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Impact of Varying Percentage of Natural Depletion Rate Coefficient of Atmospheric Methane Gas in Port Harcourt Metropolis, Rivers State, Nigeria

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Abstract

The study examined the impact of varying percentage of natural depletion rate coefficient of methane gas on methane gas emitted due to abundance of livestock cumulative density in Port Harcourt Metropolis, Rivers State, Nigeria. The study employed the mathematical formulation for the emission of methane gas due to livestock cumulative density. The descriptive statistics were used to analyse the data. Findings showed thata monotonic increasing pattern in the relative abundance in the coordinates of N1, N2 and N22 of which the value of the coordinates of N1 was recorded as 906 in abundance on the four hundredth and twentieth (420^{th}) day to a saturating value of 992 in abundance on the seven hundredth and twentieth (720^{th}) day. Due to the impact of 90% variation, from the numerical result obtained, we observed that on the three hundredth and ninetieth (390^{th}) day of our experimental time, the relative abundance of N1 was recorded as 881 in abundance whereas N2 and N22 records 863 and 959 in abundance with eleven (11) percentages expected effect in quantification. Furthermore, from the four hundredth and twentieth (420^{th}) day up to the seven hundredth and twentieth (720^{th}) days, the data base result shows a monotonic increasing pattern in the relative abundance in the coordinates of N1, N2 and N22 of which the value of the coordinates of N1 was recorded as 906 in abundance on the four hundredth and twentieth (420^{th}) day to a saturating value of 992 in abundance on the seven hundredth and twentieth (720^{th}) day. the impact of 150% variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 0(30)360 in days, three different scenarios are considered, denoted as N1, N2 and N22 which are the livestock cumulative density relative abundance, methane gas emission due to fixed parameter values and methane gas emission due to variation. The study concluded that a monotonic increasing pattern in the relative abundance at both 90% and 150% variation of methane gas emissions. The study recommended among others that periodic monitoring of methane gas emission should be carefully looked at at different ecological locations and at both rural and urban locations.

Keywords: Percentage, Natural, Coefficient, Methane gas, Cumulative density

Introduction

The Niger Delta region of Nigeria is a significant source of methane emissions due to extensive oil and gas operations. Understanding the qualitative behavior of methane gas in the Niger Delta area in relation to meteorological variables is crucial for assessing its impact on regional and global climate change. However, limited research has been conducted specifically focusing on the qualitative behavior of methane gas and its interactions with meteorological variables in this region. Therefore, there is a need to investigate the qualitative behavior of methane gas and its relationship with meteorological variables in the Niger Delta area to enhance our understanding of the regional methane emissions and their potential climate implications.

Research focusing on the qualitative behavior of methane gas in the Niger Delta area and its interactions with meteorological variables is limited. However, studies conducted in other regions have provided insights into the influence of meteorological variables on methane emissions and behavior. For example, research by Karl *et al*. (2015) emphasizes the importance of temperature in methane emissions, with higher temperatures generally leading to increased microbial activity and methane production. Wind speed and direction have been identified as significant factors influencing the dispersion and transport of methane emissions from various sources (Pepin *et al*., 2015). Furthermore, atmospheric stability conditions, such as temperature inversions or stable atmospheric layers, can impact the trapping and accumulation of methane emissions (Pepin *et al*. 2015). In the Niger Delta region, where oil and gas operations are prevalent, understanding the qualitative behaviour of methane gas and its interaction with meteorological variables is of utmost importance. However, there is a lack of comprehensive studies specifically focusing on this aspect in the Niger Delta area. Addressing this research gap is crucial for developing effective mitigation strategies and policies to reduce methane emissions and mitigate climate change impacts in the region. Previous studies did not real the impact of time varying percentage of natural depletion rate coefficient of atmospheric methane gas emissions. The present study examined the impact of time varying percentage of natural depletion rate coefficient of methane gas emissions on the of livestock cumulative density in Port Harcourt Metropolis, Rivers State, Nigeria

Materials and Methods

The study area is Port Harcourt Metropolis, a coastal area in the southernmost part of Nigeria. Port Harcourt city lies within the Longitude 7°0'0" E and Latitude 4°46'30" N (Figure 1). In general, Port Harcourt has a tropical monsoon climate (Koppen Climate Classification). Rainfall in Rivers State is seasonal and heavy. The state is characterized by a humid sub-equatorial long wet season which last from March to October and a short dry season which last from November to February. Rain occurs on the average every month of the year but with varying duration. Total annual rainfall ranges from 4,700mm on the coast (south of the state) to about 1,700mm in the north of the state. The mean monthly temperature is in the range of 25C to 28C, while the mean annual temperature is 26C. The relative humidity of the state throughout the year is high but slightly low in the dry season (Online Nigeria, 2003). Soils in the general area are fertile and are of two types. Along the coast are the sandy soils which support the cultivation of pineapple, sugar cane and coconut. Outside the coastal area are muddy and loamy soils. However, the top soil is not very thick.There are three features in economic development of the Bonny people which contribute to their living. These include fishing, farming and petty trading. Fishing and farming have been the major ways of sustaining among the Bonny people. Fishing is done to a very large extent, even up to Cameroon. There is inter-dependency on each other among the Bonny people in the farming system. This is because people work farms and are being paid. Even the youths are being hired by fisher men for fishing into the high sea. Sequel to industrialization of Bonny Island the Youths and Middle-aged population are mostly engaged in Industrial activities. This Industrialization has open up other sources of income to the residence of the Island city. Three study locations were chosen randomly from Port Harcourt Metropolis and these included D Line, Rumuokoro and Okulogu (Figure 1). The study made use of logistics model for livestock cumulative density (Equ 1 to 5), mathematical formulation for the emission of methane gas due to livestock cumulative density (6 to 7) and analytical solutions (Equ 8 to 66) to generate the data for the study.

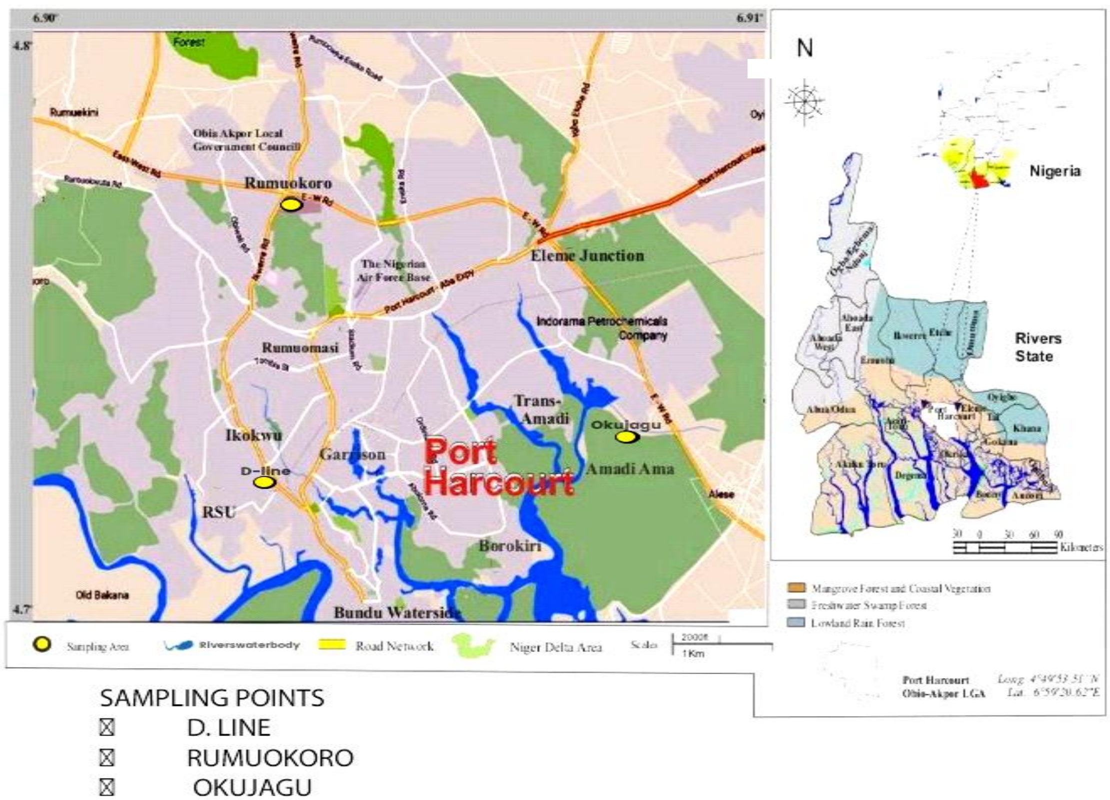

Figure 1: Map of Port Harcourt Showing the Sampling Points

Logistics Model for Livestock Cumulative Density

The required logistics model for life stock cumulative density projection (Akpodee, 2019, Akpodee and Ekaka-a, 2019) is stated as:

$$\frac{dN}{dt} = N(t)[\alpha - \beta N(t)], \quad N(0) = N_0 > 0 \quad \text{Equ 1}$$

In other to obtain the general solution trajectory of this model, we resolved it analytically before computational approach which is more efficient and precise for our various analysis.

From the equation

$$\frac{dN}{dt} = N(t)[\alpha - \beta N(t)], \qquad \text{Equ. 2}$$

$$N(0) = N_0 > 0 \qquad \text{Equ. 3}$$

Here: $\frac{dN}{dt}$ represents the rate of change of wind speed with respect to time.
N represents the wind speed.
αrepresents the intrinsic growth rate of the wind speed.
βrepresents the intra-competition coefficient of the wind speed.
N (0) represents the initial value of the wind speed at the base year here called the initial condition.
t represents time.
Using analytical approach to obtain the solution map from the given equation:

$$\frac{dN}{dt} = N(t)[\alpha - \beta N(t)] \quad \text{Equ 4}$$

$$\frac{dN}{dt} = N[\alpha - \beta N] = \alpha N - \beta N^2 \quad \text{Equ 5}$$

Mathematical Formulation for the Emission of Methane Gas due to Livestock Cumulative Density

Due to the livestock cumulative density, methane gas is emitted into the atmosphere from dumps of the livestock population. The required model for such a relationship is expressed mathematically as

$$\frac{dC_a(t)}{dt} = r_a C_a(t)[1 - \frac{C_a}{k_a}] \quad \text{Equ 6}$$

$$C_a(0) = C_{a_0} > 0$$

$$\frac{dC(t)}{dt} = Q_0 + \lambda_1 C_a - \lambda_0 C \quad \text{Equ 7}$$

$$C(0) = C_0 > 0$$

Where,

$\frac{dC_a(t)}{dt}$: represents the rate of change of cumulative density of the livestock population with respect to time.

$\frac{dC(t)}{dt}$: represents the rate of change of Methane gas released into the atmosphere due to the cumulative density of the livestock population with respect to time.

$C_a(t)$: represents the cumulative density of the livestock population present at any time,

$C(t)$: represents the Relative abundance of Methane gas released into the atmosphere within the study area at any time, t.

t : represents time.

$C_a(0)$: represents the initial condition of livestock cumulative density

$C(0)$: represents the initial condition of the Methane gas concentration.

r_a: represents the intrinsic growth rate parameter of the cumulative density of the livestock population in the study area.

k_a: represents the carrying capacity of the cumulative density of the livestock population in the study area.

λ_0: represents the natural depletion rate coefficient of atmospheric methane gas in the study area.

λ_1: represents the emission rate coefficient of the cumulative density of the livestock population in the study area.

Q_0: represents the constant input of methane gas from various natural sources such as wetland, water swamp within the study area.

Method of Analytical Solution

$$\frac{dC_a}{dt} = \alpha C_a \left[1 - \frac{\beta C_a}{\alpha}\right] \quad \text{Equ 8}$$

Let $K_a = \frac{\alpha}{\beta}$ be the saturated value (carrying capacity)

So that $\frac{I}{K_a} = \frac{I}{\frac{r_a}{\beta}} = \frac{\beta}{r_a}$ Equ 9

Substituting into the logistics equation we have:

$\frac{dC_a}{dt} = r_a C_a \left[1 - \frac{C_a}{K_a}\right]$ Equ 10

Separating variables,

Dividing through by $C_a\left[1 - \frac{C_a}{K_a}\right]$we have: Equ 11

$\frac{dC_a}{C_a\left[1-\frac{C_a}{K_a}\right]dt} = r_a$ Equ 12

Multiplying through by dt, we have:

$\frac{dC_a}{C_a\left[1-\frac{C_a}{K_a}\right]} = r_a dt$ Equ 13

Integrating both side of the equation

$\int \frac{1}{C_a\left[1-\frac{C_a}{K_a}\right]} dC_a = r_a \int dt$ Equ 14

Using partial fraction method, to every factor in the denominator of a compound fraction in the form of$\frac{1}{C_a\left[1-\frac{C_a}{K_a}\right]}$, there is a partial fraction in the form $\frac{1}{C_a\left[1-\frac{C_a}{K_a}\right]} \equiv \frac{A}{C_a} + \frac{B}{1-\frac{C_a}{K_a}}$

Where A and B are constants to be obtained, from L.H.S, we resolve by partial fraction

$\frac{1}{C_a\left[1-\frac{C_a}{K_a}\right]} \equiv \frac{A}{C_a} + \frac{B}{1-\frac{C_a}{K_a}}$ Equ 15

$\frac{1}{C_a\left[1-\frac{C_a}{K_a}\right]} \equiv \frac{A\left(1-\frac{C_a}{K_a}\right)+BC_a}{C_a\left[1-\frac{C_a}{K_a}\right]}$ Equ 16

$1 \equiv A\left(1 - \frac{C_a}{K_a}\right) + BC_a$ Equ 17

$1 \equiv A - \frac{A}{K_a}C_a + BC_a = A + \left(B - \frac{A}{K_a}\right)C_a$ Equ 18

Comparing constant:

$$A = 1$$

Comparing coefficient of N:

$B - \frac{A}{K_a} = 0$ Equ 19

$\mathrm{B} = \frac{A}{K_a} = \frac{1}{K_a}$ Equ 20

Substituting gives

$\frac{1}{C_a\left(1-\frac{C_a}{K_a}\right)} \equiv \frac{1}{C_a} + \frac{\frac{1}{K_a}}{\left(1-\frac{C_a}{K_a}\right)}$ Equ 21

Substituting into the integral

$\int \frac{dC_a}{C_a\left(1-{}^{C_a}/_{K_a}\right)} = \int \frac{1}{C_a} dC_a + \frac{1}{K_a}\int \frac{1}{\left(1-{}^{C_a}/_{K_a}\right)} dC_a$ Equ 22

Let

$u = 1 - \frac{C_a}{K_a}$ Equ 23

$du = -\frac{1}{K_a} dC_a$ Equ 24

$dC_a = -K_a du$ Equ25

Substituting we have

$\int \frac{dC_a}{C_a\left(1-\frac{C_a}{M}\right)} = \int \frac{1}{C_a} dC_a + \frac{1}{K_a}\int -\frac{K_a du}{u}$ Equ 26

$$\int \frac{dC_a}{C_a\left(1-\frac{C_a}{K_a}\right)} = \int \frac{1}{C_a}\, dC_a - \int \frac{1}{u}\, du \qquad \text{Equ 27}$$

$$\int \frac{dC_a}{C_a\left(1-\frac{C_a}{K_a}\right)} = Log_e C_a - Log_e u \qquad \text{Equ 28}$$

$$\int \frac{dC_a}{C_a\left(1-\frac{C_a}{K_a}\right)} = Log_e \left(\frac{C_a}{u}\right) \qquad \text{Equ 29}$$

$$\int \frac{dC_a}{C_a\left(1-\frac{C_a}{K_a}\right)} = Log_e \left(\frac{C_a}{1-\frac{C_a}{K_a}}\right) \qquad \text{Equ 30}$$

Substituting into the required equation

$$\int \frac{dC_a}{C_a\left[1-\frac{C_a}{K_a}\right]} = r_a \int dt \qquad \text{Equ 31}$$

We have the result as:

$$Log_e \left(\frac{C_a}{1-\frac{C_a}{K_a}}\right) = r_a t + c \qquad \text{Equ 32}$$

Taking exponential of both sides, we have

$$\left(\frac{C_a}{1-\frac{C_a}{K_a}}\right) = e^{(r_a t + c)} \qquad \text{Equ 33}$$

$$\frac{C_a}{1-\frac{C_a}{K_a}} = e^{r_a t} e^{c} \qquad \text{Equ 34}$$

$$\frac{C_a}{1-\frac{C_a}{K_a}} = Ae^{r_a t} \qquad \text{Equ 35}$$

(Where A = e^c)

$$C_a = Ae^{\alpha t}\left[1 - \frac{C_a}{K_a}\right] \qquad \text{Equ 36}$$

$$C_a = Ae^{\alpha t} - \frac{AC_a e^{r_a t}}{K_a} \qquad \text{Equ 37}$$

$$K_a C_a = AK_a e^{\alpha t} - AC_a e^{r_a t} \qquad \text{Equ 38}$$

$$K_a C_a + AC_a e^{\alpha t} = AK_a e^{r_a t} \qquad \text{Equ 39}$$

$$C_a[K_a + Ae^{\alpha t}] = AK_a e^{r_a t} \qquad \text{Equ 40}$$

$$C_a(t)[K_a + Ae^{\alpha t}] = AK_a e^{r_a t} \qquad \text{Equ 41}$$

$$C_a(0) = C_{ao} \qquad \text{Equ 42}$$

$$C_{ao}\left[K_a + Ae^{\alpha(0)}\right] = AK_a e^{r_a(0)} \qquad \text{Equ 43}$$

$$C_{ao}[K_a + A] = AK_a \qquad \text{Equ 44}$$

$$C_{ao}K_a + C_{ao}A = AK_a \qquad \text{Equ 45}$$

$$AK_a - C_{ao}A = C_{ao}K_a \qquad \text{Equ 46}$$

$$A[K_a - C_{ao}K_a] = C_{ao}K_a \qquad \text{Equ 47}$$

$$A = \frac{C_{ao}K_a}{K_a - C_{ao}} \qquad \text{Equ 48}$$

$$C_a(t) = \frac{K_a A e^{r_a t}}{K_a + Ae^{r_a t}} \qquad \text{Equ 49}$$

Substituting A into the equation

$$C_a(t) = \frac{K_a\left[\frac{C_{ao}K_a}{K_a - C_{ao}}\right]e^{r_a t}}{K_a + \left[\frac{C_{ao}K_a}{K_a - C_{ao}}\right]e^{r_a t}} \qquad \text{Equ 50}$$

Dividing both the numerator and the denominator by $e^{r_a t}$, we have

$$C_a(t) = \frac{K_a\left[\frac{C_{ao}K_a}{K_a - C_{ao}}\right]}{K_a e^{-\alpha t} + \left[\frac{C_{ao}K_a}{K_a - C_{ao}}\right]} \qquad \text{Equ 51}$$

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dividing through by $\frac{C_{ao}K_a}{K_a - C_{ao}}$ we have

$C_a(t) = \frac{K_a}{\frac{K_a}{\frac{C_{ao}K_a}{K_a - C_{ao}}}e^{-\alpha t} + 1}$, Here we $let\ k = \frac{K_a(K_a - C_{ao})}{C_{ao}K_a} = \frac{(K_a - C_{ao})}{C_{ao}}$ Equ 52

$C_a(t) = \frac{K_a}{Ke^{-\alpha t} + 1}$ 7.25

Thus the qualitative behavior of the solution trajectory of the cumulative livestock density over a longer period of time will be the limit of $C_a(t)\ as\ t \to \infty$ $lim C_a(t) = lim\left(\frac{K_a}{Ke^{-r_a t} + 1}\right) =$

$K_a lim\left(\frac{1}{Ke^{-r_a t} + 1}\right) = K_a$ Equ 53

being the carrying capacity of cumulative livestock cumulative density in the study area.

Solving the methane gas emission model

$\frac{dc(t)}{dt} = Q_{o+\lambda_1 C_{a-}\lambda_o C}$ Equ 54

$\frac{dC(t)}{dt} + \lambda_o = Q_{o+\lambda_1 C_a}$ Equ 55

But $C_a(t) = \frac{K_a}{Ke^{-r_a t} + 1}$ Equ 56

Where $K = \frac{K_a(K_a - C_{ao})}{C_{ao}K_a} = \frac{K_a - C_{ao}}{C_{ao}}$ Equ 57

Substituting $C_a(t)$ into $\frac{dc(t)}{dt}$; Equ 58

$\frac{dC(t)t}{dt} + \lambda_o C = Q_{o+\lambda_1}\left(\frac{K_a}{Ke^{-r_a t} + 1}\right)$ Equ 59

This is a linear ODE in the form $\frac{dc}{dt} + P(t)C = Q(t)$

Using the integrating factor

I.F = $e \int P(t)\, dt = e \int \lambda_{odt} = e^{\lambda_o t}$

Multiplying both side using I.F on Equ 41

$e^{\lambda_o t}\frac{dc}{dt} + e^{\lambda_o t}\lambda_o C = \left(Q_o + \lambda_1\left(\frac{K_a}{Ke^{-r_a t} + 1}\right)\right)e^{\lambda_o t}$ Equ 60

$\frac{dc}{dt}\left(e^{\lambda_o t}C\right) = \left(Q_o + \lambda_1\left(\frac{K_a}{Ke^{-r_a t} + 1}\right)\right)e^{\lambda_o t}$ Equ 61

$\left(e^{\lambda_o t}C\right) = \left(Q_o + \lambda_1\left(\frac{K_a}{Ke^{-r_a t} + 1}\right)e^{\lambda_o t}\right)dt$ Equ 62

Integrating both side

$\int d\left(e^{\lambda_o t}C\right) = \int\left(Q_o + \lambda_1\left(\frac{K_a}{Ke^{-r_a t} + 1}\right)e^{\lambda_o t}\right)dt$ Equ 63

$e^{\lambda_o t}\, C(t) = \int Q_o e^{\lambda_o t}dt\ + \lambda_1 \int\left(\frac{K_a e^{\lambda_o t}}{Ke^{-r_a t} + 1}\right)dt + h_1$ Equ 64

$C(t) = \frac{1}{e^{\lambda_o t}}\left[\frac{Q_o}{\lambda_o}e^{\lambda_o t} + K_a\lambda_1 \int \frac{e^{\lambda_o t}}{Ke^{-r_a t} + 1}dt\right] + \frac{h_1}{e^{\lambda_o t}}$ Equ 65

$C(t) = \frac{Q_o}{\lambda_o} + \frac{K_a\lambda_1}{e^{\lambda_o t}}\int \frac{e^{\lambda_o t}}{Ke^{-r_a t} + 1}dt + h_1 e^{-\lambda_o t}$ Equ 66

This is the required predictive solution trajectory for the emission of methane gas.Descriptive statistics were used to describe the results of the analysis.

Results and Discussions

The results of the analysis in Table 1, Table 2, Table 3 and Table 4 showed the impact of 90%and 150% for a time interval of 0(30)360 in days and 390(30)720 in days variations of the natural depletion rate coefficient of atmospheric methane gas on methane gas emission.Table

1shows the database of the impact of 90% for a time interval of 0(30)360 in days, Table 2 shows the database of the impact of 90% for a time interval of 390(30)720 while Table 3 shows the database of the impact of 150% for a time interval of 0(30)360 in days and Table 4 shows the database of the impact of 150% for a time interval of 0(30)720 in days.Figure 2 summarizes the solution trajectory of the relative abundance of livestock cumulative density and methane gas emission against time using the same step size h= 30 at time interval 0(30)720.

Table 1: Impact of 90% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 0(30)360 in days

Time(days)	**N1**	**N2**	**N22**	**EPE(%)**
0 200.0000	250.0000	250.0000	0	
30.0000	245.0306	670.1774	743.2997	10.9109
60.0000	296.4429	686.2021	762.1622	11.0696
90.0000	353.5904	703.2917	781.3611	11.1006
120.0000	415.2523	721.6486	801.1043	11.0103
150.0000	479.6876	740.3583	822.6195	11.1110
180.0000	544.8059	759.9451	843.6724	11.0175
210.0000	608.4272	779.3277	865.5758	11.0670
240.0000	668.5658	798.0584	886.3485	11.0631
270.0000	723.6632	814.5386	904.4568	11.0392
300.0000	772.7150	829.5389	921.4573	11.0807
330.0000	815.2823	842.1255	935.2381	11.0569
360.0000	851.4103	853.6298	948.3028	11.0906

Table 2: Impact of 90% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 390(30)720 in days.

Time(days)	N1	N2	N22	EPE(%)
390.0000	881.4993	863.1631	959.3049	11.1383
420.0000	906.1669	871.0713	967.0204	11.0151
450.0000	926.1299	876.8190	974.3169	11.1195
480.0000	942.1170	881.7827	979.2695	11.0557
510.0000	954.8130	885.7856	984.2960	11.1213
540.0000	964.8282	889.0619	987.8034	11.1063
570.0000	972.6872	891.6783	990.1246	11.0406
600.0000	978.8286	893.3225	993.3307	11.1951
630.0000	983.6124	894.5806	994.2870	11.1456

660.0000	987.3292	895.8322	995.3745	11.1117
690.0000	990.2115	897.3684	996.7232	11.0718
720.0000	992.4431	897.5056	997.3049	11.1196

Table 3: Impact of 150% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 0(30)360 in days.

Time(days)	N1	N2	N22	EPE(%)
0 200.0000	250.0000	250.0000	0	
30.0000	245.0306	670.1774	447.9205	33.1639
60.0000	296.4429	686.2021	458.0742	33.2450
90.0000	353.5904	703.2917	469.5993	33.2284
120.0000	415.2523	721.6486	481.6196	33.2612
150.0000	479.6876	740.3583	494.3620	33.2267
180.0000	544.8059	759.9451	507.5971	33.2061
210.0000	608.4272	779.3277	520.3866	33.2262
240.0000	668.5658	798.0584	532.2849	33.3025
270.0000	723.6632	814.5386	543.6388	33.2581
300.0000	772.7150	829.5389	553.6186	33.2619
330.0000	815.2823	842.1255	562.0230	33.2614
360.0000	851.4103	853.6298	569.3929	33.2974

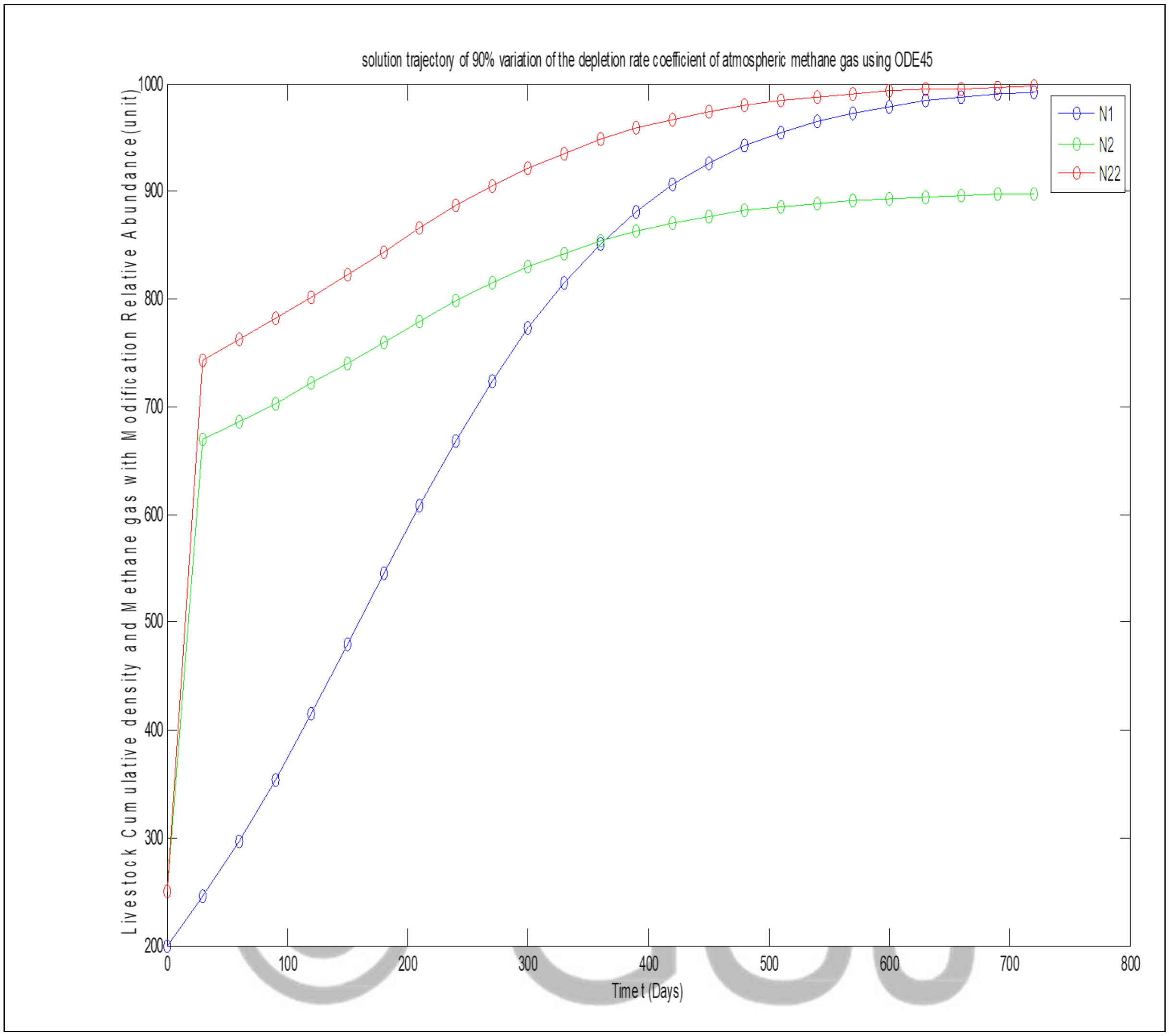

Figure 2**: Solution trajectory of the Impact of 90% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 0(30)720 in days.**

Table 4: Impact of 150% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 390(30)720 in days.

Time(days)	N1	N2	N22	EPE(%)
390.0000	881.4993	863.1631	575.9680	33.2724
420.0000	906.1669	871.0713	580.8019	33.3233
450.0000	926.1299	876.8190	584.4966	33.3390
480.0000	942.1170	881.7827	588.0391	33.3125
510.0000	954.8130	885.7856	591.0732	33.2713
540.0000	964.8282	889.0619	592.7596	33.3275
570.0000	972.6872	891.6783	594.1589	33.3662
600.0000	978.8286	893.3225	595.6634	33.3205
630.0000	983.6124	894.5806	596.8691	33.2794
660.0000	987.3292	895.8322	597.3050	33.3240
690.0000	990.2115	897.3684	598.0535	33.3547

720.0000	992.4431	897.5056	598.3991	33.3264

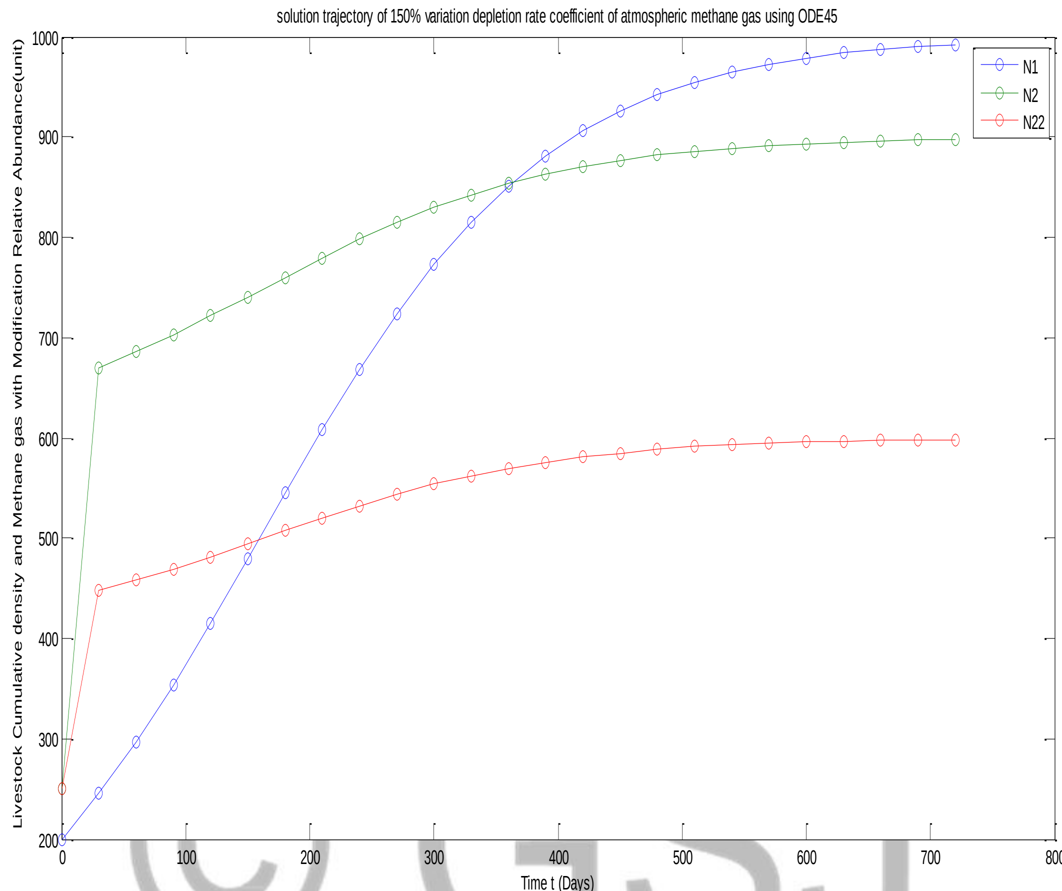

Figure 3: Solution trajectory of the Impact of 150% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 0(30)720 in days.

Discussion of Findings

Findings showed that due to the impact of 90% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane gas emission for a time interval of 390(30)720 in days, three different scenarios are considered as well denoted as N1, N2 and N22 which are the livestock cumulative density relative abundance, methane gas emission due to fixed parameter values and methane gas emission due to variation. From the numerical result obtained, we observed that on the three hundredth and ninetieth (390th) day of our experimental time, the relative abundance of N1 was recorded as 881 in abundance whereas N2 and N22 records 863 and 959 in abundance with eleven (11) percentages expected effect in quantification. Furthermore, from the four hundredth and twentieth (420th) day up to the seven hundredth and twentieth (720th) days, the data base result shows a monotonic increasing pattern in the relative abundance in the coordinates of N1, N2 and N22 of which the value of the coordinates of N1 was recorded as 906 in abundance on the four hundredth and twentieth (420th) day to a saturating value of 992 in abundance on the seven hundredth and twentieth (720th) day. Furthermore, when all model parameter values are fixed, the abundance of the methane gas emission was recorded as 871 on the four hundredth and twentieth (420th) day and increases monotonically to a saturating value of 897 in abundance on the seven hundredth and twentieth (720th) day whereas due to the percentage variation, the methane gas emission shows a gain in it relative abundance with a value of 967 in abundance on the four hundredth and twentieth (420th) day and increases monotonic to a saturating value of 997 in abundance on the seven hundredth and twentieth (720th) day showing a percentage quantification within the interval $11.14 \leq EPE \leq 11.12$.

This is also in line with the findings of Saunois, *et al*., (2020), in his research on the global methane budget 2000-2017. He concluded that atmospheric concentration of methane gas is regulated by a complex interplay thatinvolves oxidation.This percentage gain in quantification of the methane gas emission due to the variation of the parameter is a good information for eco system functioning and will serve as a guide in terms of environmental planning and policies making for air pollution due to livestock cumulative density and it expected effect on the environment.

Contrary speaking, due to the impact of 90% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane gas emission for a time interval of 390(30)720 in days, three different scenarios are considered as well denoted as N1, N2 and N22 which are the livestock cumulative density relative abundance, methane gas emission due to fixed parameter values and methane gas emission due to variation. From the numerical result obtained, we observed that on the three hundredth and ninetieth (390th) day of our experimental time, the relative abundance of N1 was recorded as 881 in abundance whereas N2 and N22 records 863 and 959 in abundance with eleven (11) percentages expected effect in quantification. Furthermore, from the four hundredth and twentieth (420th) day up to the seven hundredth and twentieth (720th) days, the data base result shows a monotonic increasing pattern in the relative abundance in the coordinates of N1, N2 and N22 of which the value of the coordinates of N1 was recorded as 906 in abundance on the four hundredth and twentieth (420th) day to a saturating value of 992 in abundance on the seven hundredth and twentieth (720th) day. Furthermore, when all model parameter values are fixed, the abundance of the methane gas emission was recorded as 871 on the four hundredth and twentieth (420th) day and increases monotonically to a saturating value of 897 in abundance on the seven hundredth and twentieth (720th) day whereas due to the percentage variation, the methane gas emission shows a gain in it relative abundance with a value of 967 in abundance on the four hundredth and twentieth (420th) day and increases monotonic to a saturating value of 997 in abundance on the seven hundredth and twentieth (720th) day showing a percentage quantification within the interval $11.14 \leq EPE \leq 11.12$. This is also in line with the findings of Saunois, *et al*., (2020), in his research on the global methane budget 2000-2017. He concluded that atmospheric concentration of methane gas is regulated by a complex interplay thatinvolves oxidation.This percentage gain in quantification of the methane gas emission due to the variation of the parameter is a good information for eco system functioning and will serve as a guide in terms of environmental planning and policies making for air pollution due to livestock cumulative density and it expected effect on the environment.

In studying the impact of 150% variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 0(30)360 in days, three different scenarios are considered, denoted as N1, N2 and N22 which are the livestock cumulative density relative abundance, methane gas emission due to fixed parameter values and methane gas emission due to variation. From the numerical result obtained, we observed that on the based day of our experimental time here called the initial condition, the relative abundance of N1 was recorded as 200 in abundance whereas N2 and N22 records 250 in abundance which are same values with zero (0) percentages in changes. Furthermore, from the thirtieth (30th) day up to the three hundred and sixtieth (360th) days, the data base result shows a monotonic increasing pattern in the relative abundance in the coordinates of N1, N2 and N22 of which the value of the coordinates of N1 was recorded as 245 in abundance on the thirtieth (30th) day to a saturating value of 851 in abundance on the three hundred and sixtieth (360th) day. Moreso, when all model parameter values are fixed, the abundance of the methane gas emission was recorded as 670 unit on the thirtieth (30^{th}) day and increases monotonically to a saturating value of 853 unit in abundance on the three hundredth and sixtieth (360^{th}) day whereas due to the percentage variation, the methane gas emission shows a depletion in it relative abundance with a value of 447 unit on the thirtieth (30^{th}) day and increases monotonic to a saturating value of 569 unit in abundance on the three hundredth and sixtieth (360^{th}) day showing a percentage quantification within the interval $33.16 \leq EPE \leq 33.30$.

This is also in line with the findings of Saunois, *et al*., (2020), in his research on the global methane budget 2000-2017. He concluded that atmospheric concentration of methane gas is regulated by a complex interplay that involves oxidation. This percentage depletion in quantification of the methane gas emission due to the variation of the parameter is a good information for eco system functioning and will serve as a guide in terms of environmental planning and policies making for air pollution due to livestock cumulative density and it expected effect on the environment. Similarly, due to theimpact of 150% percent variation of the natural depletion rate coefficient of atmospheric methane gas on methane Gas Emission for a time interval of 390(30)720 in days, three different scenarios are considered as well-denoted as N1, N2 and N22 which are the livestock cumulative density relative abundance, methane gas emission due to fixed parameter values and methane gas emission due to variation. From the numerical result obtained, we observed that on the three hundredth and ninetieth (390^{th}) day of our experimental time, the relative abundance of N1 was recorded as 881 in abundance whereas N2 and N22 records 863 and 575 in abundance with thirty three (33) percentages expected effect in quantification due to depletion. Furthermore, from the four hundredth and twentieth (420^{th}) day up to the seven hundredth and twentieth (720^{th}) days, the data base result shows a monotonic increasing pattern in the relative abundance in the coordinates of N1, N2 and N22 of which the value of the coordinates of N1 was recorded as 906 unit in abundance on the four hundredth and twentieth (420^{th}) day to a saturating value of 992 unit in abundance on the seven hundredth and twentieth (720^{th}) day. Furthermore, when all model parameter values are fixed, the abundance of the methane gas emission was recorded as 871 unit on the four hundredth and twentieth (420^{th}) day and increases monotonically to a saturating value of 897 unit in abundance on the seven hundredth and twentieth (720^{th}) day whereas due to the percentage variation, the methane gas emission shows a depletion in it relative abundance with a value of 580 unit in abundance on the four hundredth and twentieth (420^{th}) day and increases monotonic to a saturating value of 598 unit in abundance on the seven hundredth and twentieth (720^{th}) day showing a percentage quantification in depletion within the interval $33.27 \leq EPE \leq 33.33$. This is also in line with the findings of Saunois, *et al*., (2020), in his research on the global methane budget 2000-2017. He concluded that atmospheric concentration of methane gas is regulated by a complex interplay that involves oxidation.This percentage depletion in quantification of the methane gas emission due to the variation of the parameter is a good information for eco system functioning and will serve as a guide in terms of environmental planning and policies making for air pollution due to livestock cumulative density and it expected effect on the environment.

Conclusion and Recommendations

The study concluded that there is a monotonic increasing pattern in the relative abundance at both 90% and 150% variation of methane gas emissions. The study recommended among others that periodic monitoring of methane gas emission should be carefully looked at at different ecological locations and at both rural and urban locations.

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