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MATHEMATICAL ANALYSIS OF DENGUE FEVER INFECTION IN INDIA

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Abstract. In this work, we investigate a nonlinear system for studying the dengue fever infection. Here, we consider only the transmissions of dengue fever and formulate the mathematical model. The nonlinear system can be solved using asymptotic methods for the empirical values of parameters. Finally, the simulations are reported to support the presented our model results. Further, the graph of the proposed model is compared with the real life data of the Dengue infected patient in Tamil Nadu.

Key words: Dengue fever; Simulation; Mosquitoes; Asymptotic method; Disease transmission.

1. Introduction

Dengue is a mosquito-borne viral disease commonly found in tropical and sub-tropical areas around the globe. Transmission has risen predominantly in urban and semi-urban regions in latest years and has become a significant public health concern [1].There are four separate but tightly linked virus serotypes that cause dengue disease (DEN-1, DEN-2, DEN-3 and DEN-4). Recuperation from disease by one professional- vides long lasting resistance against that specific serotype. In any case, cross-immunity to the other serotypes after recuperation is as it were halfway and transitory. Ensuing contaminations by other serotypes increment the hazard of creating seriousDengue. Appropriately to the World Health Organization (WHO), [1-7], over 2.5 billion individuals are presently at chance for Dengue. Right now, the WHO gauges that there may be 50-100 million Dengue contaminations around the world.

Not as it were is the number of cases expanding as the infection spreads to unusedranges,but there are also explosive outbreaks. Therisk of a conceivable episode of Dengue fever presently exists in Europe and neighborhood transmission of Dengue was detailed for the primary time in France and Croatia in 2010 and imported cases were identified in three other European nations. In 2012, an flare-up of Dengue on Madeira Islands of Portugal brought about in over 2000 cases and imported instances were identified in 10 other nations in Europe separated from terrain Portugal. Syafruddin Side[8] analyzed the SIR model for the spread of dengue fever illness using stability analysis and simulation. S.M. Garba addressed the use of normal incidence in the modeling of 21 dengue illnesses that trigger the backward bifurcation phenomenon of dengue disease. [9]. Recently, Babatunde Gbadamosi[10] has analyzed a deterministic mathematical model of dengue virus with a nonlinear incidence function in the population.Besides, Parasuraman Ganeskumar [11] has assessed the age particular frequency of dengue and considers to produce dengue sero predominance data analysis.

Mathematical modeling is a strong instrument for testing and comparing distinct intervention approaches that may be helpful in managing or eliminating Dengue, which is particularly essential in our restricted resource globe. The different mathematical models offer assistance us conceptualize the transmission flow in a quantitative way as well as permit us to test distinctive theories to get it their significance. In this paper we analyze and propose the models of Dengue.

The aim of this research was to match empirical data with model simulation. Subsequently, the dengue demonstrate displayed in this paper is aiming to be a trusted reference and as a control instrument in managing with dengue fever in Tamil Nadu. The first section of this paper defines a demonstrate for transmission of dengue fever, the second section analyzes the model and the last section simulates the model for Tamil Nadu.The simulation is compared to a hypothetical calculation generation by MATLAB.

2. Mathematical analysis for dengue model

The fundamental demonstrate for the transmission elements of dengue is given by the taking after deterministic framework of nonlinear systems 10]:

$$
\begin{aligned}
\frac{dS_h}{dt} &= \pi_h - \frac{b\beta_{hv}S_hI_v}{1+v_hI_v} - \mu_hS_h + \omega R_h \\
\frac{dE_h}{dt} &= \frac{b\beta_{hv}S_hI_v}{1+v_hI_v} + \mu_1M_h - (\mu_h + \sigma_h)E_h \\
\frac{dI_h}{dt} &= \sigma_hE_h + \mu_2M_h - (\mu_h + \tau_h + \delta_h)I_h \\
\frac{dM_h}{dt} &= \pi_{mh} - (\mu_1 + \mu_2 + \mu_h)M_h \\
\frac{dT_h}{dt} &= \tau_hI_h - (\mu_h + \gamma_1)T_h \\
\frac{dR_h}{dt} &= \gamma_1T_h - \mu_hR_h - \omega R_h \\
\frac{dA_v}{dt} &= \pi_v - (\gamma_m + \mu_v + C_a)A_v \\
\frac{dS_v}{dt} &= \gamma_mA_v - \frac{b\beta_{vh}S_vI_h}{1+v_vI_h} - (\mu_v + C_m)S_v \\
\frac{dE_v}{dt} &= \frac{b\beta_{vh}S_vI_h}{1+v_vI_h} - (\theta_c + \sigma_v + \mu_v + C_m)E_v \\
\frac{dI_v}{dt} &= (\theta_c + \sigma_v)E_v - (\delta_v + \mu_v + C_m)I_v
\end{aligned}
\tag{1}
$$

The initial conditions become

$$
when\, t = 0, S_h = S_h^*, E_h = E_h^*, I_h = I_h^*, M_h = M_h^*, T_h = T_h^*, R_h = R_h^*, A_v = A_v^*, S_v = S_v^*, E_v = E_v^*, I_v = I_v^* \tag{2}
$$

In particular case, we can take empirical value of the above conditions, we've

$$when\, t=0,\ S_h=\frac{\pi_h}{\mu_h}, E_h=0, I_h=0, M_h=0, T_h=0, R_h=0, A_v=\frac{\pi_v}{\gamma_m+\mu_v+C_a}, S_v=\frac{\gamma_m\pi_v}{(\gamma_m+\mu_v+C_a)(\mu_v+C_m)},$$
$$E_v=0, I_v=0 \tag{3}$$

$$S_h=\left[S_h^*-\frac{\pi_h}{\mu_h}\right]e^{-\mu_h t}+\frac{\pi_h}{\mu_h}+\left[\begin{array}{l}\dfrac{jv_h\pi_h I_v^*}{\mu_h-\delta_v-\mu_v-c_m}-\dfrac{jv_h I_v^*\mu_h\left[S_h^*-\dfrac{\pi_h}{\mu_h}\right]}{\delta_v+\mu_v+c_m}-(jb\beta_{vh}+j\mu_h v_h)\left[\begin{array}{l}\dfrac{-\left[S_h^*-\dfrac{\pi_h}{\mu_h}\right]I_v^*}{\delta_v+\mu_v+c_m}\\ +\dfrac{\dfrac{\pi_h}{\mu_h}I_v^*}{\mu_h-\delta_v-\mu_v-c_m}\end{array}\right]\\ \dfrac{jwR_h^*}{w}-\dfrac{jwv_h R_h^* I_v^*}{w+\delta_v+\mu_v+c_m}\end{array}\right]e^{-\mu_h t}$$
$$+\frac{jv_h I_v^* e^{-(\delta_v+\mu_v+c_m)t}\mu_h\left[S_h^*-\dfrac{\pi_h}{\mu_h}\right]e^{-\mu_h t}}{\delta_v+\mu_v+c_m}-\frac{jv_h\pi_h I_v^* e^{-(\delta_v+\mu_v+c_m)t}}{\mu_h-\delta_v-\mu_v-c_m}+(jb\beta_{vh}+j\mu_h v_h)\left[\begin{array}{l}\dfrac{-\left[S_h^*-\dfrac{\pi_h}{\mu_h}\right]e^{-\mu_h t}I_v^* e^{-(\delta_v+\mu_v+c_m)t}}{\delta_v+\mu_v+c_m}\\ +\dfrac{\dfrac{\pi_h}{\mu_h}I_v^* e^{-(\delta_v+\mu_v+c_m)t}}{\mu_h-\delta_v-\mu_v-c_m}\end{array}\right]+$$
$$\frac{jwR_h^* e^{-(\mu_h+w)t}}{w}+\frac{jwv_h R_h^* I_v^* e^{-(\mu_h+w+\delta_v+\mu_v+c_m)t}}{w+\delta_v+\mu_v+c_m} \tag{4}$$

where S_h is the susceptible human, E_h is the exposed human, I_h is the infected human, M_h is the migrated population, T_h is the treatment class and R_h is the recovered human, A_v is the aquatic class, S_v is the susceptible mosquitoes, E_v is the exposed mosquitoes, I_v is the infectedmosquitoes. π_h, π_v is the recruitment rate of human and mosquitoes respectively. π_{mh} is the recruitment rate of migrated population, β_{hv} is the transmission rate from host to vector, β_{vh} is the transmission rate from vector to host, b is the biting rate of vector, v_h, v_v are theproportion of antibody produced by a human in response to the incidence of infection caused by the vector and the proportion of antibody produced by a vector in the response to the incidence of infection caused by the human, μ_h, μ_v is the natural death rate of humans and vectors respectively. μ_1, μ_2 is the transition rate between exposed human and infectious human, σ_h is the progression rate of exposed human to infectious class, σ_v is the progression rate of the exposed vector to the infectious class, τ_h is the treatment rate of the infectious individuals, ω is the per capita rate of loss of immunity in human, γ_1 is the recovery rate due to treatment, γ_m is the mean aquatic transition rate, δ_h, δ_v disease-an induced death rate of humans and vector respectively, The solution of the above equation becomes

$$E_h = E_h^* e^{-(\mu_h+\sigma_h)t} + \left[\begin{array}{l} \dfrac{j v_h(\mu_h+\sigma_h)E_h^* I_v^*}{\delta_v+\mu_v+c_m} + jb\beta_{hv}\left[\dfrac{(s_h^* - \pi_h/\mu_h)I_v^*}{\sigma_h-\delta_v-\mu_v-c_m} + \dfrac{\pi_h/\mu_h\, I_v^*}{\mu_h+\sigma_h-\delta_v-\mu_v-c_m}\right] \\ + j\mu_1\left[\dfrac{\mu_h^* + (\pi_{mh}/\mu_1+\mu_2+\mu_h)}{\sigma_h-\mu_1-\mu_2} - \dfrac{\pi_{mh}}{(\mu_1+\mu_2+\mu_h)(\mu_h+\sigma_h)}\right] \\ + j\mu_1 v_h\left[\dfrac{I_v^*\left[\mu_h^* + (\pi_{mh}/\mu_1+\mu_2+\mu_h)\right]}{\sigma_h-\mu_1-\mu_2} - \dfrac{\pi_{mh} I_v^*}{(\mu_1+\mu_2+\mu_h)(\mu_h+\sigma_h-\delta_v-\mu_v-c_m)}\right] + \\ \dfrac{j(\mu_h+\sigma_h)v_h I_v^* E_h^*}{\delta_v+\mu_v+c_m} \end{array}\right] e^{-(\mu_h+\sigma_h)t}$$

$$- j v_h\left[\frac{(\mu_h+\sigma_h)E_h^* e^{-(\mu_h+\sigma_h)t} I_v^* e^{-(\delta_v+\mu_v+c_m)t}}{\delta_v+\mu_v+c_m}\right] - jb\beta_{hv}\left[\frac{(s_h^* - \pi_h/\mu_h)e^{-\mu_h t} I_v^* e^{-(\delta_v+\mu_v+c_m)t}}{\sigma_h-\delta_v-\mu_v-c_m} + \frac{\pi_h/\mu_h\, I_v^* e^{-(\delta_v+\mu_v+c_m)t}}{\mu_h+\sigma_h-\delta_v-\mu_v-c_m}\right]$$

$$- j\mu_1\left[\frac{\mu_h^* + (\pi_{mh}/\mu_1+\mu_2+\mu_h)e^{-(\mu_1+\mu_2+\mu_h)t}}{\sigma_h-\mu_1-\mu_2} - \frac{\pi_{mh}}{(\mu_1+\mu_2+\mu_h)(\mu_h+\sigma_h)}\right]$$

$$- j\mu_1 v_h\left[\frac{I_v^* e^{-(\delta_v+\mu_v+c_m)t}\left[\mu_h^* + (\pi_{mh}/\mu_1+\mu_2+\mu_h)\right]e^{-(\mu_1+\mu_2+\mu_h)t}}{\sigma_h-\mu_1-\mu_2} - \frac{\pi_{mh} I_v^* e^{-(\delta_v+\mu_v+c_m)t}}{(\mu_1+\mu_2+\mu_h)(\mu_h+\sigma_h-\delta_v-\mu_v-c_m)}\right]$$

$$- \frac{j(\mu_h+\sigma_h)v_h I_v^* e^{-(\delta_v+\mu_v+c_m)t} E_h^* e^{-(\mu_h+\sigma_h)t}}{\delta_v+\mu_v+c_m} \tag{5}$$

$$I_h = I_h^* e^{-(\mu_h+\tau_h+\delta_h)t} + \left[\frac{j\sigma_h E_h^*}{\tau_h+\delta_h-\sigma_h} + \frac{j\mu_h\left[\mu_h^* + \pi_{mh}/(\mu_1+\mu_2+\mu_h)\right]}{\tau_h+\delta_h-\mu_1-\mu_2} - \frac{j\pi_{mh}}{(\mu_1+\mu_2+\mu_h)(\mu_h+\tau_h+\delta_h)}\right] e^{-(\mu_h+\tau_h+\delta_h)t}$$

$$- j(\mu_h+\tau_h+\delta_h)I_h^* e^{-(\mu_h+\tau_h+\delta_h)t} t - \frac{j\sigma_h E_h^* e^{-(\mu_h+\sigma_h)t}}{\tau_h+\delta_h-\sigma_h}$$

$$M_h = \left[M_h^* + \frac{\pi_{mh}}{\mu_1+\mu_2+\mu_h}\right] e^{-(\mu_1+\mu_2+\mu_h)t} - \frac{\pi_{mh}}{\mu_1+\mu_2+\mu_h} + \left[\frac{2(1+j)\pi_{mh}}{\mu_1+\mu_2+\mu_h}\right] e^{-(\mu_1+\mu_2+\mu_h)t} - \frac{2(1+j)\pi_{mh}}{\mu_1+\mu_2+\mu_h} \tag{7}$$

$$T_h = T_h^* e^{-(\mu_h+\gamma_1)t} + \frac{j\tau_h I_h^*}{\gamma_1-\tau_h-\delta_h} e^{-(\mu_h+\gamma_1)t} - \frac{j\tau_h I_h^*}{\gamma_1-\tau_h-\delta_h} e^{-(\mu_h+\tau_h+\delta_h)t} \tag{8}$$

$$R_h = R_h^* e^{-(\mu_h+w)t} + \frac{j\gamma_1 T_h^*}{w-\gamma_1} e^{-(\mu_h+w)t} - \frac{j\gamma_1 T_h^*}{w-\gamma_1} e^{-(\mu_h+\gamma_1)t} \tag{9}$$

$$A_v = \left[A_v^* + \frac{\pi_v}{\gamma_m+\mu_v+c_a}\right] e^{-(\gamma_m+\mu_v+c_a)t} - \frac{\pi_v}{\gamma_m+\mu_v+c_a} + \frac{2(1+j)\pi_v}{\gamma_m+\mu_v+c_a} e^{-(\gamma_m+\mu_v+c_a)t} - \frac{2(1+j)\pi_v}{\gamma_m+\mu_v+c_a} \tag{10}$$

$$S_v = S_v^* e^{-(\mu_v+C_m)t} + \left[\begin{array}{l} \dfrac{jv_m\left[A_v^* + \dfrac{\pi_v}{\gamma_m+\mu_v+C_a}\right]}{C_m-\gamma_m-C_a} - \dfrac{jv_h(\mu_v+C_m)S_v^*I_h^*}{\mu_h+\tau_h+\delta_h} - \dfrac{j\gamma_m\pi_v}{(\gamma_m+\mu_v+C_a)(\mu_v+C_m)} \\ + \dfrac{j\gamma_m v_h I_h^*\left[A_v^* + \dfrac{\pi_v}{\gamma_m+\mu_v+C_a}\right]}{C_m-\gamma_m-C_a-\mu_h-\tau_h-\delta_h} - \dfrac{j\gamma_m v_h I_h^*}{(\gamma_m+\mu_v+C_a)(\mu_v+C_m-\mu_h-\tau_h-\delta_h)} + \\ (jb\beta_{vh} + j\mu_v v_h + jC_m v_h)\left[\dfrac{S_v^* I_h^*}{\mu_h+\tau_h+\delta_h}\right] \end{array} \right] e^{-(\mu_v+C_m)t}$$

$$+\frac{jv_hS_v^*I_h^*(\mu_v+C_m)e^{-(\mu_v+C_m)t}e^{-(\mu_h+\tau_h+\delta_h)t}}{\mu_h+\tau_h+\delta_h} - \frac{j\gamma_m\left[A_v^* + \dfrac{\pi_v}{\gamma_m+\mu_v+C_a}\right]}{C_m-\gamma_m-C_a} e^{-(\gamma_m+\mu_v+C_a)t} + \frac{j\gamma_m\pi_v}{(\gamma_m+\mu_v+C_a)(\mu_v+C_m)}$$
$$-\frac{j\gamma_m v_h\left[A_v^* + \dfrac{\pi_v}{\gamma_m+\mu_v+C_a}\right]e^{-(\gamma_m+\mu_v+C_a)t}I_h^*e^{-(\mu_h+\tau_h+\delta_h)t}}{C_m-\gamma_m-C_a-\mu_h-\tau_h-\delta_h} + \frac{j\gamma_m v_h\pi_v I_h^* e^{-(\mu_h+\tau_h+\delta_h)t}}{(\gamma_m+\mu_v+C_a)(\mu_v+C_m-\mu_h-\tau_h-\delta_h)} \tag{11}$$

$$E_v = E_v^* e^{-(\theta_c+\sigma_v+\mu_v+C_m)t} + \left[\begin{array}{l} \dfrac{jb\beta_{vh}S_v^*I_h^*}{\theta_c+\sigma_v-\mu_h-\tau_h-\delta_h} - \dfrac{jv_v(\theta_c+\sigma_v+\mu_v+C_m)E_v^*I_h^*}{\mu_h+\tau_h+\delta_h} \\ + \dfrac{(\theta_c+\sigma_v+\mu_v+C_m)v_vI_h^*E_v^*}{\mu_h+\tau_h+\delta_h} \end{array} \right] e^{-(\theta_c+\sigma_v+\mu_v+C_m)t}$$
$$-\frac{jb\beta_{vh}S_v^*I_h^*e^{-(\mu_v+C_m)t}e^{-(\mu_h+\tau_h+\delta_h)t}}{\theta_c+\sigma_v-\mu_h-\tau_h-\delta_h}$$

(12)

$$I_v = I_v^* e^{-(\delta_v+\mu_v+c_m)t} + \left(\frac{j(\theta_c+\sigma_v)E_v^*}{(\delta_v-\theta_c-\sigma_v)}\right)e^{-(\delta_v+\mu_v+c_m)t} - \frac{j(\theta_c-\sigma_v)E_v^*e^{-(\theta_c+\sigma_v+\mu_v+c_m)t}}{\delta_v-\theta_c-\sigma_v} \tag{13}$$

3. Numerical Simulation

In the following, the numerical simulations obtained for the solution of the deterministic dengue model are shown by applying the proposed method described in Section 4. We utilized the rate constants are shown in Table 1[9], which wasobtained from the experimental results.The numerical results are given to confirm the effectiveness and the accuracy of the presented method and real life data in Tables 1 and 2. The MATLAB programme is shown in Appendix.

4. Discussion

In this paper, we propose a mathematical model that studied the dynamics of transmission of human-mosquitoes diseases called dengue. To begin withsituation (Fig. 1) illustrates that a significantdiminish in a mosquito populace can essentiallydiminish the estimate of the episode. From the figure we see that the reliance is nearlydirect. In the event that we diminish the number of mosquitoes by two times, we get nearly 50 % diminish of taintedpopulace. Another curiouslyperception is that the day when the crest of the flare-up is come to remains the same and does not depend on the number of mosquitoes.The momentsituation (Fig. 2) illustrates that the mosquito enrollment rate has nearly no affect on the flare-up. In any case, the mosquito enrollment rate can impressivelymove the susceptible-infected dispersion among mosquitoes. Fig. 3 represents dimensionless concentration of $S_h, E_h, I_h, M_h, T_h, R_h, A_v, S_v, E_v$ and I_v versus dimensionless time for experimental values of parameter using equations (4-13).

A simulation was carried out utilizing ODESOLVE, MATLAB. Data on the number of dengue fever cases within the state of Tamil Nadu are given in Fig. 4, and comes about for the dengue show for the state of Tamil Nadu are portrayed in Figs. 4 and 5, where the x-axis is time (A long time) and the y-axis is the division of the factors.These figurescan be compared with the data obtained from the Tamil Nadu, Ministry of Health as shown in Figs. 4 and 5. The product of the dengue model diagram is compatible with the diagram product of real data.

5. Conclusion

This paper presents a deterministic demonstrate for the transmission elements of a single strain of dengue illness. The demonstrate, which practicallyreceives a standard frequencydetailing, permits dengue transmission by uncoveredpeople and mosquitoes. The model was amplified to incorporate a flawedimmunization for dengue. Agreeing to our comes about dengue cannot as it were be controlled by decreasing the contamination rate between people and mosquitoes, but too by diminishing the contact rate between the mosquitoes and people, and the utilize of dynamic dengue drugs, bug sprays, and, treated bed nets would diminish the mosquitoes populace, which will keep the human populacesteady.Be that as it may, indeedin spite of the fact that mosquito action level shows up to have higher affect on the episode, it appearstroublesome to control it. The less demanding way to control the flare-up is to executeopenapproaches to decrease the measure of the mosquito populace. Cases of such arrangementsincorporate: pulverizinglocales where hatchlingscreate or utilizingmethodologies to anticipatehatchlingsadvancement when water-filled holders are display.At the same time, less difficult approaches like family screening, air-conditioning and other strategies to seal living range from mosquitoes are toocompelling in avoiding dengue. In future, we'll incorporateideal control approach to control the spread of dengue and bifurcation examination in this demonstrate**.**

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Appendix

```
function main
options= odeset ('RelTol',1e-6,'Stats','on');
%initial conditions
s=0.1;
e=0;
i=0;
m=0;
t=0;
r=0;
a=0.1;
s1=0.1;
e1=0;
i1=0;
Xo = [s, e, i, m, t, r, a, s1, e1, i1];
tspan = [0,250];
xspan = [0,3000];
tic
[t,X] = ode45(@TestFunction,tspan,Xo,options);
toc
figure
plot(t,X(:,1),t,X(:,2),t,X(:,3),t,X(:,4),t,X(:,5),t,X(:,6),t,X(:,7),t,X(:,8),t,X(:,9),t,X(:,1),'.',t,X(:,2),'.',t,X(:,
3),'.',t,X(:,4),'.',t,X(:,5),'.',t,X(:,6),'.',t,X(:,7),'.',t,X(:,8),'.',t,X(:,9),'.',t,X(:,10),t,X(:,10),'.')
ylabel('x')
xlabel('t')
return
function [dx_dt]= TestFunction(t,x)
P=2.5;
b=1;
B=0.75;
v=0.75;
m=0.0149;
w=0.1;
m1=0.1;
d=0.5;
m2=0.01;
t=0.1428;
D=0.003;
P1=500;
r1=0.328;
P2=5000;
r=14;
M=0.02941;
c1=0.375;
v1=0.375;
c2=0.75;
o=0.01;
d1=0.1666;
D1=0.001;
```

```
dx_dt(1) =P-(b*B*x(1)*x(10))/(1+v*x(10))-m*x(1)+w*x(6);
dx_dt(2) =(b*B*x(1)*x(10))/(1+v*x(10))+m1*x(4)-(m+d)*x(2);
dx_dt(3) =d*x(2)+m2*x(4)-(m+t+D)*x(3);
dx_dt(4)=P1-(m1+m2+m)*x(4);
dx_dt(5)=t*x(3)-(m+r1)*x(5);
dx_dt(6)=r1*x(5)-m*x(6)-w*x(6);
dx_dt(7)=P2-(r+M+c1)*x(7);
dx_dt(8)=r*x(7)-(b*B*x(1)*x(3))/(1+v1*x(3))-(M+c2)*x(8);
dx_dt(9)=(b*B*x(1)*x(3))/(1+v1*x(3))-(o+d1+M+c2)*x(9);
dx_dt(10)=(o+d1)*x(9)-(D1+M+c2)*x(10);
dx_dt = dx_dt';
return
```

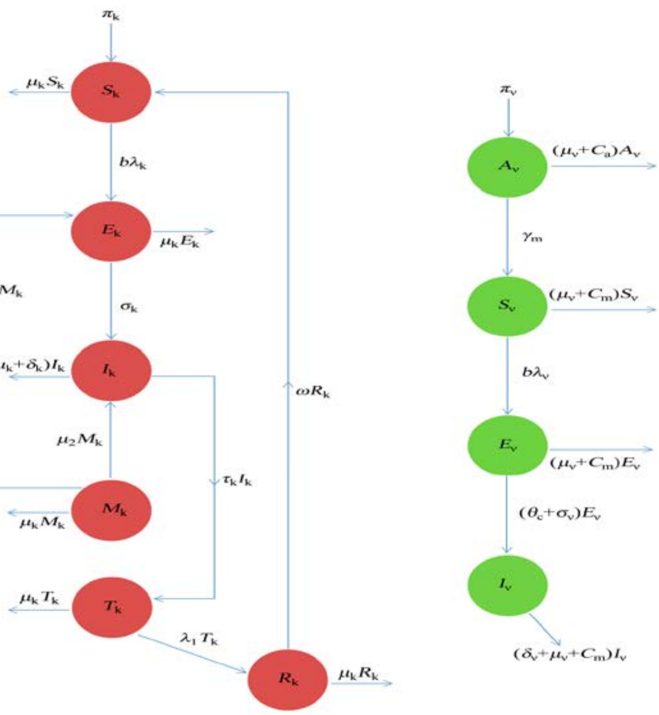

Fig. 1: Schematic illustration of the Dynamic transmission of the dengue model.

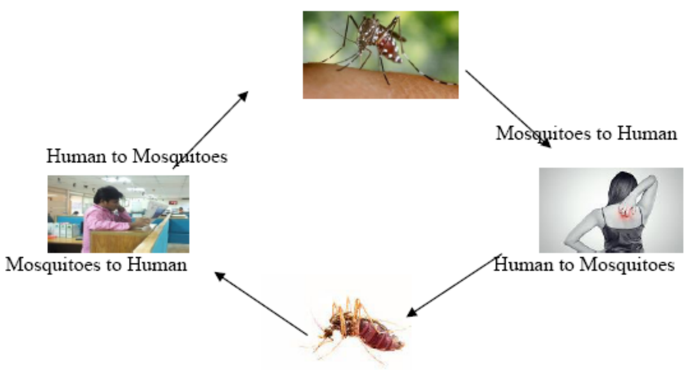

Fig. 2: Man-Mosquito-Man cycle in the transformation circle of Dengue.

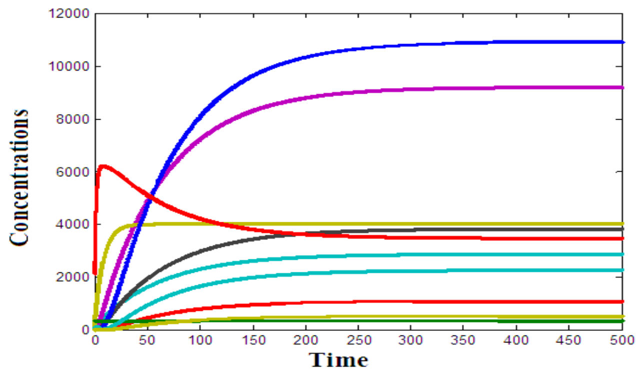

Fig 3:Comparison of our concentrations of dengue model versus time using equations (5-13) (—) with the numerical simulation (…) for experimental values of parameters [9].

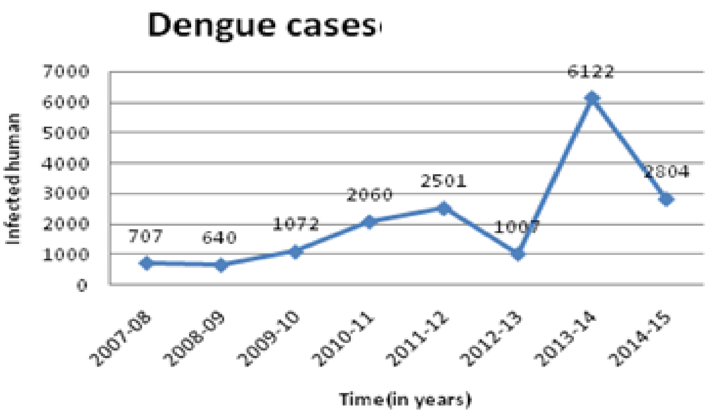

Fig. 4: Number of dengue cases reported to Tamil Nadu(Kanchipuram-Kanyakumari) in 2007 -2015 years.

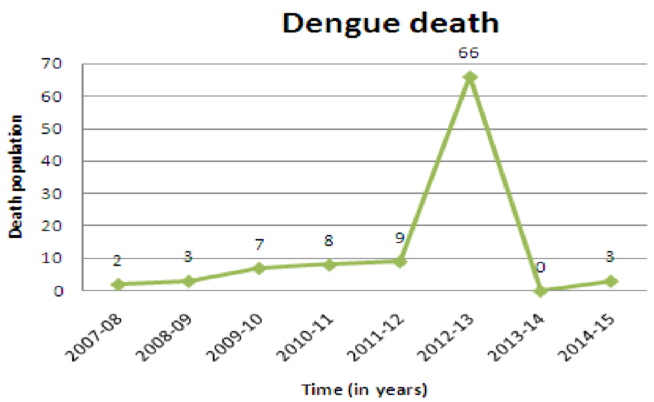

Fig. 5: Number of dengue death reported to Tamil Nadu (Kanchipuram-Kanyakumari) in 2007 -2015 years.

Table 1: Dengue cases versus time in years for empirical values of parameters in ministry of Health, Tamil Nadu

Year	Real life data	Analytical value	Error(%)
2007-08	707	707.1	0.01414
2008-09	640	640.05	0.00781
2009-10	1072	1072.33	0.03077
2010-11	2060	2060.02	0.00097
2011-12	2501	2501.001	4E-05
2012-13	1007	1007.04	0.00397
2013-14	6122	6122.01	0.00016
2014-15	2804	2804.04	0.00143

Table 2: Dengue death versus time in years for empirical values of parameters in ministry of Health, Tamil Nadu

Year	Real life data	Analytical value	Error(%)
2007-08	2	2.05	0.2494
2008-09	3	3.001	0.0333
2009-10	7	7.04	0.5682
2010-11	8	8.01	0.1248
2011-12	9	9.003	0.0333
2012-13	66	66.02	0.0303
2013-14	0	0.00	0.0000
2014-15	3	3.42	1.3807