionally, different types of drones, including fixed-wing, rotary-wing, and flapping-wing systems, can be developed. Furthermore, various environments where drones can be deployed are considered, such as aerial, underwater, marine, and space. Modeling, analysis, and discussions on the bioinspiration and biomimicry side of drones are also appreciated in order to better understand the locomotion of biological systems and their effectiveness. (Yadav et al., 2013). To reach optimal efficiency and endurance, aerodynamic, structural, fluid–structure interaction modeling should be performed analytically, numerically, or experimentally during development. (Laneve and Luciani, 2015). The primary stages of development include the modelling of the drone to give it a definitive design, the assembly of its different parts and the configuration of the drone. During the configuration, the drone is programmed to do specific jobs including getting a 3D image of agricultural lands which can be very useful in surveillance during oil spillage monitoring (Hensley et al., 2012).

*Corresponding Author: XXXX

Fig 6: Development of a drone device (Laneve and Luciani, 2015).

2.5.4 The benefits of development of dynamic drone devices for crude oil spillage detection

Over the years, several approaches have been developed to detect and monitor crude oil spillage in Agricultural lands. Most of these methods proved futile with an increasing report of oil spillage in Nigeria today. The dynamic drone device has the ability to determine the presence and levels of total petroleum hydrocarbons in soil during actual spillage into the Agricultural lands. It has the ability to give an estimate of affected agricultural lands thereby facilitating remediation and recovery. In this same way, the effect of oil spillage on plant life can be determined.

Initially, agriculture utilized drone technology for chemical spraying, but today they are a fantastic tool for capturing aerial imagery with platform-mounted cameras and sensors. Images can range from straightforward visible-light photographs to multispectral imagery that users can use to evaluate various activities. (Goodman, 2014). Drone working in agriculture offers increased efficiency. It enables users to capture high-resolution imagery more quickly than other methods, especially in volatile conditions, estimate annual yield, help guide decisions and manage expectations, and perform activities that may not be simple to carry out on foot. Before discussing drone technology in sustainable agriculture, it would be prudent to define it. (Saleem et al., 2021). Sustainable agriculture comes in various ways, but ultimately it seeks to sustain farmers, resources, and communities by promoting profitable, environmentally friendly, and beneficial farming practices and methods. Insufficient or inappropriate policies, such as pricing, subsidy, and tax policies, have motivated the excessive and often uneconomical use of inputs such as fertilizers and pesticides. Still, with the advent of drone technology, farmers and experts can achieve sustainable agriculture much more quickly. (Goodman, 2014)

Aside from agriculture technology, drone security is a rapidly expanding industry highly beneficial to farm management. It will help curtail illegal oil drilling leading to oil spillage in the soil. Using drones to monitor remote areas of a farm without physically going there saves time and enables more frequent monitoring of inaccessible regions. Drone cameras can provide a daily overview of a farm's operations to ensure everything is running smoothly and locate any equipment in use. Instead of employing additional security personnel, security drones can monitor fencing and perimeters of more valuable crops and the soil. (Daou et al., 2021).

2.6 Theoretical Framework

2.6.1 Sustainable Livelihood Theory

This theory was used here to support each other in parts in which there is a gap that would promote the achievement of an approach to management and detection of oil spillage in Nigeria.

The Brundtland Commission proposed the concept of sustainable livelihoods for the first time in its 1986 World Commission on Environment and Development report. An international conference in 1992 called for sustainable livelihoods to be adopted as an overall objective in the fight against poverty (Krantz, 2001). Skills, activities, and resources necessary for making a living are included in a sustainable way of life according to Knutsson (2006). It is also important to maintain or increase one's capacity and assets today and in the future, without damaging the natural resource base, in order for a lifestyle to be considered sustainable. As stated by Morse et al. (2009), social, health, and educational aid are the primary building blocks of this strategy. There is a lack of water and grazing land, as well as security issues, which makes it difficult for residents to access their possessions. An international framework for sustainable livelihoods, represented in Figure 2, was employed in this study as a beginning point for the research. The asset portfolio, which is a sign of a person's basic means of subsistence; vulnerability context and policy; institutions and procedures; and the loop connecting a person's methods for subsistence with his or her actual results, according to the Department for International Development (2008)

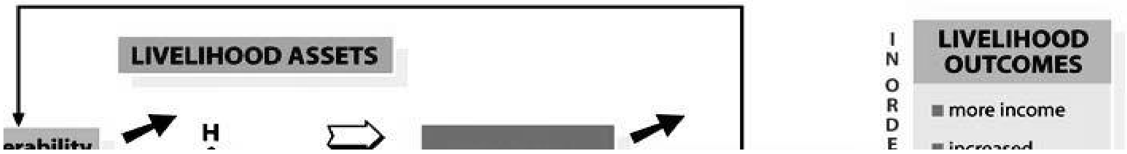

Figure 7: Sustainable Livelihood Framework (Source: DFID, 2008).

For this research, the Sustainable Livelihoods approach is a good fit because it clearly demonstrates the impact of various oil-related activities on specific livelihoods promoting activities like pastoralism or small-scale farming as well as other physical and social infrastructures in the oil drilling fields. There is a significant rate of residents giving up their traditional sources of income to work in the oil industry. In light of the oil industry's cyclical nature, the subject of the long-term viability of the local economy should constantly be on the table (Gyagri et al., 2017). Investment in infrastructure, water supplies, and urban growth have all resulted from oil and gas exploration as a result of corporate social responsibility from the investors (Lauwo et al., 2016). However, these studies failed to explore the sustainability principles of the first developments which come with these kinds of initiatives, a problem which this study investigated under the idea of sustainable livelihoods. An economic crisis could occur if local communities as well as investors do not have adequate policies in place to strengthen their capacity and educate them on the importance of diversifying their sources of income.

People participation and engagement, empowerment, and sustainability in resource and structure use are all part of the sustainable livelihoods approach's essential normative concepts for addressing community difficulties (Morse et al., 2009).

People-centered sustainable livelihood strategy, says Carney (2003), means that the focus should be on the livelihoods of poor people rather than the resources or services they utilize. It should empower the people and give them a voice in their own lives. This strategy also should be responsive and participative in order to encourage the active participation of individuals in identifying and addressing their own problems. Her final point is to emphasize the importance of incorporating economic, social and ecological sustainability into all aspects of the project. Ecologically sustainable management in the context of oil and gas exploration is one of the goals of this study, which aims to push the agenda outlined above among the oil field communities. In Nigeria's extractive oil industry, procedures must be put in place to achieve a balance between oil and gas exploration, management of people' livelihoods, and ecology.

2.7 Study Gap

Studies on the effect of crude oil spillage and its operations and its effect on sustainable management are growing in importance, not only because they provide the foundation for understanding the reprehensible activities of oil exploration, but also because they reveal the ideological and intellectual perspective of the connection between oil drilling operations and environmental degradation. In addition, understanding this aspect will provide ways in detection and monitoring of crude oil spillage in Nigeria.

According to Agbonibo (2015), a lot of emphasis has been paid to the economic benefits of oil, but little focus has been shone on the ecological ramifications, influence on pre-existing revenue sources that they have and ways to monitor the incessant crude oil spillage. To put it another way, damaged ecosystems affect people's income sources and lead to conflict as resources become more scarce and individuals seek recompense for the loss of their resources. (Kadafa & Ayuba, 2013). This study therefore highlights the ecological implication of crude oil spillage and provide advanced ways to detect and monitor them through the development of a dynamic drone device.

Kadafa & Ayub (2012) have found that there are numerous biophysical environmental issues, including land degradation, soil, air, and water pollution, poor waste management, as well as negative socioeconomic effects, like loss of livelihood perhaps because of the influx of people, loss of jobs, conflicts, crime, and environmental degradation. Sustainable environmental management is critical in Nigeria, although it has yet to be successfully addressed. A number of oil and gas drilling features have been addressed from the Nigerian perspective, but little attention has been paid to long-term maintenance performance, this study will therefore identify a modern and a possible life long process that can eliminate and monitor crude oil spillage especially in Agricultural farms today.

III. RESEARCH METHODOLOGY

3.1 Research Design

This research was a construction based experimental study design, involving a dynamic drone device for surveillance in Agricultural lands in Imo State and Rivers State. The device was constructed manually and tested quantitatively to generate results on Agricultural lands in Imo and Rivers State in order to detect crude oil spill in the location. The research made use of quantitative analysis of results generated through the primary data provided by direct collection of experimental results from the study location. The results were collected in such a way it will also answer the research questions. The quantitative method is an efficient and systematic way of collecting information based on individual and specific analysis of each sample in a numerical form permitting empirical investigation on various issues relating to the objectives of the study. (Murab, 2014).

3.2 Duration of study

The research lasted for a period of two months from December, 2021 till January, 2023.
During this period, the drone was constructed and experimented towards a technical assertion of the research.

3.3 Area of study

The area used for this research was Rivers State and Imo State. Imo State is a state in the South-East geopolitical zone of Nigeria, bordered to the north by Anambra State, Rivers State to the west and south, and Abia State to the east. Rivers State is a state in the Niger Delta region of southern Nigeria (Old Eastern Region). It is bounded by the states of Anambra and Imo on the north, Abia and Akwa Ibom on the east, and Bayelsa and Delta on the west. Imo State and Rivers state were selected as the study area because of the incidence of crude oil spillage in those areas which provided the location for the experiment.

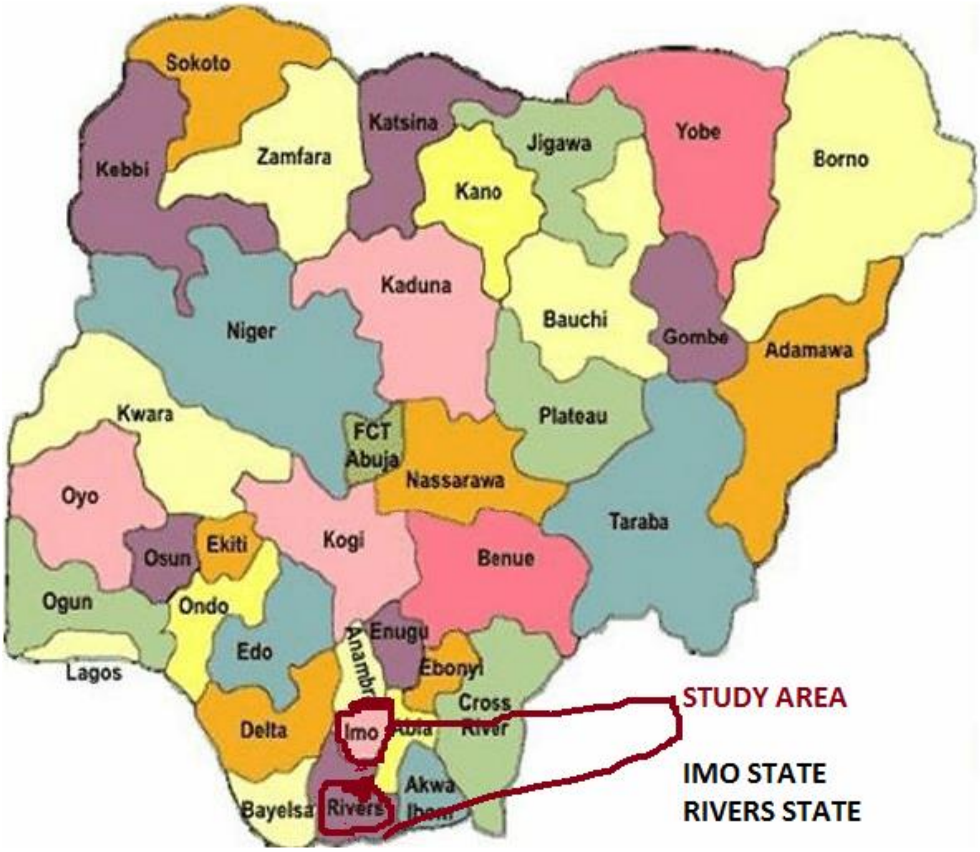

Fig 3.1: Map of Nigeria showing Imo and Rivers State.

3.4 Study Population

The target population for this study included the entire group of samples to which the results were generated. This include soil samples which were tested for the presence and levels of total petroleum hydrocarbon content, the drone and the plant which was tested to determine the impact of the crude oil spill on its lifespan. This means that the sample population were collected quantitatively which provided primary data for the research

3.5 Sample size

A total of 5 agricultural lands (3 in Rivers State, 2 in Imo State) was estimated, 10 plant samples (5 from each state) was also estimated.

Inclusion criteria

1. All selected Agricultural lands with crude oil spillage
2. Affected plants
3. Recently affected agricultural lands

Exclusion criteria

1. Soil from unaffected land
2. Lands outside Rivers and Imo State

3.6 Data selection

A dynamic drone was constructed specifically for detecting crude oil spill in selected Agricultural lands in Imo and River State. A four channel RC transmitter in the dynamic drone was used for the purpose of giving freedom to control throttle, pitch, roll and yaw individually. To obtain an accurate response set points and minimum and maximum ranges must be determined before transmission execution. The drone was taken to the affected agricultural land and positioned directly to the location with the aim of capturing affected areas with crude oil spills in both locations. At the end of the experiment, the data gotten were recorded and analysed with SPSS.

3.7 Ethical approval

The study was approved by the Department. Permission was obtained, confidentiality was kept. The benefit of this study was added to the literature in relation to the level of heavy metals in water, aquatic sediments and crabs in Lagos Lagoon.

3.8 Data collection method

A quantitative approach was used to collect primary data from the experiment. The quantitative research approach will explain the phenomena by collecting numerical data that are analyzed using mathematically based methods (Muijs, 2010). To collect the data, a dynamic drone was constructed after which it was used to collect data from various sites on crude oil spillage in Imo and Rivers State.

3.8.1 Materials used for the study

1. Hardware components (Frame, microcontroller, electronic speed controller)
2.Inertia measurement unit
3. The battery pack
4. Brushless motor
5. Gyroscope
6. Transmitter and receiver
7. Crude oil sample
8. Recording device and Camera
9. Agricultural lands
10. Measurement device

3.8.2 Construction of the dynamic drone

Fig 3.2 Overall hardware connection to the microcontroller

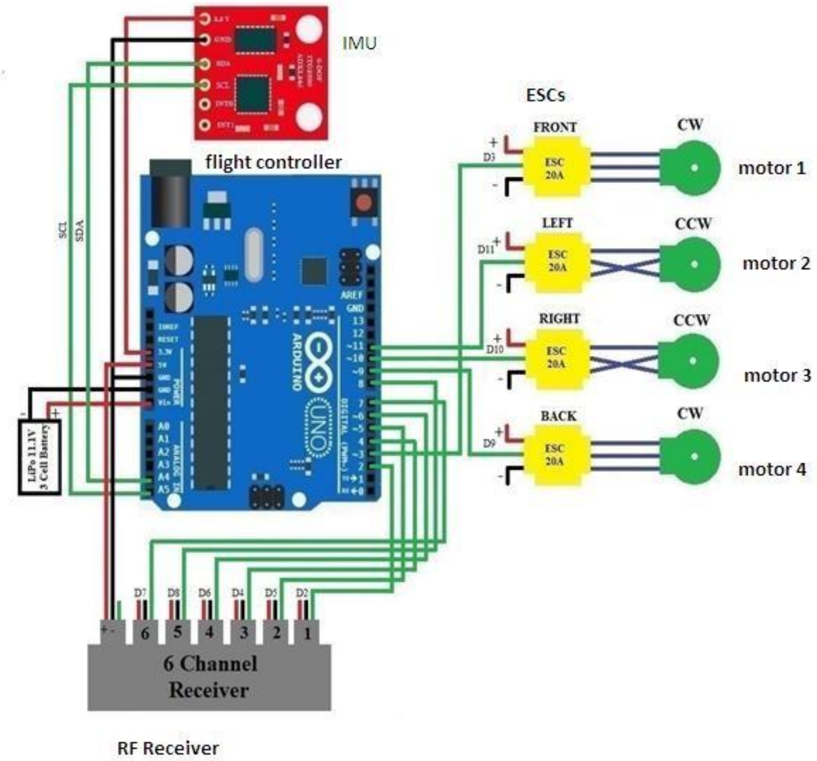

Figure : Overall Quadcopter hardware connection

4.2 Hardware Components

4.2.1 The Frame of the Quadcopter

Typical quad-rotors utilize a four-spar method, with each spar anchored to the central hub. The frame of the quad copter is composed of a combination of materials chosen for their strength, weight and flexibility.

When designing an autonomous quad-rotor, there are several material options which must be considered. When designing a machine capable of flight, weight must be greatly well thoughtout.

The airframe is the mechanical structure of an aircraft that supports all the components, much like a “skeleton” in Human Beings. Designing an airframe from scratch involves important concepts of physics, aerodynamics, materials engineering and manufacturing techniques to achieve certain performance, reliability and cost criteria.

The Microcontroller – Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

Figure 3.3: Arduino UNO Microcontroller Board

Electronic Speed Controllers

An electronic speed control or ESC is a circuit with the purpose to control an electric motor's speed, its direction and possibly also to act as a dynamic brake in some cases. ESCs are often used on electrically powered brushless motors essentially providing an electronicallygenerated three phase electric power, with a low voltage source.

An ESC interprets control information in a way that varies the switching rate of a network of field effect transistors (FETs), not as mechanical motion as would be the case of a servo. The quick switching of the transistors is what causes the motor itself to emanate its characteristic high-pitched whine, which is especially noticeable at lower speeds. It also allows much smoother and more precise variation of motor speeds in a far more efficient manner than the mechanical type with a resistive coil and moving arm once in common use.

The ESC generally accepts a nominal 50 Hz Pulse Width Modulation (PWM) servo input signal whose pulse width varies from 1ms to 2ms. When supplied with a 1ms width pulse at 50 Hz, the ESC responds by turning off the DC motor attached to its output. A 1.5ms pulse-width input signal results in a 50% duty cycle output signal that drives the motor at approximately 50% speed. When presented with 2.0ms input signal, the motor runs at full speed due to the 100% duty cycle (on constantly) output.

The correct phase varies with the motor rotation, controlled and monitored by the ESC. The orientation of the motor is determined by the back EMF (Electromotive Force). The back EMF is the voltage induced in a motor wire by the magnet spinning past its internal coils. Finally, a PID algorithm in the controller adjusts the PWM to maintain a constant RPM.

Reversing the motor's direction may also be accomplished by switching any two of the three leads from the ESC to the motor.

Ideally the ESC controller should be paired to the motor and rotor craft with the following considerations.

1. Temperature and thermal characteristics.
2. Max Current output and Impendence.
3. Needs to be Equipped with a BEC (Battery Eliminator Circuit) to eliminate the need of a second battery.
4. Size and Weight properties.
5. Magnet Rating.

Figure 3.4: 30A Brushless ESC

Additionally, the speed controller has fixed throttle settings so that the "stop" and "full throttle" points of all the various modes which can be cut through cleanly. The controller produces audible beeps to assist in navigating through the program modes and troubleshooting logs.

Table 3.1 : Specification for 30A Brushless ESC

30A Brushless ESC Output	**Continuous 30A, burst 40A up to 10 Sec**
Input voltage	2-4 cells lithium battery or 5-12 cells NiCd/NiMH battery
BEC	2A / 5V (Linear mode).
Max speed	210,000rpm for 2 poles BLM, 70,000rpm for 6 poles BLM, 35,000rpm for 12 poles BLM. (BLM: Brushless Motor
Size	45 * 24 * 11mm / 1.8 * 0.9 * 0.4in
Weight	25g / 0.9oz
Item total weight	480g / 1.06Lbs

Inertial Measurement Unit

Precision and accuracy is important when it comes to Accelerometer and gyroscope measurement. We require a 3-axis accelerometer and gyroscope that provides reliable and accurate data. It is also an advantage if they can be on the same chip. For this reason, we went with the MPU-600, which is a small, thin, ultralow power, 3-axis accelerometer and gyroscope. The device is very accurate, as it contains 16-bis analog to digital conversion hardware for each channel. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. The sensor has a "Digital motion processor" which can be programmed with firmware and is able to do complex calculations with the sensor values.

Figure 3.5: MPU6050 IMU used in our quadcopter

IMU interface with ARDUINO

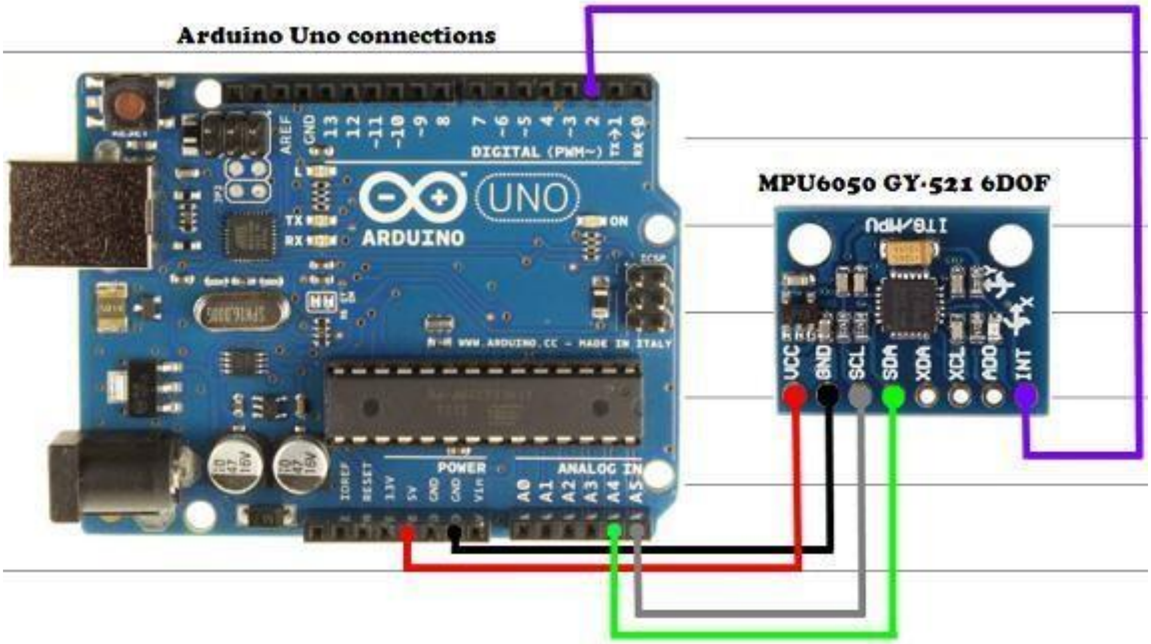

Figure 3.6: MPU6050 Interface with Arduino

The Battery Pack
Selecting the proper battery for our rotor copter was a challenging task. Nickel Cadmium (NiCd), Nickel Metal Hydride (NiMH), and Lithium Polymer (LiPo) were common choices with the advantages and disadvantages of each battery pack.
NiCd batteries are reasonably inexpensive, but they have a number of negatives. NiCd batteries need to be fully discharged after each use. If they aren't, they will not discharge to their full potential (capacity) on following discharge cycles, causing the cell to develop what's commonly referred to as a memory. Additionally, the capacity per weight (energy density) of NiCd cells is commonly less than NiMH or LiPo cell types as well. Finally, the Cadmium that is used in the cell is quite destructive to the environment, making disposal of NiCd cells an issue.
NiMH cells have many advantages over their NiCd counterparts. NiMH cell manufacturers are able to offer significantly higher capacities in cells approximately the same size and weight of equivalent NiCd cells. NiMH cells have an advantage when it comes to cell memory as well, as they do not develop the same issues as a result of inappropriate discharge care.
Lithium Polymer (LiPo) cells are one of the newest and most revolutionary battery cells Available. LiPo cells maintain a more consistent voltage over the discharge curve when compared to NiCd or NiMH cells. The higher nominal voltage of a single LiPo cell (3.7V vs. 1.2V for a typically NiCd or NiMH cell); making it possible to have an equivalent or even higher total nominal voltage in a much smaller package LiPo cells typically offer very high capacity for their weight, delivering upwards of twice the capacity for ½ the weight of comparable NiMH cells.
Lastly, a LiPo cell battery needs to be carefully monitored during charging since overcharging and the charging of a physically damaged or discharged cell can be a potential fire hazard and possibly even fatal.
LiPo Pro's:

- Highest power/weight ratio.
- Very low self-discharge.
- Less affected by low temperatures than some.

LiPo Con's:

- Intolerant of over-charging.
- Intolerant of over-discharging Battery.
- significant fire risk

Figure 3.7: 3S LiPo Battery

Table 3.2 : LiPo batteries 3S 11.1V 2600MAH 30C packs

Capacity	**2600mAh**
Configuration	3S1P
Dimensions	116X34X26mm
Weight	200g
Constant Discharge	30C
Burst Discharge	60C
Balance connector	ST-XHR
Discharge plug	T plug
Use	Vehicles & Remote-Control Toys
Material EVA	

The Brushless Motors

Each of the four rotors comprises of a Brushless DC Motor attached to a propeller. The Brushless motor differs from the conventional Brushed DC Motors in their concept essentially in that the commutation of the input voltage applied to the armature's circuit is done electronically, whereas in the latter, by a mechanical brush. As any rotating mechanical device, it suffers wear during operation, and as a consequence it has a shorter nominal life time than the newer Brushless motors.

In spite of the extra complexity in its electronic switching circuit, the brushless design offers several advantages over its counterpart, to name a few: higher torque/weight ratio, less operational noise, longer lifetime, less generation of electromagnetic interference and much more power per volume. Virtually limited only by its inherent heat generation, whose transfer to the outer environment usually occurs by conduction.

Figure 3.8 : A2212/13T 1000 KV BLDC (Brushless DC Motor)

Table 3.3 : Specifications of A2212 / 920 KV out runner motor

No. of Cells:	2 - 3 Li-Poly 6 - 10 NiCd/NiMH
Kv:	1000 RPM/V
Max Efficiency:	80%
Max Efficiency Current:	4 - 10A (>75%)
No Load Current:	0.5A @10V
Resistance:	0.090 ohms
Max Current:	13A for 60S
Max Watts:	150W
Weight:	52.7 g / 1.86 oz.
Size:	28 mm diameter x 28 mm bell length
Shaft Diameter:	3.2 mm
Poles:	14
Model Weight:	300 - 800g / 10.5 - 28.2 oz.

Propellers

Propeller is a set of rotating blades design to convert the power (torque) of the Engine in to thrust. The Quadrotor consists of four propellers coupled to the brushless motor. Among These four propellers, two clockwise and the remaining other two are counter clockwise. Clockwise and anticlockwise propellers cancel their torque from each other. Propellers are specified by their diameter and pitch. The propeller used is 1045 Fixed-pitch, symmetric, tapered Normal Rotation Carbon Fiber Propeller, shown in (figure):

Figure 3.9: 1045 fixed-pitch, Carbon fiber Propeller

Software Implementation

Quadcopter Flowchart

The operation flow of the quadcopter is illustrated in figure below demonstrating steps at which quadcopter flows in order to fly and satisfy pilot commands.

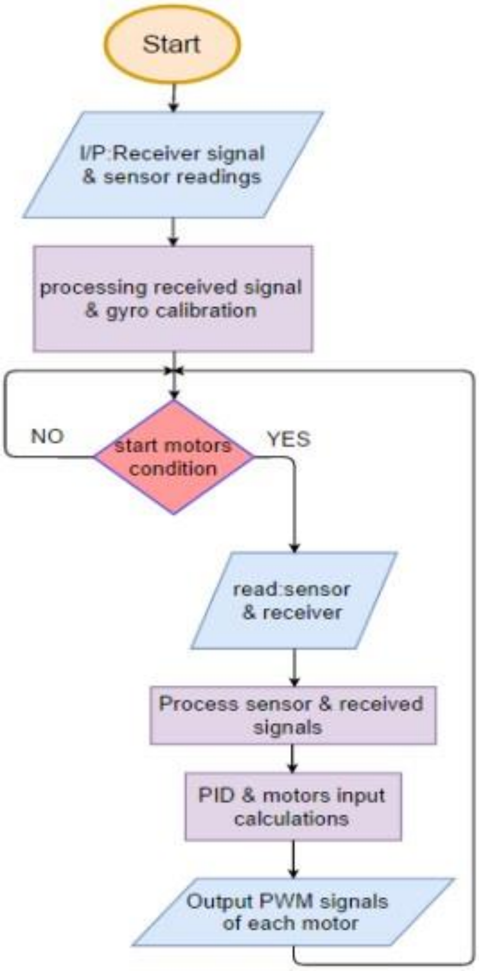

Figure 3.10: Quadcopter flow chart

Transmitter and Receiver

A four channel RC transmitter is used for the purpose of giving freedom to control throttle, pitch, roll and yaw individually. To obtain an accurate response set points and minimum and maximum ranges must be determined before transmission execution.

Since the main loop of the code executes sequentially - one line at a time- an interrupt needs to occur enabling receiving signals transmitted from the RC; Arduino allows pins to allow interrupt only if the interrupt for a specific pin was declared in the code.

Before declaring the interrupt pins, interrupt mode must be activated through the following syntax:

```
PCICR |= (1 << PCIE0);
```

After enabling interrupt mode four pins are declared as receiver interrupt pins each for each channel of the transmitter, the pins being Arduino pins 8, 9,10 and 11 declared as following:

```
PCMSK0 |= (1 << PCINT0);
PCMSK0 |= (1 << PCINT1);
PCMSK0 |= (1 << PCINT2);
PCMSK0 |= (1 << PCINT3);
```

Gyroscope

In order to determine the error, the actual quadcopter readings and the received signal needs to be compared with each other; the gyroscope is interfaced with an I2C interface- pronounced Isquared-C, is a multi-master, multi-slave, single-ended, serial computer bus invented- typically used for attaching lower-speed peripheral ICs to processors and micro-controllers in short-distance, intra-board communication.

3.8.3 The use of drone in mapping out oil spilled areas

The function of Drone mapping will involve taking pictures from the air and using software to digitally "stitch" them together into a 3D map of a worksite. In addition to being used for photography purposes, drone imagery will provide aerial images captured by drones, and effectively gather essential data and use it to create 3D images and topographical maps.

The selection of UAV was critically important to the success of the project. The small and often crowded deck of a response vessel renders fixed wing drones unsuitable for this type of mission. Therefore, Vertical Take-Off and Landing (VTOL) UAVs are ideal for this type of scenario. Keresnasami adds UAVs equipped with Extended Visual Line of Sight (EVLOS) or Beyond Visual Line of Sight (BVLOS) capabilities are best suited for this type of work.

EVLOS extended beyond the line of sight of the pilot with so-called spotters relaying its flight information to the controller. BVLOS, an increasingly popular capability, enabled flights to go even further. They are controlled by a pilot who is informed about their position, altitude, speed and direction by onboard instruments.

The plan was to use software to track the flight path of the drone in real-time, while the UAV was used to fly the perimeter of the simulated spill area. Real-time transmission of videos and GPS coordinates was incredibly helpful to identify the exact location of a spill so that other vessels with spill containment equipment such as booms and dispersants can be directed to the incident location.

3.8.4 To determine the impact of oil spill on Agricultural land

The images generated by the dynamic drone was analysed to determine the actual impact of crude oil spill in the affected areas. It was used to detect oil spill and record the findings. The results provided information on the impact of oil spill on agricultural lands and on plant life. The number of plants affected were recorded same with the number of agricultural lands. The effectiveness of the findings was compared with the qualitative results available online on the impact and incidence of crude oil spillage on Agricultural lands.

3.9 Data analysis

This is the integral part of the research since it ensures that data collected were properly organized, described and preserved. Statistical analysis was carried out using SPSS for windows, version 23. Descriptive frequency and ANOVA were the method of choice used in the analysis. The descriptive analysis generated frequency distribution charts and tables as means of presenting data for the quantitative analysis. The ANOVA test provided the mean and standard deviation of the baseline values of the tests. It provided baseline comparism with the variables. The data was summarized, analyzed and interpreted in such a way it answers the research questions.

REFERENCES

[1]. Adamu, K.U. (2012). Environmental Protection: Law and Practice, Ibadan: Ababa Press Ltd.

[2]. Adekola O., Mitchell G (2011). The Niger Delta wetlands: threats to ecosystem services, their importance to dependent communities and possible management measures, *International Journal of Biodiversity Science, Ecosystem Services & Management*, 7(1): 50-68.

[3]. Adelana, S. O., Adeosun, T. A., Adesina, A. O., & Ojuroye, M. O. (2011). Environmental pollution and remediation: challenges and management of oil Spillage in the Nigerian coastal areas. American Journal of Scientific and Industrial Research, 2(6): 834-845

[4]. Adeoti, J.O. (2008). Environmental Policy and Industrial Response in Nigeria, International Journal of Technology Management and Sustainable Development, 7(2): 119-136.

[5]. Akpan, W. (2010). Oil, People and the Environment: Understanding Land-Related Controversies in Nigeria's Oil Region, 5. Available at: http://www.codesria.org/IMG/pdf/akpan.pdf.

[6]. Allen, F. (2012). The Enemy Within: Oil in the Niger Delta, (June, 12), World Policy. Available at https://worldpolicy.org/2012/06/12/the-enemy-within-oil-in-the-niger-delta/

[7]. Anifowose, B. (2008). Assessing the Impact of Oil & Gas Transport on Nigeria's Environment. U21 Postgraduate Research Conference Proceedings 1, University of Birmingham UK. 25(7):7-9.

[8]. Barenboim GM, Borisov VM, Golosov VN, Saveca AY. (2015). New problems and opportunities of oil spill monitoring systems. Proceedings of the International Association of Hydrological Sciences. 366:64-67

[9]. Bayode, O.J.A., Adewunmi, E.A., and Odunwole, S. (2011). Environmental Implications of Oil Exploration and Exploitation in the coastal region of Ondo State, Nigeria: A Regional Planning Appraised, Journal of Geography and Regional Planning, 4(3): 100-121

[10]. Benka-Coker, M. O., & Ekundayo, J. A. (2015). Effects of an oil spill on soil physico-chemical properties of a spill site in the Niger Delta Area of Nigeria. Environmental Monitoring and Assessment, 36(2): 93-104.

[11]. Cheremisinoff, N.P. (2006). Environmental Management Systems Handbook for Refineries - Pollution Prevention through ISO 14001. Gulf Publishing Company. Available at: http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=1481&VerticalID=0

[12]. Chinweze, C., Abiola, G., Onyeri, I., Echetebu, C.K., Jideani, C. (2012) Oil And Gas Activities And The Nigerian Environment 'IAIA12 Conference Proceedings 'Energy Future The Role of Impact Assessment 32nd Annual Meeting of the International Association for Impact Assessment 27 May -1 June 2012, Centro de Congresso da Alfândega, Porto Portugal (www.iaia.org)

[13]. Collins, J. & Hussy, R. (2014). Business Research: A practical guide for undergraduate and postgraduate students. 4th ed. United Kingdom: Palgrave Macmillan Higher Education.

[14]. Daly, H.E. (1990). Toward some operational principles of sustainable development. Ecological Economics 2: 1–6.

[15]. Daou G, Maroun CB, Hammoud B. (2021). Advanced iterative multi-frequency algorithm used by radar remote-sensing Systems for oil-Spill Thickness Estimation. International Conference on Electrical, Computer and Energy Technologies. 16(9): 1-6

[16]. Derefaka, J.O. (2014). Waste Management Challenges in the Oil & Gas Industry with Special Focus on Limited Disposal Infrastructures: Shell Companies in Nigeria (SCiN) Challenges and Lessons Learnt; Conference Paper. Available at:

[17]. https://www.researchgate.net/publication/291338594

[18]. Egwu, S.A. (2012) Oil Spill Control and Management. Petroleum Technology Development Journal Quarterly, 19(3): 457- 478

[19]. Fingas MF, Brown CE. (2017). Review of oil spill remote sensing. Spill Science & Technology Bulletin. 4(4):199-208

[20]. Fingas M. (2018). The challenges of remotely measuring oil slick thickness. Remote Sensing. 10(2):319-322

[21]. Goodman R (2014). Overview and future trends in using drones in agriculture. Spill Science & Technology Bulletin. 1(1):11-21

[22]. Hensley S, Jones C, Lou Y (2012). Prospects for operational use of airborne polarimetric SAR for disaster response and management. International Geoscience and Remote Sensing Symposium. 58:103-106

[23]. Hollinger JP, Mennella RA. (2013). Oil spills: Measurements of their distributions and volumes by multifrequency microwave radiometry. Science. 181(4094):54-56

[24]. Hou Y, Li Y, Liu B, Liu Y, Wang T. (2017). Design and implementation of a coastal-mounted sensor for oil film detection on seawater. Sensors. 18(1):70-76

[25]. Ite, A.E., Ibok, U.J., Ite, M.U. and Petters, S.W. (2013). "Petroleum Exploration and Production: Past and Present Environmental Issues in the Nigeria's Niger Delta." American Journal of Environmental Protection, 1(4): 78-90.

[26]. Jha MN, Levy J, Gao Y. (2008). Advances in remote sensing for oil spill disaster management: State-of-the-art sensors technology for oil spill surveillance. Sensors. 8(1):236-255

[27]. Jiang Z, Zhang J, Ma Y, Mao X. (2021). Hyperspectral remote sensing detection of marine oil spills using an adaptive long-term moment estimation optimizer. Remote Sensing. 14(1):157-161

[28]. Kadafa, A. A. (2012). Oil exploration and spillage in the Niger Delta of Nigeria. Civil and Environmental Research, 2(3):38-51.

[29]. Kialegee A. (2005). "The Economy of Conflict in the Oil Rich Niger Delta Region of Nigeria". Nordic Journal of African Studies, 14(2): 208-234.

[30]. Laneve G, Luciani R (2015). Developing a satellite optical sensor based automatic system for detecting and monitoring oil spills. International Conference on Environment and Electrical Engineering (EEEIC). 15: 1653-1658

[31]. McEachern W A (1997). Economics: A Contemporary Introduction. Ohio: South-Western College Publishing. Nigerian Environmental Study/Action 12:16-21.

[32]. Nenibarini, Z. (2004). Impacts of Extractive Industries on the Biodiversity of the Niger Delta. National Workshop on Coastal and Marine Biodiversity Management.

[33]. Nwilo, P. C., & Badejo, O. T. (2005). Oil spill problems and management in the Niger Delta. International oil spill conference 2(1): 567-570).

[34]. Olamide, A.J. (2000). Petroleum Production, the environment and Nigeria Development. African Journal of Environmental Studies, 1 (1 and 2), 29-35

[35]. Olujimi J.A.B (2010). The Roles of the Stakeholders in the Usage and Management of the Environment. Challenges of Environment and the Imperative of Urban and Rural Development 33:20-34

[36]. Osondu, C. A. (2012). Our Common Environment: Understanding the Environment, Law & Policy; University of Lagos Press, 2012

[37]. Osuji, L. C., Erondu, E. S., & Ogali, R. E. (2010) upstream petroleum degradation of mangroves and Intertidal shores: The Niger Delta experience. Chemistry & Biodiversity, 7(11)60-128

[38]. Pena V.M. and Mara, D. (2004). Waste Stabilisation Ponds. IRC International Water and Sanitation Centre. 56(9):16-23.

[39]. Saleem A, Al Maashri A, Eldirdiry O, Ghommam J, Bourdoucen H, Al-Kamzari A (2021). eDetection of oil spill pollution in seawater using drones: Simulation & lab-based experimental study. International IOT, Electronics and Mechatronics. 65:1-5

[40]. Shih WC, Andrews AB (2008). Infrared contrast of crude-oil-covered water surfaces. Optics Letters. 33(24):3019-3021

[41]. Sridhar MKC 1996. Women in Waste Management. A Seminar Paper Sponsored by LHHP and the British Council on Educating Women for Sustainable Environmental Management, Owerri, Nigeria, March 5- 7

[42]. Steiner, R. (2008). Double Standards? International Best Practices Standards to Prevent and Control Pipeline Oil Spills, Compared with Shell Practices in Nigeria, University of Alaska, USA. November. Available at http: www.milleudetensie.nl/English/shell/thepeopele-of-nigeria-verse-shell Sustainability Review 2011, BP, 31, (2011), available at

[43]. http://www.bp.com/assets/bp_internet/globalbp/STAGING/global_assets/e_s_assets/e_s_assets_2010/downloads_pdfs/bp_sustainability_review_2011.pdf (stating BP's approach to safety).

[44]. Tyonongo, A.M. (2008). Economic implications of environmental degradation on the society. International Journal of Economics and Development Issues, 7(1): 33- 38.

[45]. Xu L, Wong A, Clausi DA.(2016). An enhanced probabilistic posterior sampling approach for synthesizing Sar imagery with sea ice and oil spills. IEEE Geoscience and Remote Sensing Letters. 14(2):188-192

[46]. Yadav M, Sharma D, Sharma O (2013). Propagation of electromagnetic waves in multilayer structure. International Journal of Research Review in Engineering Science and Technology. 2(3):81-82

[47]. Yakubu (2008) Gas-flaring, assaulting communities, jeopardizing-the-world. Development journal. available at:http://milieudefensie.nl/publicaties/rapporten/gas-flaring-assaulting-communities-jeopardizing-the-worldassessed on the 24thJan 201