FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 8 No. 5, October, 2024, pp 232 - 237
DOI: https://doi.org/10.33003/fjs-2024-0805-2686

ESTIMATION OF OIL SPILLAGE AND SALVAGE REVENUE IN KOKORI OIL FIELD USING NUMERICAL METHODS AND PYTHON ALGORITHM

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ABSTRACT

The study aimed to estimate oil spillage in the Kokori Oil Field, discovered in 1958, using a linear model. The field has 23 oil wells and produced 383 million barrels of oil. A linear model was developed using Python programming, comparing it with the trapezoidal method and salvage revenue. Results showed a linear relationship between oil spill quantity, duration, and mitigation measures. This study provides a valuable model for estimating oil spillage in the Kokori oil field, emphasizing the importance of accurate estimation for environmental and economic purposes. The study presents a comprehensive model for estimating oil spillage in the Kokori oil field, emphasizing the significance of accurate estimation for environmental and economic purposes. The correlation coefficient value supports the model's sufficiency, and the calculated salvage revenue indicates a commendable projected value for the Kokori oil field at its end of use. Salvage revenue is the estimated value of an asset at the end of its useful life, which is crucial in determining the cost of goods sold and depreciation charge. It lowers the asset's cost, influences its usable life, resale value, and replacement cost. Salvage revenue is calculated by subtracting revenue generated without mitigation measures from revenue realized with mitigation measures.

Keywords: Oil Spillage, Kokori oil field, Linear model, Integration method, Trapezoidal method of Python, Algorithm

INTRODUCTION

Over the years, particularly in the last decade, there has been a growing use of machine learning to solve problems in today's world. Areas where machine learning has been applied successfully include but are not limited to population forecasting (Atajeromavwo et. al., 2024); diabetes mellitus subtype classification and identification (Rufai et. al., 2024); cyberbullying detection (Maikano, 2024); breast cancer detection (Olofintuyi S. S., 2023); and child delivery (Abdulmumini et. al., 2022) etc. More areas of applications have been explored, and one of such areas is the oil and gas sector, particularly issues involving oil spillage.

Oil spillage can be defined as the release of oil into the environment, typically as a result of human activity or natural disasters. This normally occurs during various stages of oil exploration production, transportation and storage. Oil spillage can have a great consequence and effects on the environment, wildlife, and human communities. Some common causes of oil spillage are: Pipeline rupture leaks, tankers accidents or collisions, offshore platforms failure, refining or storage tank leaks, and natural disasters like hurricanes or earthquakes. Olujobi et al (2018) applied an enduring model that could assist to regenerate natural environment conservation.

It has been reported previously that oil spills can lead to water pollution and contamination, wildlife death and injury, damage to ecosystems, economic loses for industries like fishing and tourism and health risks for humans and wildlife NOSDRA (2021), and, the need for the remediation of crude oil impacted ecosystem cannot be overemphasized (Nnaji et al., 2023). The major oil spills in the world include: Deep Nalu Horizon of 2020, Exxon Valdez of 1989, Amoco Cadiz of 1978, and Torrey Canyon of 1967 as reported by Wang et al (2001).

Kokori Oil field was discovered by Shell Petroleum Development Company in 1958. The Oil Field is located in the onshore of Niger Delta, where there is abundance of crude oil. The Kokori Oil field is one of 11 Fields covered by the OML 30 License. The number of Oil well in Kokori field is 23. Automated Oil wells have been in operation since 1994, and the last recorded revenue from Kokori oil fields in 1994 was 68 billion Naira (N68 BN) Vanguard Newspaper, July 20th, 2020.The operator of the Kokori Oil field is Shoreline Natural Resources and Nigerian Petroleum Development Company. Shoreline Natural Resources owned 45% while Nigerian Petroleum Development have equity of 55%. The cumulative production of the oil field is approximately 383 million barrel of oil. The current production of Kokori oil field is approximately 2.19 million barrel of oil per year. The Kokori oil field crude is second best crude in the world because it is devoid of Sulphur, which causes sour petroleum. Thus, the crude from the Kokoro Oil Field can rightly be termed as sweet crude.

Ifeoma et al (2019) used Analysis of Variance Approach for estimation of oil spillage and causes in Niger Delta Region of Nigeria. However, in this present work, the oil spillage in Kokori Oil Field will be modeled using linear model of the integration and trapezoidal method of area under the curve with Algorithm of Python Programming. This methods were adopted due to their straightforwardness, simplicity and high accuracy.

The Trapezoid Method is a numerical technique used to approximate the area under a curve. In the context of linear models, it has been widely applied to estimate the area under the curve to a linear function. One of the earliest applications of the trapezoid method for estimating the area under a linear curve was by Atajeromavwo et al (2015 & 2021), who used it to calculate the area under a linear exponential growth curve in Population. Since then, numerous studies have employed

the Trapezoid method for various applications, including Atajeromavwo et al (2021) & Agboola et al (2023).
The Trapezoid method has been shown to be simple and efficient technique for estimating the area under a linear curve (Miller, G., 2023) and Gupta, S. (Gupta, S., 2010). It involves dividing the area under the curve. The method is particularly useful when the linear function is complex or difficult to integrate analytically, Zang, Y. (2010).
From the foregoing, it is imperative to succinctly state that the main objective of this study is to build a linear model of oil spillage and salvage revenue using the Python trapezoidal method of numerical analysis and the integration method of the oil spillage area under curve. The specific objectives are to: develop an algorithm for the oil spillage area under a curve for the Kokori Oil Field; estimate the oil spillage area under the performance curve using the Trapezoidal method of numerical integration and integration method; compare the oil spillage prediction result with the Trapezoidal Python library; and evaluate the accuracy of the oil spillage area under the performance curve.

MATERIALS AND METHODS

Data of Collection

The data utilized for the linear model derivation involving the oil spillage of Kokori Oil Field were collected from Nigerian National Petroleum Corporation (NNPC) of Nigeria, Abuja in 1997. From the corroded manifold, according to the obtained data, the quantity of oil spilled on the first day in the Kokori Oil Field was approximately 1300 barrels per day (bpd).

Derivation of Linear Model of Oil Spillage and the Integration Method of Oil Spillage Area Under Curve Estimation

The oil spillage in 1997, for the initial day was 1300 barrel. There was persistent drop in the oil spillage from the site of the eruption of the corroded manifold for the initial day at t = 0 to 60 days. The observed drop in oil spillage with days was due to appropriate mitigation steps carried out by NOSDRA and team of NPDC experts.
In deriving the linear model for the oil spillage, let:

$$S(t) = 1300 - \left(\frac{1300}{60}\right)t \qquad (1)$$

t is from t $\geq 0 \leq 60$
Where:
S is Oil spillage in barrels
t is the time of days during oil spillage
t ranges from zero to 60 days duration of the oil spillage in Kokori Oil Field.
This linear model of oil spillage of equation (1) when compared with a linear equation of straight

Y = MX + C (2)

M = -1300/60 represent the gradient of the linear model of the oil spillage in Kokori Oil Field
C = 1300 is the general intercept of the linear model of the oil spillage in Kokori Oil Field.

$$S(t) = 1300 - \left(\frac{1300}{60}\right)t \qquad (3)$$

Where t is the time in days
($0 \leq t \leq 60$)
Upon integration within the specified limits,

$$S = \int_0^{60} 1300 - \left(\frac{1300}{60}\right)t \quad dt \qquad (4)$$

The area under the curve of Total oil spillage of Kokori Oil Field originate from range of zero to 60 days.

$= ((1300 * t - \left(\frac{1300}{60*2}\right) * t\text{^}2)$

= [(78000- 3 9,000)]-(0)

= 39000 barrels

Trapezoidal Method Algorithm of Estimation of Oil Spillage in Kokori Oil Field for 60 Days

i. Begin
ii. Define function f(x)
iii. Read Lower Border of integration, upper Border of integration of Oil Spillage in Kokori Oil Field and number of Sub interval
iv. Calculate strip size = (upper Limit Oil Spillage in Kokori Oil Field) - lower Limit Oil Spillage in Kokori Oil Field } divided by number of sub interval
v. Set: Integration value = f(lower limit Oil Spillage in Kokori Oil Field) + f(upper limit Oil Spillage in Kokori Oil Field)
vi. Set: i = 1
vii. If i > number of sub interval then goto
viii. Calculate: K = lower limit + i*h
ix. Calculate: Integration value = Integration Value Oil Spillage in Kokori Oil Field = +2*f(k)
x. Increment I by 1, that is, i = i+1 and goto step 7
xi. Calculate: Integration value = Integration value Oil Spillage in Kokori Oil Field *step size/2
xii. Display integration value Oil Spillage in Kokori Oil Field as required answer
xiii. Stop

Python Library for Trapezoidal Technique of Estimation of Oil Spillage in Kokori Oil Field for 60 Days.

This is founded on the application of the Trapezoidal Technique Algorithm for the Total Oil Spillage occurred for a duration 60 days in Kokori Oil Field.

```
import math
def trapezoidal_rule_formula(y):
    h = 3
    n = len(y) - 1 #Number of interval
    #sum of the first and last and multiply by the area
    integral = (h/2) * (y[0] + y[-1])
    #sum all y_values except the first and last
    sum_y_values = sum(y[1:-1])
    #Multiply the sum by 2 and add  b to integral
    integral + = 2 * sum_y_values
       return integral
#list containing y values
y_values= [
1300,1235,1170,1105,1040,975,910,855,780.715,650.585,520,455,390,325,260,195,130,65,0]
result = trapezoidal rule formula (y_values)
print(round(result,2))
26,670.00
26,670 barrels.
```

Trapezoidal rule using Manual Method of Estimation of Oil Spillage in Kokori Oil Field

Trapezoidal rule Area = $\frac{h}{2}$ [(Sum of the first and last ordinate) + 2 (other ordinates)] (5)

h= (upper limit- lower limit) /number of ordinates or intervals (6)

Trapezoidal rule:

$$\text{Area} \approx \frac{h}{2}\left[(S_0 + S_n) + 2\sum_{i=1}^{n-1} S_i\right] \qquad (7)$$

Upper limit = 60; Lower limit = 0, and number of interval =20
h = (60-0)/20
h = 3
Trapezoidal rule Area =

$$\frac{h}{2}\left[(S_0 + S_{20}) + 2((S_1 + S_2 + S_3 + S_4 + \ldots\ldots + S_{19}))\right] \qquad (8)$$

Substitute the values of h and S_i into equation 8
= 26,670 barrels

It is crucial to state here that multiple linear regression model is adopted in this research in predicting the oil spillage in Kokori Oil Field sequel to the fact that it can handle several factors, produce quantitative predictions, and produce results that are easy to understand.

RESULTS AND DISCUSSION

Results obtained from the 60 days oil spillage in Kokori Oil Field For 60 Days depicted in Tables 1 and 2, and the relationship between the quantity of oil spilled with respect to days is shown in plots of Figures 1 and 2.

Table 1: Oil Spillage in Kokori Oil Field that occurred for a duration of 60 Days

t	$S = \int_0^{60} 1300 - (1300/60)t$	S_i
O	1300	S_o
3	1235	S_1
6	1170	S_2
9	1105	S_3
12	1040	S_4
15	975	S_5
18	910	S_6
21	855	S_7
24	780	S_8
27	715	S_9
30	650	S_{10}
33	585	S_{11}
36	520	S_{12}
39	455	S_{13}
42	390	S_{14}
45	325	S_{15}
48	260	S_{16}
51	195	S_{17}
54	130	S_{18}
57	65	S_{19}
60	0	S_{20}

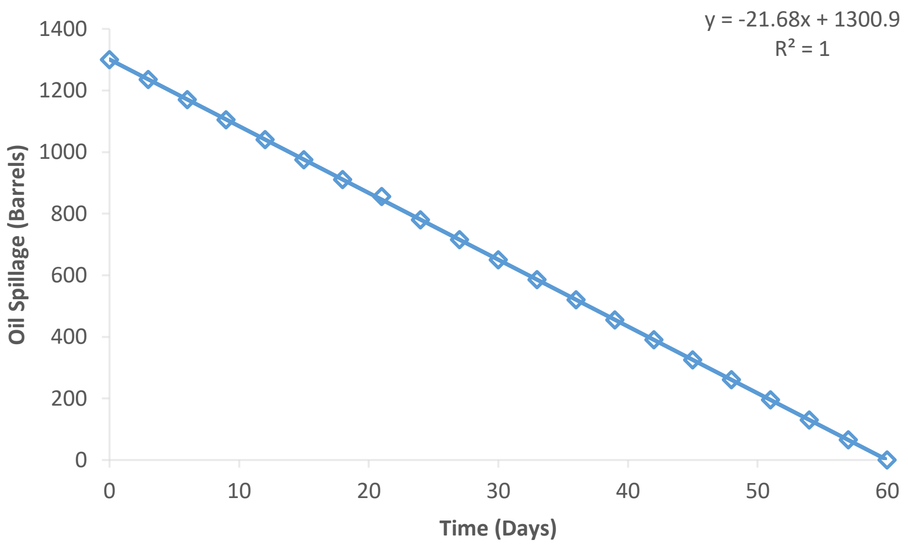

Figure 1: The graph of Oil Spillage with time of Kokori Oil Field

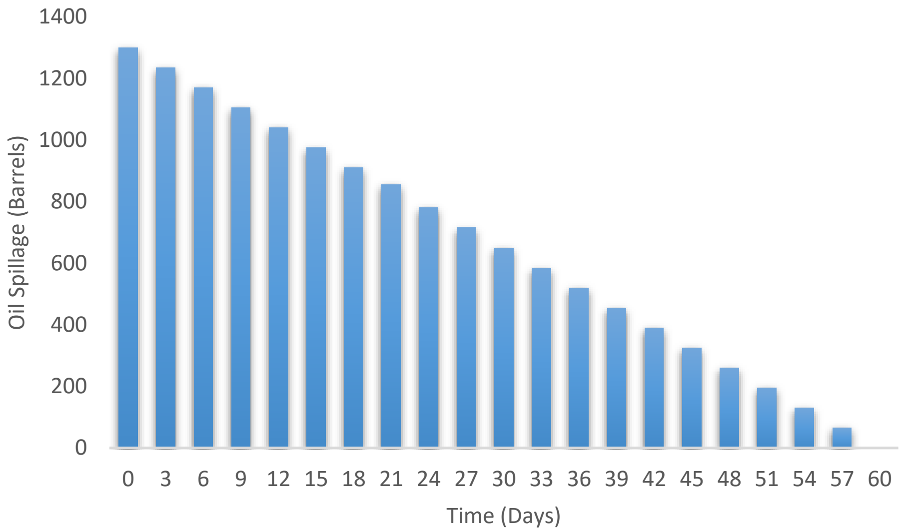

Figure 2: The Bar chart Oil Spillage with time of Kokori Oil Field

A cursory look at Figures1 and 2 show an inverse relationship between the quantity of oil spilled and time. That is, the amount of observed oil spillage decrease progressively as days progressed. While the first day the spillage commenced recorded the largest amount of oil spilled, this quantity diminished linearly downward until the spillage ceased. It can be stated that because NOSDRA and a group of NPDC professionals took the proper mitigation measures, there was an observed decrease in oil spillage over the course of days under review. The value of the coefficient of determination obtained from the line graph of Figure 1 significantly suggest the model is adequately fit in understanding the relationship between the quantity of oil spillage the time involved during which the oil was spilled.

It is pertinent to state here that in 1997, the price of Brent crude was $19.11. Hence, total revenue during the NNPC intervention and mitigation using Integration Method = Barrels of oil spillage obtained using the integration method multiply by price of crude oil (9)

= 39, 000 barrels* $19.11

= $ 745, 290

Similarly, total revenue of oil spillage during the NNPC intervention using Trapezoidal method with mitigation = Number of Barrels in Trapezoidal Method Expected in Kokori Oil Field x Price of Oil Crude (10)

= 26,670 barrels * $19.11

= $ 509, 663.7

Total Oil Spillage without intervention of government or NNPC Mitigation

Total oil Spillage expected = Number of barrels of oil spillage* Number of day.

Total cost of Revenue without Mitigation of oil spillage in Kokori Oil Field

= Total oil spillage in Kokori Oil Field * price in Dollar for the period of time (11)

Total Revenue Without mitigation = 78, 000 * $19.11

= $1,490,880

Salvage Revenue of Integration Method

Salvage Revenue from Integration Method = Total Revenue without mitigation -Total amount with mitigation using Integration Method. (12)

= $1,496,580 – $745,290

= $751,290

Salvage Revenue from Trapezoidal Method

Salvage Revenue from Trapezoidal Method = Total Revenue without mitigation -Total amount with mitigation Trapezoidal Method. (13)

= $1, 496, 580 – $509, 663.7

= $986916.3

Table 2: Summary of Oil Spillage in KoKori Oil Field in 1997

S/N	Method of Estimation of Oil Spillage	Integration Method	Trapezoidal Method by Manual	Trapezoidal Method by Python	Calculation of Oil spillage in 60days Without government Intervention and NNPC Operator.
1	Total Oil Spillage Area obtained by Intervention and Mitigation in Barrels	39000 barrels	26700 barrels	26700 barrels	78000 barrels
2	Total Revenue obtained by Intervention and Mitigation by government and NNPC of Oil Spillage in Barrels	745290 Dollars	509603.9 Dollars	509603.9 Dollars	Nil

3	Total Oil Revenue without Intervention and Mitigation by government and NNPC of Oil Spillage Barrels in Dollars	Nil	Nil	Nil	1490880 Dollars
4	Salvage Revenue of Oil Spillage Area in Dollars	751290 Dollars	986916.3 Dollars	986916.3 Dollars	Nil

The Table 2, captures the summary of oil spillage in KoKori Oil Field in 1997 with the associated parameters obtained from the linear model and various equations. When compared to the trapezoidal technique, the integration method provides an accurate answer for the oil leak in Kokori Oil Field. This phenomenon results from the fact that, while the trapezoidal method computes in segments of the area under the curve, the analytical integration method considers the days of the oil spill from the lowest to the highest, covering the entire duration of the spill at a glance.

CONCLUSION

The paper contributes to the body of knowledge by providing a basis for comparing results from the Integration and Trapezoidal methods in estimating a linear model of oil spillage using a Python library. In addition, The algorithm developed for predicting the area of oil spillage in the Kokori oil field visualizes results over time through graphs and bar charts (Figures 1 and 2), highlighting trends in spillage.; and the oil spillage Area under the curve of the Integration Method and Trapezoidal Method for Kokori has been obtained for 60 days.

Future research should focus on comparing the area under the curve of oil spillage estimates using the Integration Method, Trapezoidal Method, and Simpson's Rule.

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