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Formulation of a Mathematical Model for the Analysis of the Emission of Carbon Dioxide from Gaseous Fuel using Least Square Method

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ABSTRACT: In this paper we formulate a model for the emission of Carbon Dioxide from gaseous fuel in Nigeria. We considered a third degree polynomial model using a least square method using the actual data set of twenty one years on State level Carbon Dioxide emissions in Nigeria from 1994-2014. The residual analysis was used to predict the short and medium term total Carbon Dioxide emissions trend. From the results the state of affairs of Carbon Dioxide Emission for subsequent years was forecast and this will help the Government to take control measures in curtailing the emission of Carbon Dioxide in the country. © JASEM

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Research conducted globally reveals that the common atmospheric pollutant is carbon monoxide with a yearly percentage of 70% of all carbon monoxide gas emitted by automobiles (Ahmad, Noor, et al, 2014).

In every day's life a normal human being have an intake of approximately 13,000-16,000 litres of air and 400- 500 million litres of air (Bultije, 2014). The consequence of atmospheric pollutants to life differs in relation to vulnerability, quantity of atmospheric pollutants and also the living standard of the people. People without health challenges are not spare, especially, those that are prone to disease (Marion, 2009; Bellasio, 2007; Han- Ulrich, 2014).

The following are the effect of atmospheric pollutants to life; Raising cases lung cancer, High rate of chronic asthma, High rate of coughing/phlegm, High cases of upper respiratory system, High level of irritation cases in throat and other sensory organs (Oztirk, 2015).

Mahmmud (2012) carried out a comparative study on Air pollution and transportation in urban area. He stressed that has proven to be connected with how motor vehicles operate in the cities.

The aim of this paper is to formulate a mathematical model for the analysis of the emission of carbon dioxide from gaseous fuel using least square method

MATERIALS AND METHODS

We considered a third degree polynomial model using a least square method for gaseous fuels (G).

We consider the equation,

$$y(x) = a + bx + cx^2 + dx^3 \quad (1)$$

where,

y = total emission from gaseous fuel

x = year

We define the error term as;

$$E(a,b,c,d) = \sum_{n=1}^{N} \{y_n - (a + bx_n + cx_n^2 + dx_n^3)\}^2 \quad (2)$$

Where our data set variables is defined as;

$$E(a,b,c,d) = \{y_1 - (a + bx_1 + cx_1^2 + dx_1^3)\}, \ldots, \{y_N - (a + bx_N + cx_N^2 + dx_N^3)\} \quad (3)$$

To minimizes the error, we find a and b this makes us find the values of (a,b,c,d) thus;

$$\frac{\partial E}{\partial a} = \frac{\partial E}{\partial b} = \frac{\partial E}{\partial c} = \frac{\partial E}{\partial d} = 0 \quad (4)$$

Differentiating

$E(a,b,c,d)$

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University of Benin, Benin City, Nigeria. The plant was duly identified and authenticated by Mr. Shasanya Olufemi of the Forestry Research Institute of Nigeria, Ibadan (FRIN, Ibadan) where a herbarium specimen (FHI NO: 109986) was deposited for future reference. The young leaves were then carefully separated from the stem; air dried for 7 days and pulverized using an electric mill. The powered plant material (500g) was macerated in 4.5 litres of distilled water at room temperature and filtered after 24h. The filtrate was concentrated to dryness over a water bath. The dried extract obtained (Yield=12.83%) was stored in airtight glass containers in the refrigerator at 4 C till required.

Animal: Swiss albino mice (25-35g) and wistar rats (190-300g) of either sex kept at the Animal Unit of the Department of Pharmacology and Toxicology, Faculty of Pharmacy, University of Benin, Benin City, Nigeria were used. The animals maintained under standard environmental conditions were allowed to acclimatize for two weeks and had free access to standard diet (Bendel Feeds and Flour Mill, Ewu, Edo State, Nigeria) and water ad libitum. Animals were exposed to natural lighting conditions and handled in accordance with the international principles guiding the use and handling of experimental animals (National Institute of Health, USA, 2002).

Mouse writhing assay: The method described by Koster et al. (1959) was used. Mice were randomly divided into four groups of five animals per group. The extract (400-800mg/kg), normal saline (10ml/kg) or acetylsalicylic acid (100mg/kg) was administered orally to the mice according to their group 30 minutes before intraperitoneal injection of acetic acid (0.6%v/v in normal saline, 10ml/kg). Number of writhes, which consisted of constriction of the abdominal muscle together with a stretching of hind limbs, was cumulatively counted for 30minutes following acetic acid injection. Inhibition of pain was expressed as a percentage of protection using the formula:

$$Inhibition\ of\ pain = \frac{Mean\ Writhes\ (control) - Mean\ Writhes\ (treated)}{Mean\ Writhes\ (control)} \times \frac{100}{1}$$

Where mean writhes (control) is the mean writhes of the normal saline treated animals and mean writhes (treated) is the mean writhes of the animal given acetylsalicylic acid or each dose of aqueous leave extract of D. cinerea

Hot plate assay: Swiss albino mice of either sex screened for suitable reaction time, 24h before the experiment were used. The animals were randomly divided into four groups of five mice each. One hour before treatment the baseline hot plate latency of each mouse was taken. This represented the baseline latency before treatment. The extract (400-800mg/kg, orally), normal saline (10ml/kg, orally) or morphine (4mg/kg, i.p) were administered to the mice according to their group. One hour and thirty minutes after treatment with the extract, normal saline and morphine respectively, the response to nociceptive stimulus was measured with the hot plate analgesiometer (Ugo Basile, Italy) with the temperature maintained at 55 ± 1°C (Woolfe and Macdonald, 1944). A cut-off time of 60 seconds was adopted to prevent tissue damage. The time between the placements of the mice and licking or biting of the hind paw or jumping was recorded as the index of response latency. Response latencies were taken at 30 minutes intervals till 120minutes post treatment.

Carrageenan-induced paw edema: Wistar rats were allotted into four groups of five rats each. Using a venier caliper, baseline measurement of the right hind paw thickness of each rat was taken. The rats were pretreated, orally, with extract (400,800mg/kg), indomethacin (10mg/kg) or normal saline (10ml/kg) according to their group. One hour later, edema was induced in the rats by injection of freshly prepared carrageenan (0.1ml, 1%w/v in normal saline) into the plantar aponeurosis of the right hind paw of each rat (Winter et al, 1962). Measurement of the thickness of the injected paw was repeated at hourly intervals for a maximum of four hours after carrageenan injection with the aid of a vernier caliper.

Dextran- induced paw edema: Wistar rats were allotted into four groups of five rats each. Using a plethysmometer the exact baseline right hind paw volume of each rat was measured. The rats were pretreated, orally, with normal saline (10ml/kg), extract (400,800mg/kg) or diphenhydramine (60mg/kg) according to their group. One hour later, edema was induced in the rats by injection of freshly prepared dextran (0.1ml, 1.5%w/v in normal saline) into the plantar aponeurosis of the right hind paw of each rat (Glauce et al., 1998). Measurement of the volume of the injected paw was repeated at hourly intervals for a maximum of four hours after dextran injection using a plethysmometer.

Data Presentations: For formulation and analysis of our model, the following emission data from 1994 to 2014 is used.

Table 1: Real data of emission from gaseous fuel in Nigeria ('000 MT of carbon dioxide)

Year	Gas
1994	4.24
1995	5.25
1996	7.22
1997	7.59
1998	9.29
1999	12.59
2000	18.84
2001	21.17
2002	26.80
2003	30.04
2004	41.46
2005	39.34
2006	36.12
2007	30.61
2008	43.11
2009	50.50
2010	63.98
2011	37.86
2012	41.54
2013	50.61
2014	45.52

Source: *Hans-Ulrich (2014) State level gaseous emissions of Nigeria (1994-2014).*

RESULTS AND DISCUSSION

Gaseous fuels: The general mathematical model for the emission of gaseous fuel is given by:

$$y(x) = a + bx + cx^2 + dx^3 \quad (15)$$

where, x=year

The solution of the above equation is given by

$$y(x) = -1374.0413 + 0.2012x - 0.00043x^2 + 3.4377\times10^{-7}x^3$$
(16)

The result of R^2 and R^2 adjusted on gaseous fuel model are shown in the Table below.

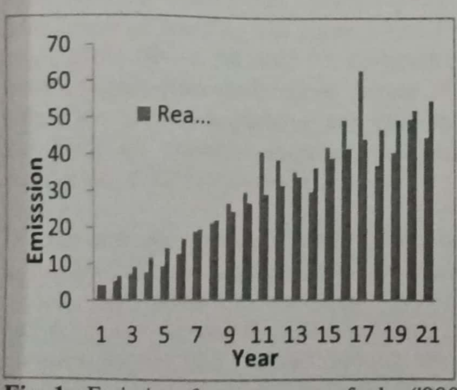

Fig 1: Emission from gaseous fuels ('000 MT of carbon dioxide)

Table 2: Values of R^2 and R^2 adjusted on gaseous fuel

R^2	R^2 adjusted
0.8316	0.8018

Table 3: Residual analysis for emissions from gaseous fuels ('000 MT of carbon dioxide)

Year	Real Data (See Table 4.1)	Generated for Model Data	Residual
1994	4.24	4.12	0.12
1995	5.25	6.66	-1.41
1996	7.22	9.20	-1.97
1997	7.59	11.75	-4.15
1998	9.29	14.30	-5.00
1999	12.59	16.85	-4.26
2000	18.84	19.41	-0.56
2001	21.17	21.97	-0.26
2002	26.8	24.53	2.27
2003	30.04	27.10	2.94
2004	41.46	29.67	11.79
2005	39.34	32.24	7.10
2006	36.12	34.81	1.30
2007	30.61	37.39	-6.78
2008	43.11	39.98	3.13
2009	50.50	42.56	7.93
2010	63.98	45.15	18.83
2011	37.86	47.74	-9.88
2012	41.54	50.34	-8.79
2013	50.61	52.94	-2.32
2014	45.52	55.54	-10.01
Mean of Residuals			8.07E-0.005
Standard error of Residuals (SE)			2.67

Table 4: Emission from gaseous fuels ('000 MT of carbon dioxide)

Year	Gas Emission
2015	72.29
2016	83.67
2017	95.06
2018	96.44
2019	97.84
2020	99.23
2021	100.62
2022	102.02
2023	103.42
2024	112.29

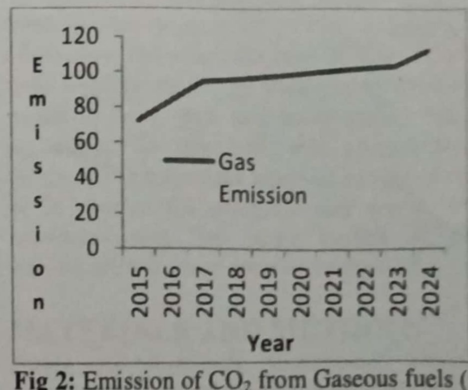

Fig 2: Emission of CO_2 from Gaseous fuels ('000 MT of carbon dioxide)

Figure 2 shows the emission from Gaseous fuels for short and medium term. From the study, we can say that appropriate measures are immediately required to control the rapid increasing of gas emission in Nigeria. Our prediction may be helpful for anticipated planning and prolific policies to curb the emission rate of carbon dioxide from different sources. We therefore recommend that government should use free carbon dioxide emission sources of energy such as; solar power, wind power, geothermal energy, low-head hydropower, hydrokinetics (wave and tidal power) and nuclear power

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