

Research Article

Evaluation of CO₂ Storage Potential of Some Depleted Hydrocarbon Reservoirs: Niger Delta Case Study

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Abstract

Recent joint efforts led by the international financial corporation (IFC) with strong support from the Federal Government of Nigeria and various industrial and policy stakeholders has produced the Nigerian CO₂ Storage Atlas, sorting prospective geological storage sites. However, the storage efficiency factors applied to the estimated resource capacity to provide low, medium and high resource estimations may not be a true representation for the underground CO₂ storage space, especially for depleted hydrocarbon reservoirs, in the Nigeria rich oil province that is very porous and permeable. We therefore present assessment of CO₂ storage potential of some depleted hydrocarbon reservoirs in the Niger Delta, derive specific approximate CO₂ Storage efficiency factors for these reservoirs, and develop a model for determining site-specific CO₂ storage efficiency factor. Comparison of results from various approaches – production-based, volumetric- based with varying CO₂ storage efficiency factors obtained from the new model and previous works, and an enhanced analytical simulation tool (EASiTool) was also carried out. The newly developed model for determining site-specific CO₂ storage efficiency factor can help improve the predictive capability of the volumetric method for CO₂ storage potential estimates, especially for depleted oil reservoirs in the Niger Delta.

Keywords

CO₂ Storage Efficiency Factor, CO₂ Storage Resources, Nigerian CO₂ Storage Atlas, CO₂ Storage Estimates, Geological Storage

1. Introduction

Carbon capture, utilization, and storage (CCUS) projects are increasing in number across the globe to ease climate change. A total of 202 carbon capture and storage (CCS) projects can be found in the United State of America (USA) and

Canada, out of which twenty-one facilities are in operation, nine in construction, eighty in advanced development and ninety-two in early development. In Europe, there are four facilities in operation, six in construction and one hundred and

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Received: 6 May 2026; Accepted: 18 May 2026; Published: 27 May 2026



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nine are in early or advanced development. The Middle East and North Africa have three facilities in operation, three in construction and three in advanced development. South America has one facility in operation and one in early development, and Asia Pacific has twelve facilities in operation, eight in construction and thirty-four in advanced or early development [14]. Some CCS progress, and initiatives by some countries and regions, and their potential storage capacity are as follows: the 420 Million tonnes per year by 2030 by the USA, through the additional funding from the 2021 Infrastructure Investment and Jobs Act and beneficial CCUS tax credit adjustments in the 2022 Inflation Reduction Act [16]; the Net Zero Industry Act was introduced by the European Union (EU), setting an annual goal of 50 Million tonnes (Mt) per year for Carbon IV Oxide (CO₂) injection by 2030 and aim to increase to 300 Mt per year by 2040 [33]; The early deployment of CCS projects with up to 30 Mt per year target by 2030, backed by billions of Pounds in the Spring Budget of 2023 [4]; The United Arab Emirate's (UAE) target of 5 Mt per year by 2030, the 44 Mt per year by 2035 set by Saudi Arabia, and Qatar committed to reducing emissions by 25% by 2030, aiming to have 7 Mt per year by 2030 [8].

Underground space for carbon sequestration is abundant to facilitate carbon emission reduction targets. The CO₂ geological storage potential in reservoirs of sedimentary bodies, which represents the reservoir maximum capacity for CO₂ storage, is much better explored and developed, with clearer characteristics and more data available in hydrocarbon reservoirs than in coal beds and deep saline aquifers. Hydrocarbon reservoirs have proven capacity for fluid injection, potential for layered storage, and existing well infrastructure for monitoring [12]. Several actual and planned CO₂ geological storage projects worldwide are in different locations and with different formation types, such as deep saline aquifers, depleted oil and gas fields, and basalt formations [34]. Some projects in deep saline aquifers are; the Sleipner field project in North Sea, Norway has an estimated storage capacity of 2) Mt [22, 23, 31], the Rangely field project in Northwest Colorado [3, 21], and the Gorgon liquified natural gas project in Western Australia has one hundred and twenty-nine (129) Mt storage capacity [41]. The CO₂-CRC project in Australia [32], the SACROC field in Texas [17], the Cranfield project in Natchez, USA [40] and the In Salah CO₂ Storage Project [30] are in depleted oil and gas reservoirs.

Many previous studies, with comprehensive datasets on the geological storage potential are predominantly from geologic provinces in the USA and Canada [25], in onshore and offshore basins across Europe, and in Asia Pacific. Reservoir-level datasets of CO₂ storage potential, such as; porosity, permeability, depth, and other critical parameters for thirty-three

(33) sedimentary basins in eight regions of the U.S. have been documented by the United States Geological Survey (USGS) [39]. There are very few technically sound studies, with comprehensive datasets on the geological storage potential in developing countries. One of the barriers in the CCS process in developing countries is availability and accessibility of data concerning potential geological CO₂ storage locations. However, recently, a collective effort led by the international financial corporation (IFC) with concrete support from the Federal Government of Nigeria and numerous public and private sector stakeholders, has produced the Nigerian CO₂ Storage Atlas, cataloguing prospective geological storage sites, to address the data gaps [20]. The Atlas reported 10,700 Gigatonnes (Gt) of prospective CO₂ storage resources (using the volumetric method outlined by the U.S. Department of Energy's National Energy Technology Laboratory (DOE-NETL) [25], with an adjustment for net, rather than gross thickness) and showed that the most suitable locations are in the Niger Delta, specifically the saline aquifers and depleted oil and gas fields within the Miocene-age formations. However, the storage efficiency factor (EF) of 0.5% for low case, 2.0% for medium case and 5.4% high case, guided by the work of Goodman et al. [15], applied to the estimated resource capacity to provide low, medium and high resource estimations may not be a true representation for the underground CO₂ storage space in the Niger Delta. This study therefore applies a production-based approach (proposed by the Carbon Sequestration Leadership Forum (CSLF), [7] to estimate the CO₂ Storage Resource potential for some depleted oil reservoirs in the Niger Delta, derives and proposes a storage efficiency factor to improve the predictive capability of the volumetric method. Results comparison of the predicted prospective CO₂ storage resources to that of Nigerian CO₂ Storage Atlas was also carried out.

2. Brief Overview of the Niger Delta, Gathered Datasets and CO₂ Storage Potential Estimations for This Study

There are five sedimentary basins of Nigeria with potential to store subsurface CO₂: Niger Delta (onshore and offshore), Dahomey Basin, Benue Trough, Bida Basin, and Chad Basin (see, Figure 1). The Niger Delta is one of the most productive deltaic petroleum systems, with decades of oil and gas exploration and exploitation activities, in the world. It has over 12,000 m of sediments, which is composed of three diachronous siliciclastic units: the deep-marine pro-delta Akata Group, the shallow-marine delta-front Agbada Group and the continental, delta-top Benin Group [20].

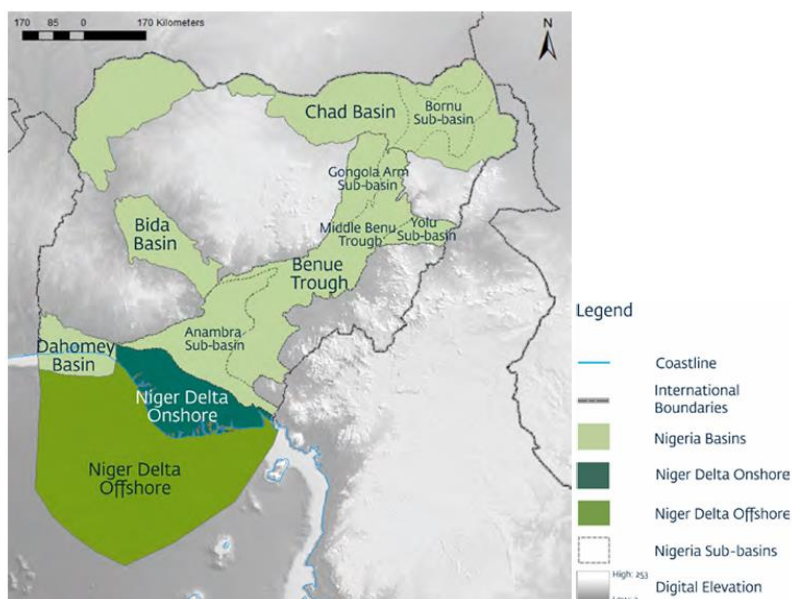


Figure 1. Map location of the Niger Delta [1].

2.1. Datasets for This Work

In the Nigerian oil and gas sector, as at 2023, there were over 200 fields, more than 1200 reservoirs and over 2500 wells with records of technical allowable rates. Details of the distribution of the reservoirs and wells in the hydrocarbon fields can be found in the website of Nigeria Upstream Petroleum Regulatory Commission (NUPRC). Geological and petrophysical information of some of these oil and gas fields can be found in some public literatures, such as [5, 27, 29, 36, 37] and websites of the fields’ operators. Dataset of 250 reser-

voirs from the Niger Delta, which were obtained from different sources - well logs, well testing, seismic analysis, simulation studies, pressure buildup test, area versus depth plot obtained from mapping packages, reservoir isochores, proprietary software to estimate probabilistic in place volumes and reservoir engineering calculations where necessary, was used for this study. Some of these datasets from oil reservoirs with small pay thickness and variable gas cap sizes have been reported by [26, 28, 35, 38].

The statistical description of the data is presented in Table 1, and relevant data information for twenty-five (25) reservoirs are also provided in Table 4 in the appendix.

Table 1. Statistical description of oil rim dataset used in this study.

Parameters	Min. value	Max. value	Mean	Standard deviation	Variance
Porosity (%)	15	35	26.1	4.08	16.62
Water saturation (%)	5.0	40.0	24.6	10.80	116.63
Oil formation volume factor (rb/stb)	1.08	6.27	1.47	273.40	74748.03
Gas cap, m-factor	0.01	4.73	0.66	0.8387	0.70
Area (acres)	19.66	64593.74	856.64	5131	26327160
Average net pay (ft)	10	524	58.53	47.92	2296.18
Temperature (oF)	125	240	175.20	25.39	644.80
(Oil up to (OUT) pressure (psi)	2148	5984	3717.40	715.06	511308.79
OUT depth (ft)	4930	13017	8486.15	1584.95	2512061.73
Rsi (scf/bbl)	76	6234	925.76	593.31	352021.17
Permeability (mD)	3.36	18225	797.97	1439.87	2073213.4
OIP (MMstb)	0.9	158.4	21.3	24.9880	624.4042

2.2. Estimation of CO₂ Storage Potential for Some Hydrocarbon Reservoirs

The volumetric method (see, Eq. (1)) proposed by the U.S. Department of Energy (US-DOE), which is based on the industry standard method for calculating original oil or gas in

$$MCO_{2(prod)} = \rho CO_2 \times E_{Roil/gas} \times A \times h \times \phi \times (1 - Sw) \tag{1}$$

$$MCO_{2(vol)} = \rho CO_2 \times [RF \times \frac{OOIP}{B_f} - V_{iw} + V_{pw}] \tag{2}$$

where, $MCO_{2(vol)}$, mass estimate of oil and gas reservoir CO₂ storage resource, tonnes; A , drainage area of the oil or gas reservoir that is being assessed for CO₂ storage, ft²; h , net oil and gas thickness of the reservoir, ft; ϕ , average effective porosity, fraction; Sw , average initial water saturation within the total area and net thickness, fraction; ρCO_2 , density of CO₂, lb/ft³; RF , oil and gas recovery factor, fraction; $E_{Roil/gas}$, CO₂ storage efficiency factor, the volume of CO₂ stored in an oil or gas reservoir per unit volume of original oil or gas in place (OOIP or OGIP), fraction; $OOIP$,

The volumetric method requires the CO₂ storage efficiency factor, which can be calculated using reservoir simulations or CO₂-Enhanced Oil Recovery experience. However, where

place (OOIP or OGIP) by the formation volume factor [6], and the production-based method (see, Eq. (2)) for CO₂ storage capacity estimation proposed by the Carbon Sequestration Leadership Forum (CSLF) are the most common approaches.

there are no reservoir simulations or CO₂-enhanced oil recovery experience, The CO₂ storage efficiency factor, guided by [15], is adopted. In the Nigeria CO₂ storage atlas report, an efficiency factor of 0.5% for low case, 2.0% for medium case and 5.4% high case, was used. Unfortunately, this may not be a true representation for the underground depleted hydrocarbon space in the Niger Delta. In this work, we therefore applied the production-based method to estimate the CO₂ storage potential of some depleted oil reservoirs, which is useful in site-specific calculations [2]. Figure 2 shows the results of CO₂ storage capacity, in Million tonnes (Mt). Majority of the reservoirs (over 200 reservoirs) have storage capacity less than 1.23 Mt. However, out of the two hundred and fifty (250) reservoirs evaluated, less than ten (10) reservoirs have CO₂ storage capacity between 1.23 and 3.68 Mt. The total storage capacity for the two hundred and fifty (250) reservoirs is about 76 Mt.

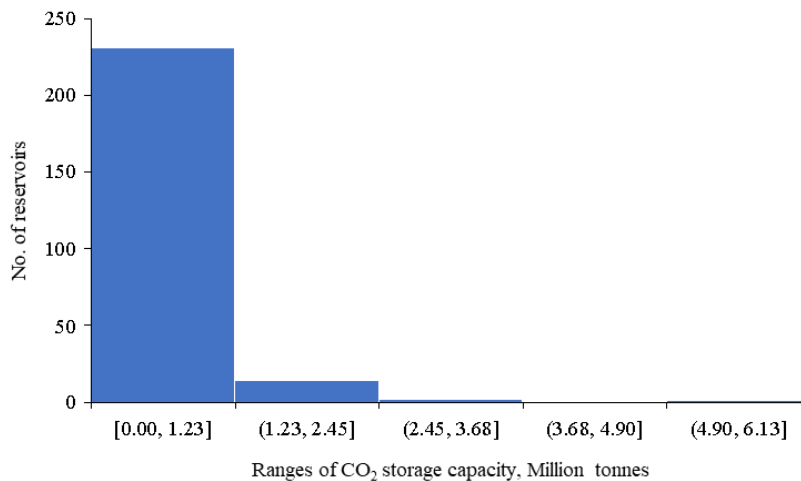


Figure 2. CO₂ storage capacity, in Million tonnes, predictions using the production-based model for the reservoirs under study.

Predictions from volumetric method (see, Equation (1)), after adopting CO₂ efficiency factor of 0.5% for low case, 2.0% for medium case and 5.4% high case, as used in the Nigeria CO₂ storage atlas report, were compared with that of the production-based model. Figures 3-5 show the spread of the percentages of deviations for the three cases. For CO₂ efficiency factor of 0.5%, over one hundred and forty (140) reservoirs

were under-predicted, with deviations less than 57% of the storage capacity predictions between the volumetric method and the production-based method, as can be seen in Figure 3. These large deviations observed can be due to uncertainties in the petrophysical properties and the generalized CO₂ efficiency factor of 0.5% may match the site-specific CO₂ efficiency factor for some reservoirs.

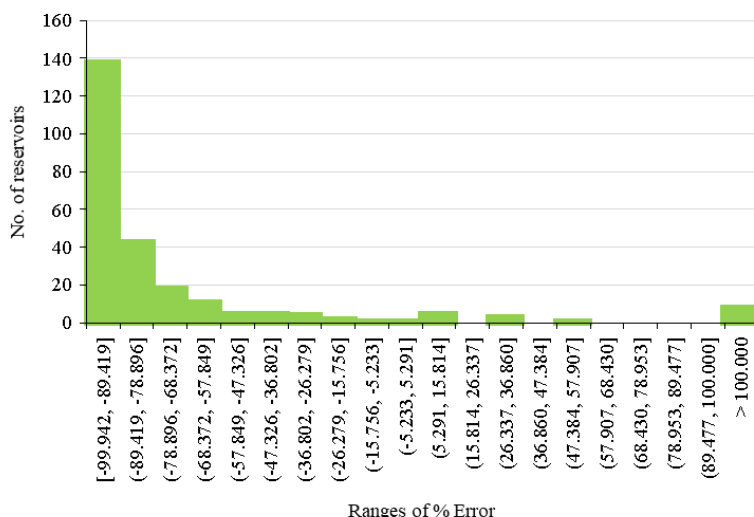


Figure 3. Ranges of percentage error for 0.5% CO₂ efficiency factor volumetric-based model, when compared with that of the production-based model.

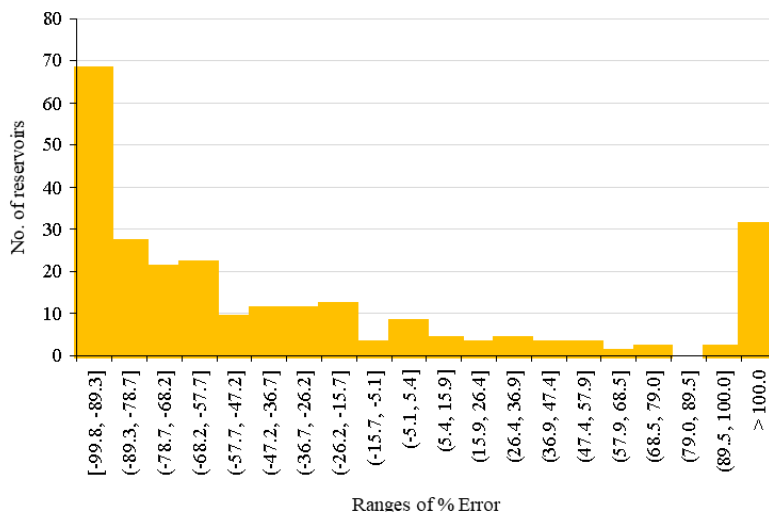


Figure 4. Ranges of percentage error for 2.0% CO₂ efficiency factor volumetric-based model, when compared with that of the production-based model.

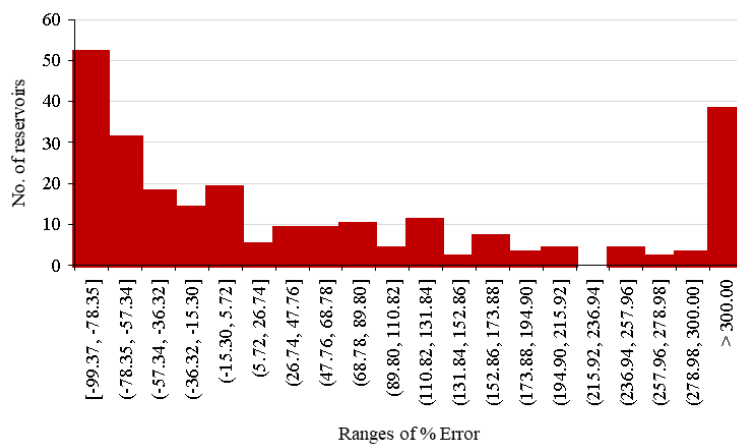


Figure 5. Ranges of percentage error for 5.4% CO₂ efficiency factor volumetric-based model, when compared with that of the production-based model.

Figure 4 shows the ranges of percentage error for 2.0% CO₂ efficiency factor; less than one hundred (100) reservoirs have percentage error bandwidth below -68%. There was increase in the number of reservoirs with improvement in predictions of the storage capacity between the volumetric method and the production-based method. The number of reservoirs increased further, when 5% CO₂ efficiency factor is applied, as can be seen in Figure 5. These analyses therefore demonstrate that the CO₂ efficiency factors can be greater than 5.4% for CO₂ storage resources in depleted oil reservoirs in the Niger Delta.

3. Development of Model for Estimation of Specific CO₂ Storage Efficiency Factor

The CO₂ storage efficiency factor, $E_{Roil/gas}$, which is the volume of CO₂ stored in an oil or gas reservoir per unit volume of original oil or gas in place (OOIP or OGIP), fraction; OOIP, is essential for realistic CO₂ storage resource estimate using the volumetric approach. Approximately 1.8% to 2.2% is the effective storage coefficient reported in the Carbon Sequestration Atlas for the United States and Canada [10, 11], developed through Monte Carlo simulation, for the P50 level. The US-DOE used a database, known as the Average Global Database (AGD) – from two main databases (the Gas Information System or GASIS (1999) and the Tertiary Oil Recovery Information System or TORIS (1995)), containing fluid and geologic properties for over 20,000 hydrocarbon reservoirs representing a wide variety of reservoir types from all over the world. CSLF proposed that, “the effective storage coefficients should be determined through numerical simula-

tions and/or field work” [7], and so no values were given. Effective storage coefficients of 2.0% to 3.3% as calculated through numerical simulations was reported by [19]. In 2011, Goodman et. al. [15] published efficiency factors based on documented ranges derived from oil and gas reservoirs and numerical simulations [19], by applying the log-odds normal distribution with Monte Carlo sampling procedure [9]; the overall efficiency for saline formations ranges from 0.40 to 5.5% for the three different lithologies (clastics, dolomites and limestones) over the 10 and 90 percent probability range, respectively.

At a site-specific scale, the [19] reported the efficiency factors to be 4.62 to 14.92%, 6.57 to 14.92%, and 4.24 to 9.82%, respectively for clastics, dolomites and limestones, over the 10 and 90 percent probability range. Goodman et. al. [15] reported 3.1 to 10%, 5.1 to 9.2%, and 3.5 to 7.3%, respectively for clastics, dolomites and limestones, according to the 10 and 90 percent probability range. So, the statement by the CSLF [7], as earlier shared, is behind the motivation of this section of this study.

3.1. Derivation of Specific Approximate CO₂ Storage Efficiency Factor

Previous studies have shown that predictions from production-based and volumetric methods are similar (US-DOE and CSLF). Ighomuaye et al [18] compared three methods – volumetric, production-based and correlation-based, using data from the Vermillion Basin, Gulf of Mexico (GOM), and observed that the CO₂ storage capacity estimates by the production-based and correlation-based methods deviate from the estimate of the volumetric methods by 7.3% and 14.6%, respectively.

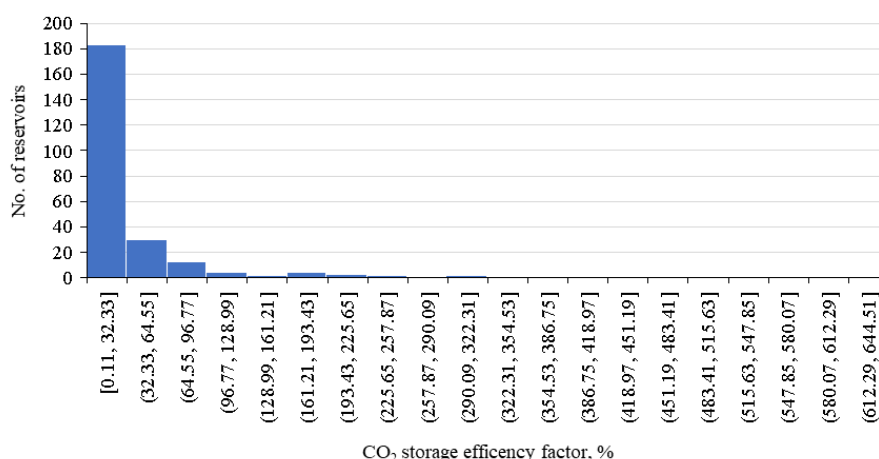


Figure 6. Distribution of the specific approximate CO₂ storage efficiency factors (%) for the reservoirs under study.

So, specific approximate CO₂ storage efficiency factors were therefore derived for the oil reservoirs considered in this

work, when we applied Eq. (1) with the assumption that the estimates of CO₂ storage potential from the production-based

approach Eq. (2) is equal to that of the volumetric method. Figure 6 shows the distribution of the specific approximate CO₂ storage efficiency factors for the reservoirs under study. One hundred and eighty (180) reservoirs have CO₂ storage efficiency factors between 0.11 and 32.33%. Less than thirty reservoirs (30) have CO₂ storage efficiency factors of 32.33 to 64.55%. From the analyses, we can also deduce that the CO₂ storage efficiency factors for hydrocarbon reservoirs may not exceed 32.33%, and it has a wide spread of values. Reservoirs with very good porosity, permeability and reservoir capacity values were observed to have high CO₂ storage efficiency factors.

3.2. Model Development for Approximate CO₂ Storage Efficiency Factor Determination

One of the simple machine learning methods was considered for this work, which is the Multiple linear regression (MLR) technique - statistical approach. The general multiple regression equation presented by [24] is expressed in Eq. (3).

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_p x_{ip} \quad (3)$$

where, $i = n$ observations; y_i is the dependent variable (predicted value); x_i , the input variables; β_0 , the intercept constant; β_p , the slope coefficients for each input variable.

The multiple linear regression tool available in Microsoft Excel package was used for the development of a model for approximate prediction of CO₂ Storage Efficiency Factor. Important input variables were considered for the development of CO₂ Storage Efficiency Factor model that will be best

suited for depleted hydrocarbon reservoirs, especially oil reservoirs in the Niger Delta, namely: reservoir thickness, h , ft; reservoir permeability, K , mD; drainage area, A , ft²; porosity, ϕ , %; water saturation, S_w , %. The dataset was partitioned into test size of 30% and training data of 70% for the multilinear regression process. The fitting performance was good, with an R-squared value of 0.71.

From the multiple linear regression process, the expressions for estimating the CO₂ Storage Efficiency Factor, EF_{CO_2} , is given in Eqs. (4) and (5).

$$EF_{CO_2} = 10^Z \quad (4)$$

where,

$$Z = b_1 \log_{10}^h + b_2 \log_{10}^K + b_3 \log_{10}^A + b_4 \log_{10}^\phi + b_5 \log_{10}^{S_w} \quad (5)$$

where, b_1 through b_5 denote the coefficients associated with the input variables. Thus, the coefficients of the developed model are presented in Table 2.

Table 2. Coefficients of the developed injection pressure model.

b_1	b_2	b_3	b_4	b_5
-2.17	5.95	-2.36	-9.61	3.37

Figure 7 shows the relationship between the percentage error and the predicted CO₂ storage efficiency factor. The percentage error bandwidth falls in the range of -52% and +37.66%, with an absolute average error of 37.03%.

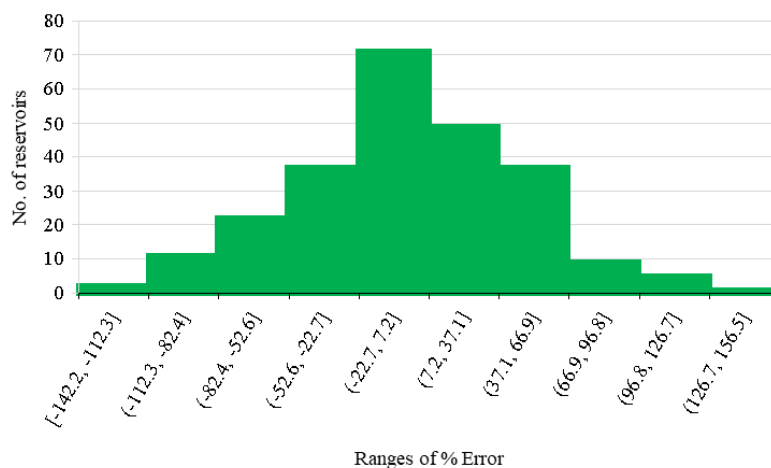


Figure 7. Percentage error and the predicted CO₂ storage efficiency factor.

Though the parameters considered in the development of the model were reservoir rock properties from less than 300 reservoirs in the Niger Delta, Eq. (3) can be a useful tool for

estimating CO₂ Storage Efficiency Factor to be used in the volumetric method for estimation of the CO₂ storage potential of depleted oil reservoirs in the Niger Delta. Where the model

predicts CO₂ storage efficiency factor above 32.33%, probabilistic estimation can be adopted with values between 0.11 and 32.33%; this is the range of values of the CO₂ storage efficiency factors for over one hundred and eighty (180) reservoirs, as earlier shown.

The standard errors from the MLR analysis show high values for the logarithmic values of the porosity and permeability,

as presented in Figure 8. So, reservoirs or storage media whose logarithmic values of the percentages of the porosities and permeabilities values are far from the mean values of 1.4125 and 2.6413, respectively, may result in over- or under-estimation of the CO₂ Storage Efficiency Factor, thereby affecting the predictive accuracy of the volumetric method in this region.

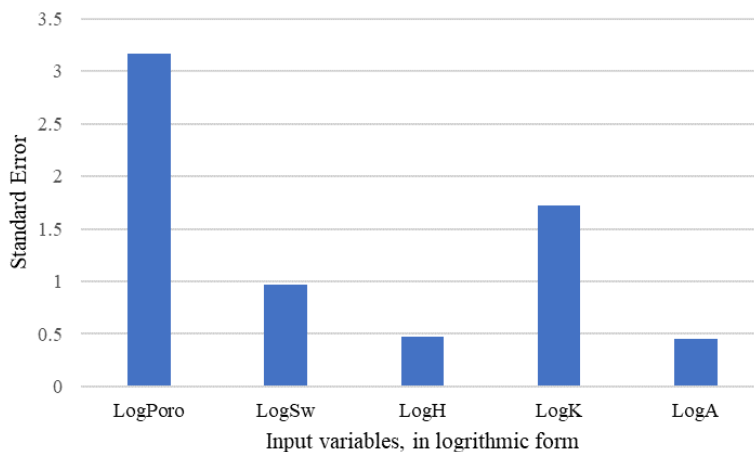


Figure 8. Standard error plot for the input variables in the MLR.

4. Predicted Results Comparison from Various Methods for Some Reservoirs

We compared the predictions from production-based, volumetric method with CO₂ efficiency factors (0.5, 2, and 5.4%) from [15] and the newly developed model, and an enhanced analytical simulation tool (EASiTool) by [13] developed to

predict pressure impact on CO₂ injectivity and reservoir-storage capacity of geological formations. For the EASiTool method, we consider one injection well with maximum injection pressure of 10% greater than the initial reservoir pressure. Information obtained from the EASiTool method include: CO₂ Storage Volume estimates, CO₂ injection rate and CO₂ plume radius. However, for this work, we only reported the CO₂ Storage Volume estimates. The results from the various methods are summarized in Table 3 and Figure 9.

Table 3. Predicted results from various approaches.

Res.	Average porosity (%)	Res. Net height (ft)	Water Sat. %	Perm., (mD)	Res. Area (Acre)	Prospective CO ₂ Storage Volume (Million tonnes)						
						Prod. Based	Site specific EF%	EASiTool	EF, New model	EF, 0.5%	EF, 2%	EF, 5.4%
1	23.0	80	17.0	422	30.5	0.0895	0.01828	0.0052	0.0283	0.0012	0.0050	0.0136
2	35.0	27	15.0	845	59.4	0.0512	0.01047	0.00044	0.0459	0.0012	0.0051	0.0140
3	19.0	18	37.0	215	179.0	0.0618	0.01264	0.00031	0.0143	0.0010	0.0041	0.0113
4	19.0	12	36.0	218	292.7	0.0732	0.01496	0.00143	0.0118	0.0011	0.0046	0.0125
5	25.0	32	25.0	395	94.1	0.0206	0.00422	0.00151	0.0195	0.0015	0.0061	0.0165
6	22.0	61	13.0	452	34.3	0.1951	0.03987	0.00101	0.0310	0.0010	0.0043	0.0117

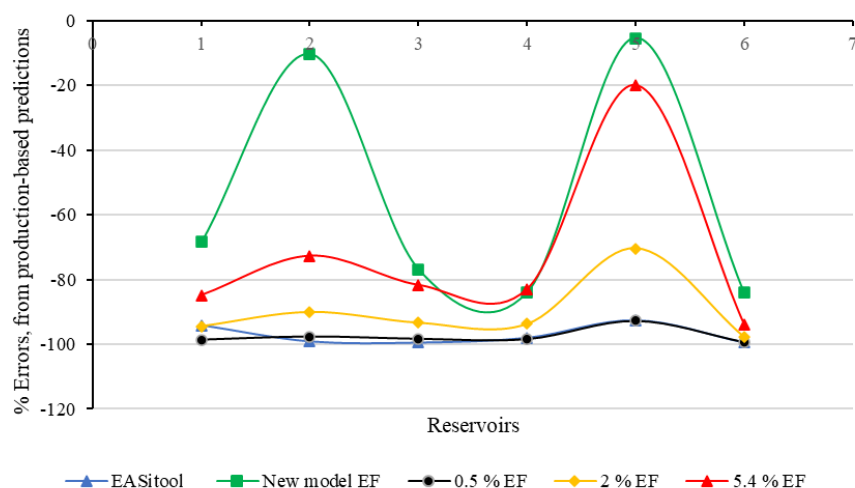


Figure 9. Comparison of predicted results from various approaches

For the six (6) reservoirs used for the comparison, all approaches under-predicted the CO₂ storage potential when referenced to results from the production-based method. All methods under-predicted the CO₂ storage potential for reservoirs designated as 1, 3, 4 and 6. However, results from the new model, for specific approximate CO₂ Storage Efficiency Factor, have the best predictions for reservoirs designated as 2 and 5; the percentage errors were less than -20%. Predictions from the EASiTool match excellently well with that of the 0.5% efficiency factor approach for all reservoirs.

5. Conclusion

There are many depleted hydrocarbon reservoirs in the Niger Delta with CO₂ storage potential. The production-based method applied to estimate the CO₂ storage potential of some depleted oil reservoirs under study gives a total storage capacity of about 76 Million tonnes. Predictions from the volumetric method with CO₂ efficiency factor of 0.5% for low case, 2.0% for medium case and 5.4% for high case, show large deviations from the production-based method. Majority of the reservoirs under study have CO₂ storage efficiency factors between 0.11 and 32.33%. The relationship between the percentage error and the predicted CO₂ storage efficiency factor, from the newly developed model, falls in the range of -52% and +37-66%, with an absolute average error of 37.03%. Under-predictions of storage capacity were observed from the volumetric method with CO₂ efficiency factors (0.5, 2, and 5.4%) from [15] and the newly developed model, and an enhanced analytical simulation tool (EASiTool) by [13], when compared to that of the production-based approach, for the six (6) reservoirs used in the analyses. However, results from the new model, for specific approximate CO₂ storage efficiency factor, have the best predictions. The findings in this work will primarily best applied to depleted oil reservoirs in the Niger

Delta, and may not be directly applicable to the region's massive saline aquifer potential, which often holds the largest volume of storage capacity in CCS projects.

Abbreviations

AGD	Average Global Database
CCS	Carbon Capture, and Storage
CCUS	Carbon Capture, Utilization, and Storage
CSLF	Carbon Sequestration Leadership Forum
CO ₂	Carbon IV Oxide
DOE-NETL	U.S. Department of Energy's National Energy Technology Laboratory
EASiTool	Enhanced Analytical Simulation Tool
EF_{CO_2}	CO ₂ Storage Efficiency Factor
EU	European Union
GOM	Gulf of Mexico
IFC	International Financial Corporation
Mt	Million Tonnes
NUPRC	Nigeria Upstream Petroleum Regulatory Commission
OGIP	Original Gas in Place
OOIP	Original Oil in Place
ODT	Oil Down to
OUT	Oil Up to
TORIS	Tertiary Oil Recovery Information System
UAE	United Arab Emirate
USA	United State of America
USGS	United States Geological Survey
US-DOE	U.S. Department of Energy

Author Contributions

Aniefiok Livinus: Conceptualization, Resources, Supervision, Writing – review & editing
Raymond Mkpouto Obot: Data curation, Formal Analysis,

Writing – original draft

Antigha Eyo: Data curation, Writing – review & editing

Ito Udofort Koffi: Data curation, Writing – review & editing

Victor E. Etuk: Writing – review & editing

study available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

The full datasets used and/or analysed during the current

Appendix

Table 4 Gathered dataset for twenty-five (25) depleted hydrocarbon reservoirs in the Niger Delta, Nigeria.

OIIP EXP	Av. Np	Poro%	Water Sat%	Avg H, ft	ODT ftss	ODT psi	Boi v/v	Res. T, oF	API	Perm, mD	A, Acres
8.90	2.50	23.00	17.00	80.00	10510.00	4576.00	1.77	218.00	34.97	423.00	30.53
25.37	0.36	35.00	15.00	27.00	6602.00	2883.00	1.19	144.00	22.30	845.33	59.48
5.67	0.21	19.00	37.00	18.00	9142.00	3974.00	1.77	196.00	45.38	215.28	179.06
3.90	1.29	19.00	36.00	12.00	9998.00	4340.00	1.96	212.00	45.38	218.25	292.78
0.90	0.27	25.00	25.00	32.00	8566.00	3751.00	1.97	182.00	39.19	395.28	94.17
6.50	1.05	22.00	13.00	61.00	9199.00	4200.00	1.59	190.00	40.85	452.51	34.35
112.70	0.60	27.00	24.00	40.00	6590.00	2880.00	1.14	125.00	17.76	452.80	42.91
95.00	1.74	28.00	21.00	20.00	6657.00	2910.00	1.14	126.00	18.55	511.21	82.41
14.80	0.09	26.00	30.00	31.00	8082.00	3530.00	1.24	155.00	28.93	382.71	65.34
15.00	0.18	26.00	42.00	8.00	8083.00	3530.00	1.20	155.00	26.60	323.45	297.68
24.10	3.31	31.00	11.00	26.00	8330.00	3640.00	1.26	160.00	29.48	822.84	62.37
68.50	4.97	28.00	21.00	42.00	8820.00	3926.00	1.50	168.00	36.15	511.21	51.86
5.40	3.43	29.00	20.00	50.00	7669.00	3365.00	1.17	142.00	23.65	552.14	33.61
7.10	0.25	27.00	26.00	22.00	7454.00	3248.00	1.35	174.00	25.72	435.04	95.27
5.10	0.31	27.00	26.00	25.00	7454.00	3248.00	1.24	174.00	25.72	435.04	76.96
41.40	0.32	23.00	16.00	110.00	7972.00	3474.00	1.33	182.00	29.30	436.02	16.50
17.10	0.82	26.00	20.00	24.00	8776.00	3824.00	1.51	184.00	36.15	468.72	90.40
39.90	2.57	24.00	20.00	100.00	8945.00	3898.00	1.58	201.00	34.97	415.69	22.60
4.10	2.62	22.00	19.00	88.00	9858.00	4278.00	1.68	220.00	35.96	374.31	27.02
4.60	1.10	22.00	19.00	27.00	9858.00	4278.00	1.68	220.00	35.96	374.31	88.07
16.20	3.51	26.00	10.00	90.00	10908.00	4734.00	1.53	221.00	30.77	662.87	21.64
2.20	1.91	26.00	10.00	30.00	10099.00	4420.00	1.71	220.00	35.36	662.87	72.49

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