

# List of Figures

2.1	Comparison of the lower bounds for $\lambda$ obtained from Lyapunov-type and Cauchy-Schwarz inequalities with the lowest eigenvalue for (2.11)-(2.12). ( $-\circ-$ : LTILB; $-*-$ : CSILB; $-\times-$ :LE - the Lowest Eigenvalue $\lambda$ ) ) .	13
2.2	Comparison of the lower bounds for $\lambda$ obtained from Lyapunov-type and Cauchy-Schwarz inequalities with the lowest eigenvalue for (2.13)-(2.14). ( $-\circ-$ : LTILB; $-*-$ : CSILB; $-\times-$ :LE - the Lowest Eigenvalue $\lambda$ ) ) .	14
3.1	Overview of Breast cancer . . . . .	19
3.2	Decay of Healthy cells and growth of Dead cells for different value of $\eta$ without treatment . . . . .	36
3.3	Growth of Healthy cells and Decay of Dead cells for different value of $\eta$ with treatment at $D(0) = 100$ . . . . .	36
3.4	Growth of Healthy cells and Decay of Dead cells for different value of $\eta$ with treatment at $D(0) = 179$ . . . . .	37
3.5	Decay of Healthy cells and growth of Dead cells for different value of $\eta$ with treatment and without z - control . . . . .	37
3.6	Growth of Healthy cells and Decay of Dead cells for different value of $\eta$ with treatment and z - control . . . . .	38
3.7	Fitting real data of Breast cancer with integer and fractional order( $r = 1$ ) models. . . . .	51
3.8	Fractional order ( $r = 1$ ) model prediction with real data. . . . .	51
3.9	Simulation of stage 1 and 2 patients with variation of fractional order. . . . .	52
3.10	Simulation of stage 3 patients with variation of fractional order. . . . .	52
3.11	Simulation of stage 4 patients with variation of fractional order. . . . .	53

3.12	Simulation of patients at disease free state with variation of fractional order.	53
3.13	Simulation of cardiotoxicity patients with variation of fractional order.	54
3.14	Effect of $\kappa$ on stage 3 patients.	54
3.15	Effect of $\kappa$ on stage 4 patients.	55
3.16	Effect of $\kappa$ on patients at disease free state.	55
3.17	Effect of $\kappa$ on cardiotoxicity patients.	56
3.18	Effect of $\omega$ on stage 4 patients.	56
3.19	Effect of $\omega$ on patients at disease free state.	57
3.20	Effect of $\omega$ on cardiotoxicity patients.	57
3.21	Effect of $\zeta$ on stage 3 patients.	58
3.22	Effect of $\zeta$ on stage 4 patients.	58
3.23	Effect of $\zeta$ on disease free state patients.	59
3.24	Effect of $\zeta$ on cardiotoxicity patients.	59
3.25	Comparison of the stage - IV Breast cancer patient incidences with the integer order model	79
3.26	Comparison of the stage - IV Breast cancer patient incidences with Caputo model	79
3.27	Comparison of the stage - IV Breast cancer patient incidences with CFC model	80
3.28	Comparison of the stage - IV Breast cancer patient incidences with ABC model	80
3.29	Comparison of the stage - IV Breast cancer patient incidences with the integer and the Caputo model	81
3.30	Comparison of the stage - IV Breast cancer patient incidences with the integer and the CFC model	81
3.31	Comparison of the stage - IV Breast cancer patient incidences with the integer and the ABC model	82
3.32	Collective comparison of the stage - IV Breast cancer patient incidences with the integer and the fractional order systems	82
4.1	Diagram for the Chikungunya virus model with adoptive immune response.	87

4.2	Diagram for the Chikungunya virus model with latently infected cells. . .	88
4.3	Behavior of within-host fractional chikungunya virus model with adaptive immune response when $b = 0.1$ . . . . .	111
4.4	Behavior of within-host fractional chikungunya virus model with adaptive immune response for when $b = 0.9$ . . . . .	112
4.5	Behavior of within-host fractional chikungunya virus model with latency when $b = 0.1$ . . . . .	113
4.6	Behavior of within-host fractional chikungunya virus model with latency when $b = 0.9$ . . . . .	114
4.7	When the Chikungunya virus transmission rate $b$ is between 0.1 and 1, susceptible cells get infected in the concentrations. . . . .	115
4.8	When the Chikungunya virus transmission rate $b$ is between 0.1 and 1, Uninfected target cells get infected due to virus in the concentrations. . .	115
4.9	Antibodies in human body respond against Chikungunya virus when the antibodies attack rate $q$ is between 0 to 1. . . . .	116
4.10	Cytotoxic T-lymphocytes (CTL) cells act as a defence system against Chikungunya virus when the virus killing rate due to CTL cells $\epsilon$ is between 0 to 1. . . . .	116
5.1	Diagram of the smoking cancer model. . . . .	122
5.2	Behavior of the susceptible class $P(t)$ for certain fractional-order between 0.9 to 1. . . . .	135
5.3	Behavior of the lately infected class $I_L(t)$ for certain fractional-order between 0.9 to 1. . . . .	135
5.4	Behavior of the chronically infected without treatment class $I_C(t)$ for certain fractional-order between 0.9 to 1. . . . .	136
5.5	Behavior of the infected without treatment class $I(t)$ for certain fractional-order between 0.9 to 1. . . . .	136
5.6	Behavior of the infected with treatment class $T(t)$ for certain fractional-order between 0.9 to 1. . . . .	137

5.7	Behavior of the cancer infected class $C(t)$ for certain fractional-order between 0.9 to 1.. . . . .	137
5.8	Behavior of the recovered class $R(t)$ for certain fractional-order between 0.9 to 1. . . . .	138
5.9	Rate of transmission from lately infected to chronically infected without treatment individuals when transmission coefficient $\beta_2$ is between 0 to 0.004.	138
5.10	When any individuals transferring form $I_L$ to $I_C$ compartment with the rate of $\alpha_1$ between 0 and 0.004. . . . .	139
5.11	Rate of transmission from infected individuals to cancer infected individuals when infective parameter $\delta_4$ is between 0.0001 and 0.0004. . . . .	139
5.12	Rate of transmission from infected individuals to Recovered individuals when infective parameter $\delta_5$ is between 0 and 0.0004. . . . .	140
6.1	Simulation for Susceptible when $b < c$ at some fractional-order $\alpha$ . . . . .	158
6.2	Concentration of minerals in water when $b < c$ at some fractional-order $\alpha$ . . . . .	159
6.3	Simulation for Recovered population when $b < c$ at some fractional-order $\alpha$ .	159
6.4	Concentration of minerals in water when $b < c$ at some fractional-order $\alpha$ . . . . .	160
6.5	Simulation for Infected population when $b > c$ at some fractional-order $\alpha$ . . . . .	160
6.6	Concentration of minerals in water when $b > c$ at some fractional-order $\alpha$ . . . . .	161
6.7	Simulation for Infected population when $b > c$ at some fractional-order $\alpha$ . . . . .	161
6.8	Concentration of minerals in water when $b > c$ at some fractional-order $\alpha$ . . . . .	162
6.9	Infected individuals at different rate of water treatment effectiveness. . . . .	162
6.10	Calcium and magnesium growth rate at different concentration level of minerals in water. . . . .	163
8.1	Tumor Volume vs Time plotted for Lewis Lung Carcinoma . . . . .	201
8.2	Breast adenocarcinoma xenografts-1 . . . . .	202
8.3	Breast adenocarcinoma xenografts-2 . . . . .	203
8.4	H226 (lung cancer cell line) . . . . .	204
8.5	HT29 (Human colon cancer cell line) . . . . .	205
8.6	Bar chart of RMSE for cancer model with different $\alpha$ . . . . .	207