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THE PARAMETER ESTIMATION OF THE PRECISE VALUES OF THE INTRA-COMPETITION COEFFICIENTS A SPECIFIC POLLUTANT IN PORT-HARCOURT METROPOLIS USING THE METHOD OF P-VECTOR NORM. (PART ONE: THE PRECISE VALUE THE INTRA-COMPETITION COEFFICIENT OF THE POLLUTANT PM2.5)

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Abstract

We have utilized the method of ODE45 numerical simulation to obtained the precise value of the intra-competition coefficient of a specific pollutant level 2.5 gases in Port-Harcourt metropolis using the method of P-vector norm parameter estimation. The effect of the P-vector on the intra-competition on several values of the carrying capacity hereby called the saturated values was recorded as there was a sudden change from a monotone decreasing to an increasing of the p-norms values behavior as the value observe were this

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sudden change occur has a unique character in which all the norms are least in values. The precise value of the intra-competition parameter value

KEYWORDS: Dynamical System, Parameter Estimation, P-vector norm, Environmental Variable.

obtained from this study is given as β= 0.026685209713024. The full novel results that we have obtained have not been seen elsewhere: these have been presented and discussed in this study.

INTRODUCTION

Environmental pollution is the pollution of air, land and water in many ways. There are several reasons for environmental pollution, such as from agriculture, industry, and urban sources. Environmental pollution has drastically changed the air, water and terrestrial ecosystems as a result of the industrial revolution in Nigeria, especially in the Niger-Delta in which Port-Harcourt is a case study. Moreover, different types of toxic gases, different forms of carbon components and heavy metals from oil spill activities and also produced from factories, transport, and energy sectors has resulted in different changes in the global climate and weather patterns, and become a source of contamination of land, as well as the ocean environment where the average temperature and acidity are increasing. In addition, many other chemicals like fertilizers used in the agricultural industry, illegal refineries also contribute to the pollution of the land, air and seas over vast areas.

Tracing back to the earlier Lotka-Volterra(lotka A.J,1956) formulation between two (2) biological species for over fifty (50) decades, most population modeling in this context has been using a system of first-order ordinary differential equations. This approached had attracted lots of contributions from the works of many ecological and environmental researchers. It is against this background that we are proposing a model formulation with which to study the mathematical properties of two specific pollutants and its impacts on a dynamical system of the interaction between environmental variables which are the relative humidity and air temperature. Here, the data sets obtained from different location in Port-Harcourt will be subjected to parameter estimation using the method of p-vector norms indexed by ODE45 numerical scheme to obtained the precise value the intra-competition coefficient of the pollutant level 2.5.

Mathematical Formulation

Using logistic model equation to build the least square value (best fit) for the $P_{m2.5}$, we will use the logistic model equation stated as follows:

$$\frac{dP_{m2.5}}{dt} = P_{m2.5}(\alpha_1 - \beta_1 P_{m2.5}); \qquad where\ P_{m2.5}(0) = 19.4$$

Where: $P_{m2.5}$ represents the quantity of the pollutants level 2.5 in the atmosphere

$\frac{dP_{m2.5}}{dt}$ represents the rate of change of the pollutant over time.

α_1 represents the intrinsic growth parameter value of the pollutant level 2.5

$P_{m2.5}(0)$ represents the initial pollutant level 2.5 at the base year.

Method of Solution

In order to carry out the parameter estimation of intra-competition coefficient using the method of p-vector norms, we have used the following measured dataset of $P_{m2.5}$ from some selected locations in Port Harcourt, as displayed in the table below:

Table 1 : Monthly Mean Data of Ambient Air Quality within Port Harcourt Metropolis From October- March, 2020

S/No	Station	Mean	Suspended Particulate matter (Concentration in μg/m³)				
			PM_1	$PM_{2.5}$	PM_7	PM_{10}	TSP
1.	October	Mean	6.3	19.4	45.5	56.1	73.1
2.	November	Mean	8.5	10.6	30.5	41.8	53.5
3.	December	Mean	15.4	365.8	852.7	1056.9	1179.1
4.	January	Mean	8.6	144.3	229.8	295.2	348.4
5.	February	Mean	10.6	152.3	235.0	349.8	458.1
6.	March	Mean	7.6	22.6	36.3	43.4	54.8
	WHO Standard		25	25	50	50	-
	FMEnv./ Standard		-	-	-	-	250

The best fits data will be obtained from the model formulation of the data in table 1, which obeys the mathematical laws of a monotone sequence which on the premises the model will be constructed and parameters will be obtained. Here we denote the following:

$$SV = saturated\ value\ of\ carrying\ capacity$$

$$\beta = intracompetition\ coefficient$$

$$\alpha = intrinsic\ growth\ rate$$

To obtain the intrinsic growth rate parameter, α and the intra-competition coefficient, β of both the $P_{m2.5}$ pollutants, we carry out the following procedure using table 1

For $P_{m2.5}$ pollutant intrinsic growth rate, α_1 we proceed as follow using October as our base year.

$$\alpha_1 = \log_e \left(\frac{Second\ data\ set}{First\ data\ set}\right) = \log_e \left(\frac{V_2}{V_1}\right)$$

$$\alpha_1 = \log_e \left(\frac{10.6}{19.4}\right) = \log_e 1.830188679$$

$$|\alpha_1| = 0.6044190656$$

To obtain the intra-competition coefficient, β_1 of the $P_{m2.5}$ pollutant, we use the relationship

$$SV_1 = \frac{\alpha_1}{\beta_1}$$

With $SV_1 = 22.7$, we have

$$\beta_1 = \frac{\alpha_1}{SV_1} = \frac{0.604419065}{22.7} = 0.026626390$$

Using the experimental data set obtained from the field as shown on table 1 on the assumption that the saturated value is subject to change, we choose

$$SV_1 = 22.0, 22.1, 22.2, 22.3, 22.4, 22.5, 22.6, 22.65, 22.75, 23.0$$

These saturated values will be use to generate the least value using the method of p-norm.

Therefore, we would measure the error between these solution map data using ODE45 indexed by 1-norm, 2-norm and ∞-norm, and choose the best fit data of the intra-competition coefficient, β for $P_{m2.5}$ pollutant. In obtaining the least-square values of 1-norm, 2-norm and the ∞-norm, various values of β will be generated for $P_{m2.5}$ as illustrated in the result displayed below and their P-norms been calculated accordingly:

For Pm2.5 best fit,

$$SV_1 = \frac{\alpha_1}{\beta_1}$$

With $SV_1 = 22.0$, we have

$$\beta_1 = \frac{\alpha_1}{SV_1} = \frac{0.604419065}{22.0} = 0.027473593$$

This procedure for obtaining the intra-competition coefficients using the saturated values is been done using the P-norms method on the $P_{m2.5}$ pollutant data set and the result displayed in the re table 2 :

RESULT

Aim: To find the local minimum for the intra-competition coefficients, $\boldsymbol{\beta_1}$ for $P_{m2.5}$.

Here, the precise value of the intra-competition coefficient of the pollutant 2.5 level is obtained using the method of p-vector norm indexed by ODE45 numerical scheme using Matlab software computational approach.

Table 2: Calculating the Precise Value for the Intra-competition Coefficient $\boldsymbol{\beta_1}$ of $P_{m2.5}$ pollutant satisfying P-vector norms properties.

Beta1	Saturated Values	1-norm	2-norm	Infinity-norm
0.027473636363636	22.00	4.183644736029969	1.707971040785982	0.698949611792958
0.027349321266968	22.10	3.583508842284104	1.462967463133138	0.598911810842385
0.027226126126126	22.20	2.983398220959135	1.217974762521995	0.498899765237223
0.027104035874439	22.30	2.364103585751188	0.965407178977487	0.408908564419715
0.026983035714286	22.40	1.766623559892565	0.721537612320483	0.308360142857779
0.026863111111111	22.50	1.170420639261987	0.478223799449382	0.207338381819948

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0.026744247787611	22.60	0.575614112924477	0.235674847032867	0.106243605062154
0.026685209713024	**22.65**	**0.281605102245507**	**0.114976659757005**	**0.047926302086022**
0.026567912087912	22.75	0.315170414074707	0.129760585979565	0.064754742260781
0.026279130434783	23.00	1.808522599853873	0.738373000900600	0.307865970540565

DISCUSSION

From table 1, several values of the intra-competition coefficient of the pollutant 2.5 level were calculated and obtained using several carrying capacity hereby called the saturated values (SV). From the trend of the behavior of the 1-norm, 2-norm and infinity norm, we observed that it follows an order of a monotonic decreasing sequence down the trend and suddenly changes in behaviour to a monotonic increasing sequence. This region were the sudden change occurs which is bolding have a unique character as all the norms have the smallest value compared to the rest of the value generated with the various saturated values. Thus the appropriate precise value of the intra-competition coefficient β, obtained using this method is stated as β= 0.026685209713024 which is a major achievement in environmental studies, ecosystem functioning and a contribution to knowledge as the value obtained is vital in the model development that will be used to study various analysis of its impact on environmental variables.

CONCLUSION

This study have used the logistic differential equation model to obtain the appropriate precise value of the intra-competition coefficient β, obtained using the p-vector norm indexed by a computational method of ODE45 Matlab numerical scheme and is stated as β= 0.026685209713024 which is a major achievement in environmental studies, ecosystem functioning and a contribution to knowledge as the value obtained is vital in the model development that will be used to study various analysis of its impact on environmental variables.

FURTHER RESEARCH

This p-vector norm method indexed by a robust numerical scheme can also be used to obtain the intra-competition coefficient of the following environmental pollutants recorded from field during the study period.

1. P_{M1} pollutant level of some selected location in Port-Harcourt metropolis.
2. P_{M7} pollutant level of some selected location in Port-Harcourt metropolis.
3. P_{M10} pollutant level of some selected location in Port-Harcourt metropolis.

   Which will be use to carry various analysis in environmental studies.

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