Chapter 7

Future Directions-An Outline

During the last few decades mathematical biology has become more familiar area of research. In advance study on the dynamics of ecological system, mathematical modelling plays an important role in inter relation between prey-predator system, host-virus system and interaction of their inter-species as well as intra-species. Also plankton dynamics has become familiar in recent research area as plankton is at the bottom of the marine food web. In marine ecology plankton bloom is controlled by marine viruses. Also the bacteria virus interaction in marine system becomes more complex. To study such complex phenomena researchers used several mathematical techniques by suitable mathematical model. In the present thesis we have tried to explain the effect of viral disease in plankton system as well as bacterial species with the help of several mathematical model. We have also tried to explain the effect of nonlinear disease transmission on plankton system and also spatial effect on this system. Also we have tried to explain the effect of time-delay in a virus-bacteria system with the help of a mathematical model. Here we mention some aspects for improvement of the present work.

Out of several crucial phenomena Allee effect is one, which has drawn considerable attention from ecologists. The mechanism related to Allee effect
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describes a positive interaction among individuals at low population densities and these interactions may be critical for survival and reproductions. The Allee effect and species competition are two basic ecological mechanisms which set lower and upper bounds on population density of species. The Allee effect is a reduced per-capita population growth rate at low densities which has important consequences in population dynamics and persistence. Competition for resources (e.g., food, space) may lead to lower population growth rate at high local population densities. Thus, small population density can be a result of competition among different species. As the intensity of the Allee effect increases, the domain of epidemic invasion reduces and the system dynamics is changed.

Allee effects are thought to mediate the dynamics of population colonization, particularly for invasive species. However, Allee effects acting on parasites have rarely been considered in the analogous process of infectious disease establishment and spread. For macroparasites, the results in [100] may be the rst evidence for a component Allee effect, and they suggest that a demographic Allee effect may slow the spread of infectious disease in a coastal marine ecosystem.

Fractional calculus is a generalization of ordinary differentiation and integration to arbitrary noninteger order. The subject is as old as the differential calculus, and goes back to time when Leibnitz and Newton invented differential calculus. In the 17th century, the Euclidean geometry was the language which, for many centuries, allowed for an explanation of the dynamics of numerous natural phenomena. A branch of mathematics which has been developing the state of affairs through the mathematical modeling of natural phenomena in many applied sciences and engineering. The idea of fractional calculus has been a subject of interest not only among mathematicians but
also among physicists and engineers [101–103].

Fractional-order models are more accurate than integer-order models, that is, there are more degrees of freedom in the fractional-order models. Furthermore, fractional derivatives provide an excellent instrument for the description of memory and hereditary properties of various materials and processes due to the existence of a memory term in a model. This memory term insures the history and its impact to the present and future [104].

Nowadays we know that if the edge of certain objects is highly irregular, or if certain natural events are subject to drastic changes in magnitude, then these factors imply that the dynamics of many phenomena, for example those that are diffusive, on these objects or events will be anomalous. Such dynamics are often impossible to model with ordinary differential methods. A diffusive-type phenomenon across a cell wall, which is fractal in shape, does not conform to the corresponding ordinary differential models; on the contrary, the diffusion will be much faster or slower. The same could be said of adsorption by the skin of a medicinal or cosmetic gel, since skin is a highly heterogeneous porous medium with strongly delineated changes in scale. So the medium can distort the dynamics of a phenomenon to such a point that it often cannot be simulated using ordinary models. Today we know that for this type of anomalous dynamics in complex systems, the "non-locality" norms of such dynamics play a decisive role. Recall that the ordinary derivative is, by definition, local, which forces the solution of an ordinary differential model, linear or not, to correspond to a continuous and smooth dynamic. In observing nature, it is easy to see that there are many phenomena whose dynamics do not follow these norms.

The fractional methods represent for modeling the dynamics of certain phenomena which ordinary models cannot. There are some basic fractional
differential equations have Weierstrass-type solutions, which we will do by introducing certain functions with a behavior similar to that of the classic Weierstrass function. This leads to the belief that other complex functions, not as drastically undifferentiable as the Weierstrass type, might also be solutions to fractional models. Naturally this leaves the door open to seriously considering the possibility that not only can fractional models be easier and, in some cases, better for modeling certain phenomena which can also be modeled with ordinary differential equations, but also that they can complement this extraordinary tool through their role in modeling phenomena typical in nature.

Thus for more investigation of the dynamics of a virus infected plankton species or bacterial community, inclusion of Allee-effect and use of fractional differential model is necessary. Future works may be performed in this direction by constructing suitable mathematical model. The effect of virus infection in plankton species and bacterial community will be more visible if one can study the dynamics in presence external forced system. In future we will perform such studies by taking into account some environmental factors. There are lot of compartments may be opened if our mathematical model includes several environmental factors. Before concluding the thesis we like to mention that to validate the analytical results of the mathematical model under consideration, experimental results or real life data or both are needed.