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A VIABLE MATHEMATICAL MODELING FOR THE ASPECTS OF MATERIAL CYCLING IN THE CONTEXT OF POWER PLANTS ENVIRONMENT

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Nutrient model.

ABSTRACT

Generally the environments in the context of power plants are to be streamlined due to the existence of species of pollutants and nutrients. Therefore it is essential to regulate the aspects of material cycling in the case of power plants because of its polluting environment. The passengers of elemental materials like carbon, phosphorus or nitrogen, shows up a linear species chain and either considered the primary production rate to be constant or represented as resource limitations especially by means of a logistic function. Basically the assumption of constant primary production is slightly opposite, when the bio-mass of primary producers does not fall very less and their productivity is limited by some factors other than element being modeled, for example "light".

However in closed systems, the elemental matters needed for primary productions must be provided through re-cycling by mortality and respiration in the case of carbon, or by mortality and excretion in the case of phosphorus or nitrogen. But some of the ecosystems in the power plants environments are closed to carbon, therefore it is very much essential to investigate the issues related to material cycling under the purview of dynamic implications of an elemental nutrient including nitrogen and phosphorus. In this context, a viable mathematical modeling is proposed for regulating the issues of species pollutions in the case of ecosystems in the power plants as a generic model.

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1. **INTRODUCTION :** In order to enhance the environmental atmosphere in the case of power plants, it is essential to capture the dynamic behavior of pollution species and its disintegration including chemical kinetic behavior of linear species with respect to resource limitation and decomposition of bio-mass as well. In this context it is mandatory to regulate the formation of polluted species with an effective mathematical modeling including the aspects of material cycling and disassociation under the cluster of dynamic implications towards elemental nutrient as a specific case, so that this integration species pollution will be streamlined in an orderly fashion to support the eco-systems in power plants as a generic model towards sustainable development.

2. **PROPOSED MODEL:**

2.1 Linear Tropic Interaction:

A model is proposed in which the losses from a linear chain and collected with a blend of nutrient compartment from which the material for primary production must be drawn.

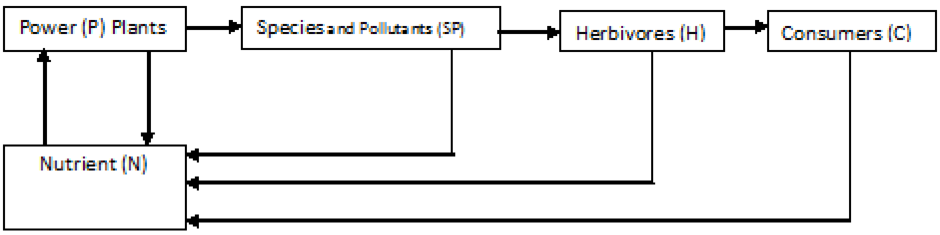

Figure 1. Linear nutrient flow in ecosystem

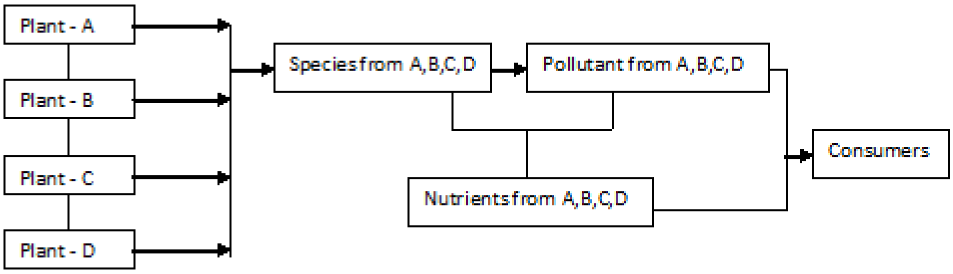

Figure 2. Non-Linear nutrient flow in ecosystem

2.2 NUTRIENT PLANT SYSTEM:

A nutrient compartment containing limiting nutrient at density N(t), and the plant functional group which can be characterized by its limiting nutrient density, P(t). It is assumed that the plants have a linear functional response, with slope α_p and a ratio of mortality/excretion rate as δ_p . The system is closed one, so that any nutrient taken up by the plants is lost to the free nutrient cluster and all nutrients lost by the plants due to death and excretion is suddenly modeled/ added the nutrient groups. By considering these assumptions, the system dynamics are expressed as;

$$\left.\begin{aligned} dp/dt &= \alpha_p NP - \delta_p P \\ dn/dt &= \delta_p P - \alpha_p PN \end{aligned}\right\} \qquad \text{equ (1)}$$

This equation implies that,

$$dp/dt + dn/dt = d\,(P+N)\,/dt = 0 \qquad \text{equ (2)}$$

In another form, it implies that the total quantity of nutrient contained in the system remains constant, so that we can expect that the given assumption leads to assume that the system is closed.

The total amount of bound and unbound nutrient in the system is "**S**", so that the simplified dynamic description implies that,

$$dp/dt = \alpha_p NP - \delta_p P$$

$$N(t) + P(t) = S \qquad \text{equ (3)}$$

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In this particular case, it is essential for substituting the conservation law N=S-P, back in the equation for the rate of charge of P. Hence,

$dp/dt = (\alpha_p S - \delta_p) P [1 - \alpha_p /(\alpha_p S - \delta_p) P]$ equ (4)

By defining $rp = (\alpha_p S - \delta_p)$ and $K_p = r_p / \alpha_p$, then

It implies that the logistic equation,

$dp/dt = r_p . P [1- P/ K_p]$ equ (5)

Therefore, it is noticed that this model have an unstable steady state at P=0, and globally steady state at

$P= K_p= [S - \delta_p /\alpha_p]$ equ (6)

For multiple nature of power plants, it is proposed to have the sum of

$K_{p1}+ K_{p2}+ K_{p3}+ K_{p4}+\ldots\ldots$ equ (7)

For example, $P= K_{p1}+ K_{p2}+ K_{p3}+ K_{p4}+\ldots\ldots\ldots$ equ (8)

$= (S_1 - \delta_{p1} /\alpha_{p1}) + (S_2 - \delta_{p2} /\alpha_{p2}) + (S_3 - \delta_{p3} /\alpha_{p3}) + (S_4 - \delta_{p4} /\alpha_{p4}) +\ldots\ldots\ldots$ equ (9)

Table 1. Steady State for Nutrient Cycling Model with Linearization Chain

CATEGORY	NP	NPH	NPHC
P* [Plants]	$S - \delta_p /\alpha_p$	δ_h /α_h	$\alpha_c/ \alpha_{ch} [S - \delta_p /\alpha_p + \delta_h /\alpha_c - \alpha_{ph} . H^* / \alpha_p]$
H* [Herbivores]	0	$\alpha_p/ \alpha_{ph} [S - \delta_p /\alpha_p - \delta_h /\alpha_h]$	δ_c /α_c
C* [Consumer]	0	0	$\alpha_h/ \alpha_{ch} [S - \delta_p /\alpha_p - \delta_h /\alpha_h - \alpha_{ph} . H^* / \alpha_p]$

For non-Linearization function comprising of multiple power plants, the sum of all these categories can be made it possible for balancing the variations in the concentrations of species and its compositions.

For Example,

$P^* = [NP + NPH + NPHC]$ category equ (10)

$= (S - \delta_p /\alpha_p) + (\delta_h /\alpha_h) + [\alpha_c/ \alpha_{ch} (S - \delta_p /\alpha_p + \delta_h /\alpha_c - \alpha_{ph} . H^* / \alpha_p)]$ equ (11)

$H^* = [NP + NPH + NPHC]$ category equ (12)

$= [0 + \alpha_p/ \alpha_{ph} [S - \delta_p /\alpha_p - \delta_h /\alpha_h] + \delta_c /\alpha_c]$ equ (13)

Similarly,

C* = [NP + NPH + NPHC] category equ (14)

$= 0 + 0 + \alpha_h / \alpha_{ch} [S - \delta_p / \alpha_p - \delta_h / \alpha_h - \alpha_{ph} . H^* / \alpha_p]$ equ (15)

$N^* = [P^* + H^* + C^*]$ equ (16)

2.3 NUTRIENT-PLANT-HERBIVORE-CONSUMER SYSTEM:

It is something like a more complex model, which is considered as the nutrient cycling equivalent of three level chain with linear tropic interaction , defined by the equation ,

$dp/dt = [\varphi - \delta_p P - \alpha_h PH] \Rightarrow [\alpha_p PN - \delta_p P - \alpha_h PH]$ equ (17)

$dh/dt = [\alpha_h PH - \delta_h H - \alpha_c HC]$ equ (18)

$dc/dt = [\alpha_c CH - \delta_c C]$ equ (19)

The system has three steady states, C=H=O with p

Given by the equation, $P^* = (\varphi/\delta_p)$

C=0 with P and H , given by the equation

$P^* = \delta_h / \alpha_h$, and $H^* = [1/ \delta_h (\varphi - \delta_p P^*)]$ equ (20)

and a Co-existence steady state with ,

$P^* = [\varphi / \delta_p + \delta_h H^*], \ H^* = \delta_c / \alpha_c$ equ (21)

$C^* = 1/ \delta_c [\varphi - \delta_p P^* - \delta_h H^*]$ equ (22)

The requirement for this state to be chemically and biologically sensible(ie. All positive) is that,

$P >= \delta_p [\delta_h / \alpha_h] + >= \delta_h [\delta_c / \alpha_c]$ equ (23)

The terms on the right-hand side are [Respiration / Mortality] loss at the plant and herbivore levels respectively, when herbivore bio-mass density is at the value required to be balance the consumer dynamics. It is recognized that the "nutrient stock" is the total system nutrient content**(S)** minus the nutrient bound in the plant, herbivore and consumer tropic levels.

This system has one stationary state in which all the nutrient held in the free nutrient group and there is no population of any organism **(P=H=C=0)**. It is consisting of three level of steady state such as NP, NPH and NPHC, to represent the compartment which contain :non-zero bio-mass".

The algebraic expressions for these levels of steady state are listed in the table 1, where a familiar pattern is observed. When the herbivores form the upper most occupied level, their steady state density responds to system enrichment to increase **"S"** , but the plant steady state is set by the demographic characteristics of the herbivores and it is insensitive to enrichment. When the consumers are the upper most occupied level, their steady state and that of the plants respond linearly to the system enrichment, but that of the herbivores is set by the demographic characteristics of the consumer and it is insensitive to the system enrichment.

In the case of 'NP" steady state, the dynamic equation can be redefined as a remodeling of the logistic equation. This ensures the stability of this state against all except the introduction of herbivores. By examining small deviation from the "**NPH"** state, it is noticed that the associate characteristic equation is expressed as ,

$$\lambda^{2} + \lambda(\alpha_p P^*) + \alpha_h(\alpha_h + \alpha_p)\, H^*.P^*=0 \qquad \text{equ (24)}$$

Provided P* and H* both are positive, the constant term and the co-efficient of **λ** are also positive, and all the eigenvalues are guaranteed to have negative real parts, the local stability of all the biologically sensible versions of this steady state is therefore assured.

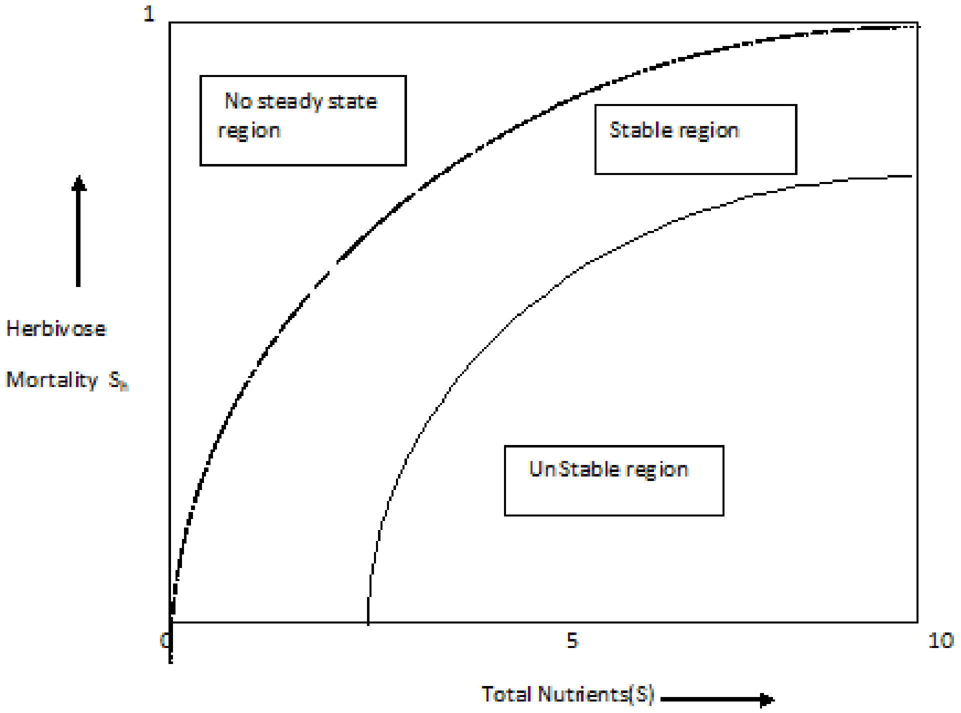

Figure 3. Functional Response of NPH Nutrient

The characteristic equation which defines the permissible eigenvalues describing small deviation from the **NPHC** steady state is considered as a cubic ie.,

$$\lambda^3 + A_1 \lambda^2 + A_2 \lambda + A_3 = 0 \qquad \text{equ (25)}$$

Where $A_1 = \alpha_p P^*$

$A_2 = \alpha^2_c H^*.C^* + \alpha_h (\alpha_h + \alpha_p) H^*.P^*$

$A_3 = (\alpha_p . \alpha^2_c + \alpha_p . \alpha_h . \alpha_c) . P^* . H^* . C^*$

If P*, H* and C* , are positive , then the condition for local stability is $\mathbf{A_1 A_2 > A_3}$ for $\mathbf{A_1}$ $\mathbf{A_2}$ and $\mathbf{A_3}$.

An expression indicates that this is equivalent to the requirement that $(\alpha_p + \alpha_h)P^* > \alpha_c . C^*$

But $\alpha_c . C^* = (\alpha_h . P^* - \delta_h)$

And it is less than $\alpha_h . P^*$. Therefore this inequality is true for all the biologically sensible steady states, which are consequently guaranteed to be locally stable.

3 RESULT AND CONCLUSION

A viable mathematical modeling for regulating the issues of material cycling in the context of power plant's environment is established by considering linear nutrients in different levels. Logistic functions and analytic proportions are introduced to balance the concentration of many species and pollutants. Steady state variation is considered for proportional changes in the species. A complete ecological balance in the environment power plants are discussed with mere and opt assumptions also towards sustainable developments irrespective of the scenarios in the environments including pollution, condensation and boiling. . Of course the influence of mathematical modeling for predicting the fluctuations can be synchronized with logic gates, digitalized environment in the power plant instrumentation along with pervasive computing facilities blended with RFID, Geographical Information Systems (GIS) and Global Positioning systems (GPS) as well as their related provisions for effectrive mathematical modeling.

References:

[1]. Abram P.A., and Roth J.D. "The Effects of Enrichment on Three Species food chains with Non-Linear-Functional Response" Ecology.75, 1118 – 1130, 1994

[2]. Bence J.R. , "Space Limited Reemitment in Open System".

[3]. Brown R.L. , "Introduction to Mathematics of Demography". Actex Publications; 3rd edition (1997), ISBN-10**:** 1566982057, ISBN**-13:** 978-1566982054

[4]. DeAngelin D.L. , "Dynamics of Nutrient Cycling and food webs", ISBN 978-94-011-2342-6

[5]. Goh B.S. "Global Stability in Many Species System". The American Naturalist, Vol 111, No 977, Jan – Feb 1977 PP 135 - 143

[6]. Goel . J.P. "Stochastic Modeling of Linear Systems".

[7]. Philip J "An Effective methodology for numerical stability"

[8]. Saxena T. P "Applied stochastic modeling for multi objective functions"

[9]. Johnson W Vanwhylon, "Dynamics behavior of mathematical equation under variable functionality"