

# Analysis of Petroleum Spillage Detection Systems Designed for use in the Niger Delta Region of Nigeria: the Missing Link

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#### Abstract

This paper examines various petroleum spillage detection systems that have been designed to checkmate the activities of oil bunkering and vandalism in the Niger Delta region of Nigeria. Comprehending economic growth and development of the country on increased and uninterrupted transportation of petroleum products to their various destinations, this paper seeks to analyze petroleum spillage systems that have been designed over the years to monitor acts of vandalism. By way of explicit analysis, predicated on available designs, the paper posits that there exist some short comings in the existing systems which make for easy overriding. Considering the side effects of pipeline vandalism such as drastic economic loss, pipeline fire, environmental degradation and loss of lives, the paper concludes that proper petroleum spillage detection topology is key to the economic emancipation of the people of Nigeria.

Keywords: Niger Delta, Oil Bunkering, Petroleum, Spillage Detection, Topology, Vandalism.

## 1. INTRODUCTION

Petroleum spillage is a subject that has continued to dominate sociopolitical discuss within and outside Nigeria and among Nigerians [1]. The increase in the rate of petroleum spillage in the Niger Delta region of Nigeria in recent times is disturbing.

The Nigerian National Petroleum Cooperation,(NNPC), stated not long ago that incidents of pipeline vandalism rose by almost five per cent in 2014 when compared to what was obtainable in the previous year. The regulatory body further stated that no less than a total of 3,732 line breaks was reported on its pipelines out of which 3,700 was as a result of vandalism. They attributed the rest to system deterioration [2]. In the same vein, the Nigeria Extractive Industries Transparency Initiative (NEITI), in their annual report also stated that the nation lost a staggering N8.6 trillion in the last four years due to criminal activities on the nation's pipeline. On the average, N2.4 trillion was stolen every year since 2012. Buttressing the figures and claims by these agencies, A former Managing Director of NNPC, Mr. Andrew Yakubu, put the yearly loss of revenue at \$12 billion (about N2.4 trillion) yearly with at least 300,000 barrels of crude oil lost per day due to unwholesome activities and criminal related vices that has continued to cripple the country's oil sector[3]; [4]; [5]; [6]; [7]. In a bid to find a lasting solution to oil pipeline vandalism in the country, the Federal government of Nigeria increased its security spending in the Niger Delta region of the country to curtail the illegal diversion of oil by devoting millions of naira annually to hire private security firms as well as equipping men and officers of the Nigeria Security and Civil Defense Corps (NSCDC) to checkmate the incessant destruction of pipelines and other oil facilities across the country [8]. Despite all these efforts, pipeline cartels with international connections have continued to grow at an alarming rate[9]. This shows that, government's investment in the oil sector in terms of security has, over the years, not been proportional to a reduction in acts of vandalism.

The rate of spillages, the nature of oil spilled, the location of the spill as well as the size of the spillages are some of the factors that determine the impact of oil spillage on the environment[10]. These factors influence the extent of damage caused to the environment. However, research by scholars has observed that even the smallest of oil spillages could cause serious harm to individuals, organisms and the entire populace. The overwhelming effects of oil spillages range from the death of species such as birds, fishes, marine animals and plants to the disruption and proper functioning of the ecosystem. Oil spillages also affect the tourism industries just as water for drinking and industry use is put at risk. Above all, the consequences of oil spillage on human lives has resulted in untold loss of human lives and almost crippled the Nigerian economy [11].

Detailed reports have asserted that because of oil exploration and exploitation in the Niger Delta region, it has become an ecological wasteland. Oil spillage incidences from pipeline vandalism is the major challenge to spillage management system in Nigeria and at present, has defiled all contingency mechanisms put in place by industry experts as vandalism still take place along major pipelines and manifolds. Political and economical reasons are often given as the driving force for pipeline vandalism. Vandals often agitate to have a just share of the natural endowment of the resources within their domain. In a recent release by the nation's security agencies, it was observed that groups of local community youths, otherwise known as "area boys or touts", destroy pipelines in the hope of securing repair contracts. In the year 2006, Shell Petroleum Development Company (SPDC), one of the major operators in Nigeria's oil industry, said it recorded 241 oil spillage incidents in the country. According to the oil firm, almost 70 percent of this total was as a result of the destruction of pipelines while 20 percent was as a result of manageable incidents such as equipment failure, corrosion or human error. The remaining about 10 percent of the incidents are yet to be classified due to access restrictions either by host communities or the current insecurity challenges in the region. Steps taken so far by the Government to manage oil spillages in Nigeria include the setting up of various legislative frameworks to govern the petroleum industry such as the Federal Environmental Protection Agency Act, 1990; the National Oil Spill Detection and Response Agency Act, 2006; the National Emergency Management Agency (NEMA) and the Ministry of Niger Delta amongst others [12].

Just recently, the Minister of State for Petroleum Resources, Dr. Ibe Kachikwu stated that the acts of vandalism in the Niger Delta region dented governments plan for the county in the just ended year 2016 just as it made for little implementation of the 2016 budget of the country. He stated that pipeline saboteurs in the oil industry destabilized the country making the country to lose 643 million litres of petroleum products amounting to N51.28 billion in 2015 alone while activities of saboteurs in the first six months of 2016 caused the country a loss of 109 million liters of petroleum products and 560,000 barrels of crude oil[13]. The minister thus said that the country needs to increase its production by 1.1 million barrels per day to meet its targets. This is a herculean task giving the extent to which vandals are operating in the region currently.

Currently, oil spillage is either monitored manually, in which case huge human labor is needed in the gathering of useful data which has proved difficult overtime or monitored with the used of models or systems, the designs of which have not been fully optimized and functional enough to detect spillage easily. The objective



of this study is to highlight points of deficiencies in order that better and more advanced models can be designed to check this menace effectively.

# 2. LITERATURE SURVEY

Oil spillage has, over the years, being a major challenge to industrial revolution since the discovery of crude oil. In Nigeria, this challenge has been increasing in a geometric proportion since oil was discovered in commercial quantity in the Niger Delta region. Saboteurs, seeking to siphon crude oil have continued to attack oil facilities in the region, stealing away huge resources and degrading the ecosystem in the process. The Niger Delta region is one of the five most severely damaged petroleum ecosystem in the world out of the 10 most important marine and wetland ecosystem in the world [14].

Vandalism is an act that involves the deliberate destruction of public or private property. Within the civil domain, vandalism is the willful destruction of public or government property for criminal or political intent. It follows therefore that oil pipeline vandalism is a deliberate destruction of oil pipelines with the intent to steal petroleum products or to sabotage the government of the day [15].

The Niger Delta region is one of the most ecologically tender in Nigeria. Oil and gas from the environmentally fragile region are the main source of revenue for the Nigerian state, accounting for up to 96 percent of the country's total export [16]. Since the discovery of oil in large quantities and its subsequent exportation, oil has dominated the country's economy with the Niger Delta, being the source of the oil. Hence, the region is very volatile to adverse environmental effects occasioned by climate changes because it's coastal region.

[17]Stated that the prevalence of oil pipeline vandalism in Nigeria is driven by the desire to accumulate wealth for selfaggrandizement. This is particularly prevalent in Nigeria where poverty or lack is seen as a disease and riches is worshiped and adored. It is to be noted, however, that oil pipeline vandalism has also been occasioned by political sabotage. This was the case in the hey-days of the Niger Delta crisis when militants used to indulge in sporadic assaults of the pipeline systems in an attempt to sabotage the activities of the oil companies as well as elicit government and international attention [18].The point to be underscored in the foregoing is that the prevalence of oil pipeline systems vulnerable to incessant breaks with untoward consequences for the political economy of Nigeria.

The nature and caliber of people involved in the act of vandalism, makes it a difficult nut to thev have infiltrated crack as these governmental agencies and parastatals. This has been a key issue in the effort to address and tackle acts of vandalism [19]. Without a reliable threat assessment or accurate data on which to such an assessment. neither law base enforcement agencies can conduct meaningful monitoring, or a coherent national response. Identifying the sponsors of these attacks is an essential first to overcoming the growing problem of pipeline vandalism.

In general, the assessment of other researchers into this issue of pipeline vandalism acknowledges that while the oil sector has brought much economic growth to the country, it has also left severe multiplier effects on the environment and the economy. The prevention of pipeline vandalism is a task that must be pursued vigorously hence there is the need to analyze existing spillage detection systems so as to pinpoint areas where improvement needs to be made in order to recue an already battered economy and ecosystem

# **3. RELATED THEORY**

Theories on crime which can be associated to vandalism have been developed overtime by scholars in an attempt to fully understand the phenomenon of organized crime, one of which is vandalism. From the theory of George Homan which can be related to human interaction at all



levels and which is governed by reward and punishment to the theory of modernity and the rational choice theory which explains the rational but destructive approaches of pipeline vandals. Other theories which can be used to explain vandals' desire and motivation to vandalize pipelines include, the ethnic succession theory, social control theory, alien conspiracy theory, queer ladder theory amongst others [20]; [21].

The queer ladder theory is of the opinion that while the act to indulge in vandalism is high, the deterrence from vandalism living is low which thus creates room for vandalism impunity and franchise. The George Homan's theory, which sees the world as a market place for people to meander their way to survival is perhaps most suitable for this discuss. Based on the assumptions of Homan, in the struggle for survival, people try to get the better of the other person and are most willing to do what is convenient for them to be able to achieve their life's goals. The notion is not about security agencies entering into interaction with vandals but about the multiplicity of approaches of the effective operation strategies of security agencies and the safety of the communities; the people and the oil pipelines, and maintaining the alliance with the government of their fatherland.



Fig. 1: Interaction theory of group formation [22]

In the context of self-actualization, the vandals seem to be established in the concept of modernization, where there is freedom of choice, advanced technology and other prevailing features of modern world are in operation. Modernization here can be viewed in terms of organic solidarity and the awakening of collective consciousness, [23]. While Organic Solidarity brings freedom and increase productivity, it also poses a lot of challenges. Taking advantage of modern ideology, actors play down on the conventional and societal values thereby creating the world of anomie.

## 4. MATERIALS AND METHODS

This paper is exploratory and qualitative in its approach. The paper qualitatively explores its subject matter by way of descriptive analysis predicated on scholarly deductions and empirical deductions. The basis of analysis was systematically prosecuted under selected headings and sub-headings designed carefully to address the core aspects of the set out objectives of the paper.

## 4.1 Analysis of a Microcontroller Based Alarm Detection System



A study using a microcontroller based Alarm detection system for petroleum pipeline vandalism detection was carried out in 2014 by [24]. The study was carried out in modules with the transceiver, microcontroller and power supply modules as the major components. The design of the module device was governed by the principle of radio frequency modulation and de modulation to establish a communication process. The microcontroller system was designed using the light sensor and the pressure sensor to sense a variation in stable operating conditions of pressure, break or light.

The designed system also used the microcontroller to turn on the system automatically when power is connected, to interpret signals and to send an alert signal to the base station.



Fig. block diagram of the microcontroller based system [24]

## 4.1.1 Limitations of the Microcontroller Based System

The microcontroller based alarm system for pipeline vandalism detection is probably the most sophisticated of all the systems analyzed. From the use of both amplitude and frequency modulators, which is very essential but requires the services of telecommunication experts for its smooth design to the use of a Nokia 1100 phone which are no longer in the market. Proper emphasis was laid on the sensors used. However, the three sensors explained to have been used, that is, the pressure sensor, the light sensor and the break sensor gives a feeling that just maybe one type of sensor with multiple functions would have done the work even better. Also, like other designed systems before and after it, the microcontroller based alarm system for pipeline vandalism detection is heavily reliant on public power supply with only a 3watts maximum contingency plan for a source of power outside the conventional power source. While this would naturally not have

been a limitation in high energy generating countries of the world, the same cannot be said of an emerging economy country like Nigeria.

#### 4.2 Analysis of oil pipeline Vandalization and Surveillance Systems

This study was carried out with the main objective of designing an electronics pipeline and surveillance system with the ability to detect intrusion into pipeline systems before actual vandalization takes place by sending a Short Message Service (SMS) to plant operators, [25]. A major feature of this system is the incorporation of a footage video camera that could be used in knowing the identities of the vandals. A major feature of this designed system is the use of a Passive Infrared Resistor (PIR) sensor to detect early intrusion and acquired communicating the information through SMS or email to plant operators. The PIR sensor has the ability to preemptively detect acts of vandalism by triggering an interrupt which will then start up the surveillance video



camera to record and take snapshots of the area where vandalism is taking place. Another essential feature of this system is the use of the Supervisory Control and Data Acquisition (SCADA) system to visualize the captured data from the remote surveillance system. SCADA is a standardized technology that has been used overtime by intelligence gathering agencies to obtain secret information of people or locations under close surveillance. In essence, oil firms can use the SCADA topology to gather information about activities of vandals as exemplified by this system.

# 4.2.1 Limitations of the pipeline Vandalization and Surveillance System

While this system is very good and could serve as the needed respite for oil firms to permanently address the prevalence of pipeline vandalism, there are a number of issues that stand on its way to being the messiah that oil firms could rely on.

First. the SCADA system needs an uninterrupted server personal computer with a broadband internet connection. While this may not be a major hindrance for advanced countries, the same cannot be said of developing countries like Nigeria where there is limited fibre optics connection. Even though Nigeria has more than enough broadband capacities which ought to have translated into a high internet access, it still has less than 10 percent of the total broadband capacities from the cable operators in the country presently [26].

Second, there is the issue of the need for Client Personal Computers (PCs) or portable devices such as Personal Digital Assistants (PDAs) and Smartphones. While technology has made smartphones and PDAs easily assessable, the problem of epileptic power supply complicates the issue for Nigeria which has continued to struggle with increasing power outages to meet the teeming needs of its citizens. While successive administrations in the country have continued to allocate a large chunk of its yearly national budget to addressing the challenge of epileptic power, the quantity of megawatts generated per day has continued to dwindle even as the country's population grows geometrically.

For this reason, the 6600mAh external solar panel power source designed to last for approximately 16 to 18 hours may not sufficiently serve the need of the detector as it is expected that since Vandalization can occur at any time, the system should be in the ON state at all time of the day.

## 4.3 Analysis of pipeline Vandalization Systems with SMS Alert

This study designed a technique for pipeline crack detection system with remote monitoring and location specification [27]. The designed system provided a continuous electrical path with the aid of a sensor network. This continuous electrical path was used in triggering an alarm and notifying the operators via SMS to a mobile phone operator. An avenue was provided in which the sensor diagram could be modified into a sheet having a signal path for either electric signal or optical signal wrapped around the pipeline over a predetermined length and can then be incorporated into the design of the pipeline by wrapping it on the outer surface to improve its reliability. Like the other systems analyzed above, this system is aimed at early detection of pipeline vandalism.

# 4.3.1 Limitations of the pipeline Vandalization Systems with SMS Alert

While this system would have been an ideal system in addressing the issue of pipeline vandalism in the Niger Delta region of Nigeria, there are some grey areas which more information is needed in order to aid the smooth design of the proposed system. The authors addressed the power supply unit adequately proposing a 12V input voltage to power the system with a bridge rectify diode to help in the removal of ripples from the system. Also, the microprocessor aspect was also addressed as it



was designed to carry out such functions as powering the system automatically and initializing the GSM module as well as interpreting signals received and notifying the operators of the result.

However, a system designer desiring to follow the procedures of this system would have challenges with some key areas of his design. The sensor interface unit, the GSM module unit, the control unit and the alarm unit does not have a blueprint that will aid the design easily to enable an independent designer or researcher carry out further studies on the proposed design. Such issues as what constitute the sensor unit would have helped in no small a measure to further the research work in this all important field of study.

#### 5. DISCUSSION OF RESULT

Analysis of the studies carried out by different researchers showed that while a lot of effort has been made to address the issue of pipeline vandalism in Nigeria, setbacks such as epileptic power supply and poor internet penetration in the hinter lands have continued to downplay the proactive measures taken by scholars in addressing the challenge. Complexities of some designs as well as inadequate explanations of designs have also left a vacuum which independent designers are trying hard to cope with in implementing the designs of fellow researchers.

#### 6. CONCLUSION

The objective of every research work is to increase knowledge and create a platform for more improvement to be done on a particular subject matter. In this paper, it was deduced that most of the designed pipeline detection, monitoring and surveillance systems are capable of addressing the issue of pipeline vandalism in the country with little modification in the designs. Particularly, we identified the challenge of power supply as the major mitigating factor against the proper functioning of design systems to effectively carry out their design objectives. The paper summits that with little alterations to most of the designed systems and an improvement in internet penetration coupled with a more assured effort in addressing the power challenge in the country, the issue of pipeline vandalism in the country will be minimized to the barest minimum.

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