



## Geospatialization of Spilling Facility From Spdc 2015 Oil Spill Reports of The Niger Delta Region of Nigeria

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Received: October 30, 2018

Accepted: December 28, 2018

Published: January 21, 2019

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### Abstract

A hundred and thirty two (132) Oil spill Incidents that occurred in year 2015 based on the existing SPDC Oil Spill Joint Investigation Visit (JIV) Reports were studied using GIS. The JIV reports were downloaded and the requisite information was acquired and incorporated into ArcMap10.2 and they were analysed to produce different maps. Result shows that about 18,233.04bbl of Oil was spilled and an area of 1,718,091.88m<sup>2</sup> was impacted in year 2015. Pipelines account for 65.15% (86) of the spills, followed by flowlines 14.39% (19), Wellheads 13.63% (18) while others account for the rest. Pipelines are the most sabotaged Production Facility with 73.63 % ( 81) of the Sabotage that occurred followed by wellhead 13.63 % (15) and, flowline 10 % (11) while other Production Facilities account for the rest. This Study also shows that JIV Reports to an extent are a good and convenient tool for characterising Oil spills and the JIV culture should be encouraged. This study should be carried out on all JIV so that they are put in a Digital Format where they can be easily queried to produce the necessary information as needed.

**Keywords:** Oil Spill, Pipeline, Niger Delta, Nigeria, Sabotage, Wellhead, Production Facility, Sabotage, Flowline

### 1. Introduction

The exploratory activities for Petroleum in Nigeria commenced around Araromi in present day Ondo state in Western Nigeria in the early 1900's. Nevertheless, these tasks were abruptly interrupted and later on terminated because of the outbreak of the very first World War (1914 -1918). Exploratory activities resumed in 1937 when Shell D'Arcy the forerunners of Shell Petroleum Development Company of Nigeria (SPDC) were awarded the sole exploratory license for oil prospecting for the entire territory of Nigeria. Ultimately Oil was found in commercial quantities in January 1956 at Oloibiri within the Niger Delta in present day Bayelsa State by Shell D'Arcy after more than 50 years of exploration<sup>1</sup>. Oil Spillage; the unwanted and unintentional release of liquid hydrocarbon into the environment is a problem endemic to the Niger Delta which is the hub of Oil and Gas Exploration and Production in Nigeria. The Niger Delta occupying over 700,000 km<sup>2</sup> is an Environmentally Sensitive Area, with a unique assemblage of flora and fauna. Oil Spillage in the Niger Delta results from Sabotage/Bunkering, Operational Spills which occur in the course of normal operations and Mystery spills whose cause cannot be easily explained as the name implies (SPDC 2016).

SPDC is a Pioneer company in the Petroleum Industry of Nigeria producing more than 30% of Nigeria's oil.

The Company's operations are centered on the Niger Delta and its shallow offshore areas<sup>2</sup>. SPDC has more than 5000 kilometers of Flowlines and Pipelines, about 87 Flow stations, 8 Gas Plants and more than 1000 producing wells<sup>2</sup>. In a reaction to the occurrences of Oil spill in Nigeria, the Department of Petroleum Resources (DPR) in 1991 released a document titled "Environmental Guidelines and Standards for The Petroleum Industry in Nigeria" (EGASPIN), which was revised in 2002 to regulate and control the activities of the Oil and Gas Industries against environmental degradation and where necessary to carry out remediation activities. In Section 5 (Spill Prevention And Counter Measures Plan) under Part IIE (Environmental Management) it posits that all spillages (Crude oil/chemical/oil products) are to be reported to the Director of Petroleum Resources in consonance with the dictates of the Oil Spillage/Notification Reporting Formats, 'A', 'B' and 'C' in APPENDIX VIII-B2) of the document and also, a Joint Spillage Investigation (JSI) team, comprising of the Licensee/Spiller/Operator, DPR and Community shall be constituted within 24 hours of getting spillage notification to investigate the spillage<sup>3</sup>.



The National Oil Spill Detection and Response Agency (NOSDRA) was also established in 2006 with the Responsibility for managing Oil spill related issues in Nigeria. In consonance with the dictates of the EGASPIN provisions, when there is an oil spill associated with any SPDC facility, A Joint Investigation Visit (JIV) is made by a team composed of the statutory government regulators which are DPR and NOSDRA, SPDC (The Spiller), the Nigeria Police Force (NPF), State Ministry of Environment (SME) and representatives of the impacted Communities. Their duty is principally to define the spread, the volume and the cause of the spill and other allied information the whole being presented as a JIV Report signed off by the participating parties. It is worthy to note that SPDC was the Pioneer International Oil Company (IOC) operating in Nigeria that periodically publishes the JIV Reports in the Public domain in addition to uploading scanned JIV Reports which they pioneered starting in 2011 making it readily available for individual perusal and investigation.

Geographic Information System or Science (GIS) is a System comprising of Hardware, Software, People and Methods which are utilized in managing, displaying, capturing, storing, and analyzing geographically referenced data. It is essentially an intersection between Fields that utilize spatial analysis and Information Technology (IT). It seeks to prefer solutions to questions such as What, Where and When with respect to spatial data.

### 1.1 AIM

The aim of this Research is to study the JIV Reports from SPDC for year 2015 and

(1) Extract information as relating to the Production Facilities associated with each individual spill incident and putting such in a digital format to enable speed and ease of access.

(2) To create maps about the Oil spill based on the production facilities from which the Oil was spilled.

### 1.2 Location of Study Area

The study area is in the Niger Delta and is limited to the Operational Areas of SPDC where there were spill incidents in the year 2015. This cuts across parts of Rivers, Bayelsa, Delta and Abia states (fig.1) accounting for twenty three (23) Local Government Areas (LGA).

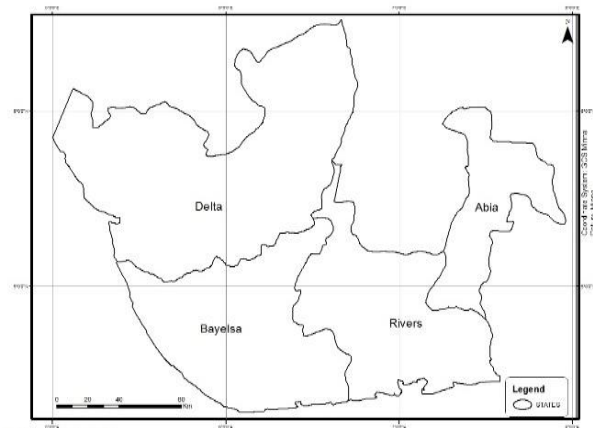


Figure 1: Showing the states covered by the Study Area

It comprises of Rivers with 15 LGA (Abua/Odual, Akuku Toru, Ahoada West, Andoni, Eleme, Degema, Etche, Bonny, Gokana, Emohua, Ikwerre, Obio/Akpor, Oyigbo,

Onelga and Tai Local Government Areas), Bayelsa with five(5) LGA (Ekeremor, Ogbia, Yenagoa, Nembe, Southern Ijaw), Delta with two(2) LGA (Burutu, Warri South West) and Abia with one(1) LGA (Ukwa West) (fig. 2). In total we have about one hundred and thirty two (132) spill sites spread across the areas mentioned above

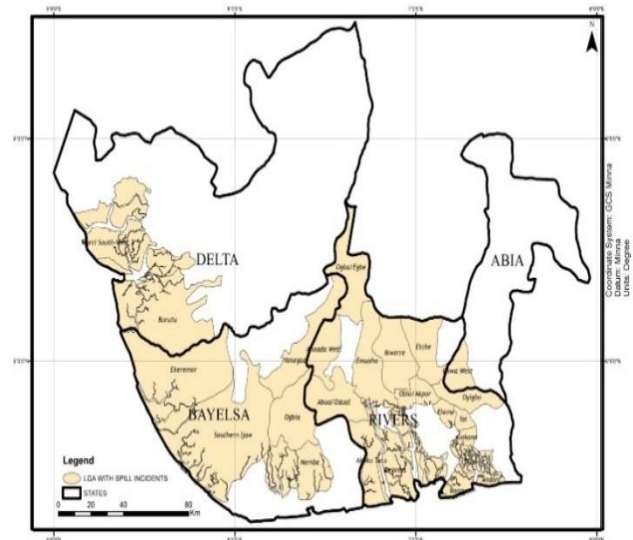


Figure 2. Showing the Local Government Areas Covered by the Study Area

### 1.3 Geology of the Niger Delta

The Niger Delta is an extensional rift basin situated in the Gulf of Guinea<sup>4</sup>. Its northern Boundary is restricted by the Benin Flank which is an East-North-East trending line, lying at the Southern part West African Basement Massif. Its North Eastern limit is demarcated by Cretaceous outcrops of the Abakaliki High and in the East-South-East by the Calabar flank. The Cameroon Volcanic line marks its offshore boundary to the east, the Dahomey Basin to the west, while to the South and Southwest it is bound by over 4000m bathymetric contour where the sediment thickness accrues to more than 2km.

#### 1.3.1 Regional Geologic Setting

The tectonic scheme of the continental margin along the Western Coast of West Central Africa is controlled by fracture zones of Cretaceous ages essentially expressed in the form of trenches and also ridges in the Atlantic Ocean. This fracture zone and its ridges also further divide the margin into disparate basins such as the Benue-Abakaliki trough which cuts deep into the West African shield (fig. 3). The trough represents an Aulacogen of the rift triple junction associated with the widening of the South Atlantic in the Jurassic, and ending in the Cretaceous with the separation of the South American Plate from the African Plate resulting in the birth of the Niger Delta. A lot of thrust faults were developed during this rifting with a history characterized by series of Regressions and Transgressions.

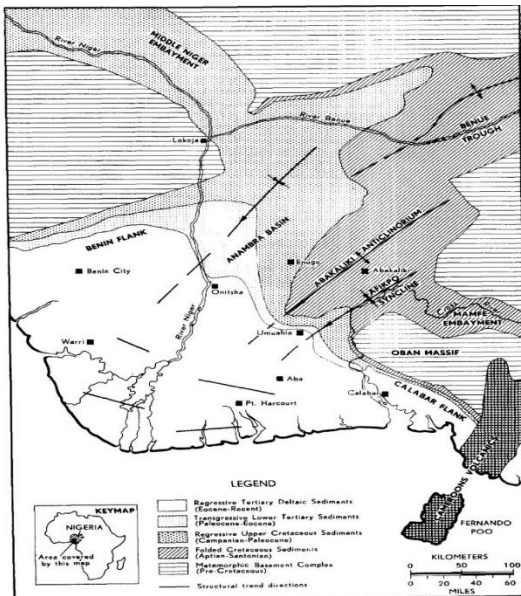


Figure 3 showing the structural units of the Niger Delta<sup>5</sup>

### 1.3.2 STRATIGRAPHY

The general Stratigraphy of the Niger Delta is essentially composed of three broad Lithostratigraphic units (fig 4) which are:

- The Benin Formation: a continental Sand Sequence which is quite shallow from the Surface to the subsurface strata.
- The Agbada Formation: composed of interchanging marine sequences of Sand and Shale.
- The Akata formation: composed of a marine shale Unit.

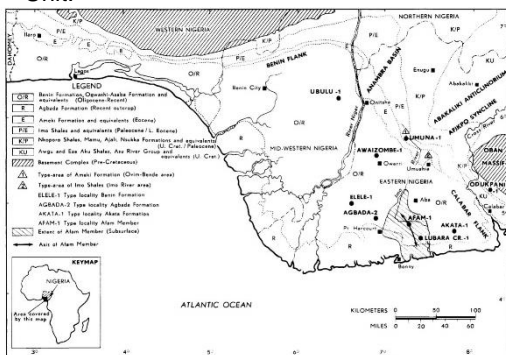


Figure 4: Geologic map of the Niger Delta after Short K.C. and Stauble A.J (1963)

Table 1: Showing the formations of the Niger Delta

SUBSURFACE			SURFACE OUTCROPS		
YOUNGEST KNOWN AGE		OLDEST KNOWN AGE	YOUNGEST KNOWN AGE		OLDEST KNOWN AGE
RECENT	<b>BENIN FORMATION</b> Alam Shale Member	OLIGOCENE	PLIOC/ PLEISTOCENE	<b>BENIN FORMATION</b>	MIOCENE?
RECENT	<b>AGBADA FORMATION</b>	EOCENE	MIOCENE	<b>OGWASHI-ASABA FORMATION</b>	OLIGOCENE
RECENT	<b>AKATA FORMATION</b>	EOCENE	L. EOCENE	<b>AMEKI FORMATION</b>	EOCENE
EQUIVALENTS NOT KNOWN			PALEOCENE	<b>IMO SHALE FORMATION</b>	PALEOGENE
			MAESTRICHTIAN	<b>NSUKKA FM</b>	MAESTRICHTIAN
			CAMPANIAN	<b>AJALI FORMATION</b>	MAESTRICHTIAN
			CAMP./MAEST	<b>MAMU FORMATION</b>	CAMPANIAN
			CONIACIAN/ SANTONIAN	<b>NKPORO SHALE</b>	SANTONIAN
		TURONIAN	<b>AWGU SHALE</b>	TURONIAN	
		ALBIAN	<b>EZE AKU SHALE</b>	TURONIAN	
			<b>ASU RIVER GROUP</b>	ALBIAN	

## 2.0 Literature Review

Many studies carried out on Oil Spillage in the Niger Delta have focused majorly on the Socio Economic and Environmental effect of the Spillage.

There is sparse study on the JIV Report and practically none in which the JIV is Geospatialized based on any parameter.

In an event titled "Improving the JIV" which took place in Port Harcourt on 27th November 2014 organised by Stakeholder Democracy Network (SDN) a Non-Governmental Organisation (NGO) established in 2004, which had in attendance the Oil Companies, the civil society and regulatory bodies, a narrative report was published. The report restates the importance of the JIV mechanism and made certain recommendations which include the following:

- Need to improve the legitimacy and integrity of the JIV mechanism.
- Need to enhance the operational capacity of NOSDRA; its financial and regulatory capacity and also increase host community participation<sup>7</sup>.

In 2015 Akpofure in a work titled "Oil Spill Management in Nigeria: SWOT Analysis of the Joint Investigation Visit (JIV) Process". He posited that the strength of the JIV process in its multiparty role; its weakness as including a lack of independence by the other parties since they rely on the spiller for Logistics and also the deficiency in Technical Competence by the Regulatory parties, regulatory agencies more so the community representatives. He further explained that there is no generally accepted Algorithm for determining the actual cause of the spillage, the volume of oil spilled and the acreage of the impacted site and it also mentions the exclusion of women from the whole process. He identified the opportunities in the JIV as including its help in building awareness and the consequent capacity building amongst the necessary stakeholders<sup>8</sup>.

He mentioned the threats to the JIV process as including Poor Government monitoring, funding and enforcement. He concluded that to make the JIV more effective, there will be need to consolidate the regulatory agencies response, more training and increased funding<sup>8</sup>.

SDN<sup>9</sup> again in 2015 published a report "Improving Oil Spill Response in Nigeria: Comparative Analysis of the Forms, Data and Related Processes of the Joint Investigation Visit (JIV) And Suggestions to How These Could Be Improved". The report examines the administrative forms that are used to record information relating to oil spills during the onshore JIV and the effectiveness of the JIV processes based on the information gathered during a sample of JIVs between January 2010 and August 2015. The forms examined and compared are the following<sup>9</sup>:

- NOSDRA Form A (Initial Spill Notification form)
  - NOSDRA Form B (Risk Based Assessment (RBA) of oil spill)
  - The NOSDRA JIV form
  - SPDC JIV form
  - NAOC/Agip/ENI JIV form
- The forms were characterised based on the following criteria:
- Reliability
  - Viability
  - Accountability
  - Accuracy

The Study concludes that the SPDC JIV forms are the most comprehensive of those compared in this study as it gives a more detailed account of the

Spill impact and always include the algorithm for getting the quantity of oil spilled.

## 2. MATERIAL AND METHODS

### 2.1 Datasets: JIV Report and Spatial Datasets

The JIV report is the basis for this study. The data in the JIV Report include but is not limited to the following: Spill Incident No, Jiv Serial No, Date Reported, Month, State, Local Government Area, Latitude(Y)/Northing, Longitude(X)/Easting, Incident Site, Production Facility/Installation, Jiv Date, Terrain, Cause, Leak Point, Estimated Spill Volume (Bbl), Clean-Up Status, Total Area of Impact (m<sup>2</sup>).

The spatial datasets refers to data that has a well defined spatial attribute. Without this kind of data, there is no GIS. The datasets made use of in this study include-Shapefile of Nigeria, Shapefile of

Local Governments in Nigeria, and Shapefile of settlements in Nigeria.

- The Latitude/Northing and the Longitude/Easting data in the JIV report is what helps us to relate the JIV report to the spatial datasets.

### 2.2 JIV Download and Database creation

The JIV report for the year in question (2015) were downloaded from SPDC website (<http://www.shell.com.ng/sustainability/environment/oil-spills.html>).

For the database creation, the parameters needed from each of the Reports were extracted and stored as a Microsoft Excel Document (table 2) such that the columns contain the Parameters needed and each row represent a complete Oil Spill incident Record.

Table 2: Showing the view of the information generated from the data gathered from the JIV

SPILL INCIDENT NO.	JIV SERIAL NO.	Date Reported	LATITUDE(Y)	LONGITUDE(X)	Incident Site	PRODUCTION FACILITY/INSTALLATION	JIV Date	Cause	LEAK POINT
1315510	00630	07.01.2015	5.4512111	2.7064399	4" Yokri Well 114L Flowline at Yokri	FLOWLINE	16.01.2015	Operational	CORROSION
1320577	00813	18.01.2015	4.4308944	6.3516547	Nembe Well 40L Wellhead Flowline at Ikovia	WELLHEAD	20.01.2015	Operational	CORROSION
1320947	00823	19.01.2015	4.5741729	7.0293598	30" Nembe Creek Pipeline at Oromakiri	OIL PIPELINE	26.01.2015	Sabotage	CRUDE OIL THEFT(BUNKERING)
1322775	00814	22.01.2015	4.4367564	6.3308217	Nembe 1 Well 11L 4" Flowline at Nembe Creek	FLOWLINE	29.01.2015	Operational	CORROSION
1324519	00824	25.01.2015	4.5456893	7.0384131	Cavhome Channel 1 W9 at Captankiri	WELLHEAD	28.01.2015	Sabotage	BEAN BOX REMOVAL(BUNKERING)
1324775	00636	25.01.2015	4.8267372	5.9124604	Seibou Well 2S Flowline at Gbantau	FLOWLINE	10.02.2015	Operational	TEAR
1328417	00826	30.01.2015	4.5723387	7.2544552	28 Bomu-Bonny Trans Niger Pipeline at Bodo West	PIPELINE	03.02.2015	Sabotage	CRUDE OIL THEFT(BUNKERING)

### 2.3 UTM CONVERSION TO LATITUDE AND LONGITUDE

Some of the coordinates in the JIV Report was written as Northing and Eastings in meters while some were denoted as Latitude and Longitude in decimal degrees. For ease of usage and uniformity, the UTM coordinates of the spill sites were converted into Latitude and Longitude using Software called CoordTransV2.3™.

### 2.4 IMPORTATION OF OIL SPILL INCIDENT RECORD INTO ARCGIS ENVIRONMENT

The Oil spill record in excel format is imported into ArcGIS Environment so that the necessary analysis can be performed. On the Menu Bar, click "File"; "Add Data"; "Add XY Data", navigate to the Excel sheet and the spill record is added to the "View" as a "Theme" with all its attribute. All other pertinent shapefiles were also added, this includes shapefiles of Nigeria, Local Governments in Nigeria, Nigerian Settlements and others. It is important to state here that Author is not aware of any known standardised Shapefile of the Nigerian Datasets put forward by the Nigerian Government or any of its divisions. However we tried to maintain accuracy of our

datasets by comparing it with standardised datasets Google Earth™ and other authoritative.

## 3. RESULTS AND DISCUSSION

### 3.1 State By State Analysis of Spilling Facility

Table 3: Showing Spilling Facility by States

SPILLING FACILITY	STATES			
	RIVERS	BAYELSA	DELTA	ABIA
Containment Facility	1			
Flowline	8	7	2	2
Flowstation		1		
Flowstation Manifold		1		
Gas Plant	1			
Pipeline	53	21	10	2
Pipeline ROW			1	
Manifold		1		
Mystery	1			
Terminal	2			
Wellhead	10	8		

#### 3.1.1 RIVERS STATE SPILLING FACILITIES

A total of seventy six (76) oil spills occurred from January to December 2015 in Rivers State based on the JIV Report (fig. 6). Spread across fifteen (15) local governments (Abua/Odual, Eleme, Akuku Toru, Etche, Andoni, Ahoda West, Bonny, Degema, Emohua, Gokana, Ikwerre, Obio/Akpor, Oyigbo, Onelga, and Tai Local Government). The spilling facilities are as shown in table 2 above.

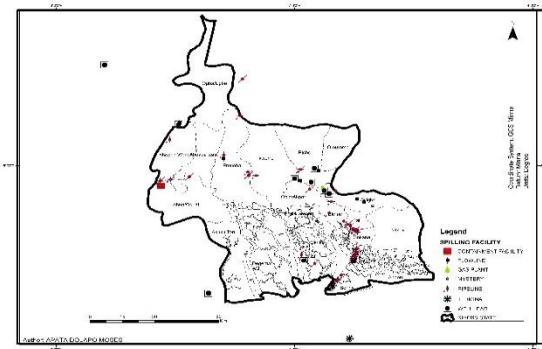


Figure 6: A map showing the Oil spill sites based on the originating Facility/Installation.

### 3.1.2 BAYELSA STATE SPILLING FACILITIE

According to the JIV Report a total of thirty nine (39) oil spill happened in Bayelsa state in the year 2015 from January to December (fig. 7). The Oil Spill cuts across five (5) Local Government Areas of Ekeremor, Ogbia, Nembe, Southern Ijaw and Yenegoa. The spilling facilities are as shown in table 2 above.

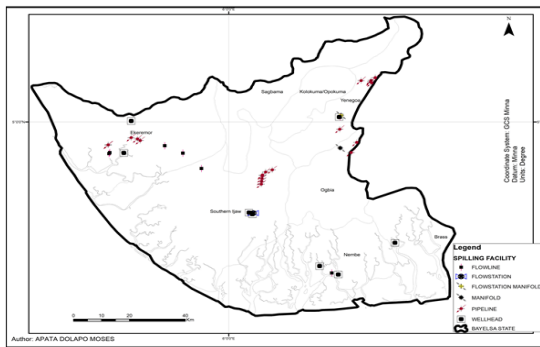


Figure 7: A map showing the Oil spill sites based on the originating Facility/Installation.

### 3.1.3 DELTA STATE SPILLING FACILITIES

According to the JIV Report a total of thirteen (13) oil spills happened in Delta state in the year 2015 from January to December (fig. 8). The Oil Spill cuts across only Two (2) Local Government Areas namely Warri South West and Burutu. The spilling facilities are as shown in table 2 above.

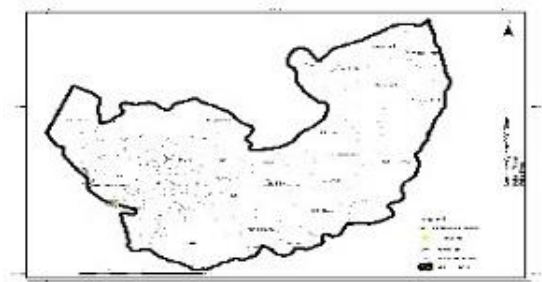


Figure 8: A map showing the Oil spill sites based on the originating Facility/Installation.

### 3.1.4 ABIA STATE SPILLING FACILITIES

According to the JIV Report a total of four (4) oil spills happened in Abia state in the year 2015 from January to December (fig. 9). All Spill incidents occurred in Ukwa West LGA (fig 2). This is the least for a state in the year 2015. The spilling facilities are as shown in table 2 above.

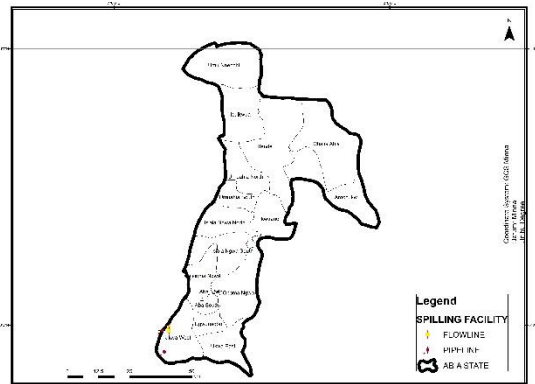


Figure 9: A map showing the Oil spill sites based on the originating Facility/Installation.

## 4. CONCLUSION

The Geospatialization of the spilling facility from the JIV reports has no doubt given us a graphical description of the spillage that occurred in the SPDC area of operations in the Niger Delta zone of Nigeria in terms the facility from which the spillage took place. Of the one hundred and thirty two(132) Oil spill Incidents that occurred in year 2015 according to SPDC Oil Spill data, and they have been studied using their JIV Reports about 18233.04 bbl of Oil was spilled and an area of 1718091.88 m<sup>2</sup> was impacted for the year 2015. Pipelines account for 65.15 % (86) of the oil spills, followed by flowlines 14.39 % ( 19), Wellheads 13.63 % ( 18) and others Facilities/Installations account for the rest. Pipelines also spilled the highest volume of Oil which is about 68 % ( 12,405.64 bbl) of the total oil spilled. Pipelines are the most sabotaged Production Facility /Installation accounting for 73.63% (81) of the Sabotage that occurred. It can safely be concluded that Pipelines are the most important facility apropos oil spillage in the Niger Delta

## 5. RECOMMENDATION

This particular study has revealed how data of erstwhile little value can be transformed to a crucial information. This study must be performed on all of the JIV reports to ensure that enormous analysis spanning many years can be done to increase the understanding of oil spillage in Nigeria in relationship to the causative factors, socio political and socioeconomic trends and also open our eyes to the nexus between the different parameters of the JIV reports and even the different JIV reports especially when we rely on the geographical location of these incidents, nexus which will could missed when the oil spill data are disparate as they are in the different oil spill JIV reports.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between both authors. Author ADM and DCO' designed the study, while Author ADM performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'Author DCO' and 'Author FTB' managed the analyses of the study. 'Author ADM' managed the literature searches. All authors read and approved the final manuscript.

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