PREFACE

Thesis contains eight chapters in which Chapter 1 is the introductory chapter, which contains about groundwater contamination, reaction-advection-diffusion equation, fractional calculus and fractional-order reaction-advection-diffusion equation. Basic concepts of reaction-advection-diffusions, definitions and literature review related to the related field have been discussed in this chapter. This chapter deals with the Mathematical models for solving solute transport problems with the help of finite difference method, Bellman method and shifted Legendre collocation method.

In chapter 2, the advection-diffusion equation having a nonlinear type source/sink term with initial and boundary conditions are solved using finite difference method. The solution of solute concentration is calculated numerically and also presented graphically for conservative and non-conservative cases. The emphasis is given for the stability analysis, which is an important aspect of the proposed mathematical model. The accuracy and efficiency of the proposed method are validated by comparing the results obtained with existing analytical solutions for a conservative system. The novelty of the chapter is to show the damping nature of the solution profile due to the presence of the nonlinear reaction term for different particular cases in less computational time by using the reliable and efficient finite difference method.

In Chapter 3, the Laplace transform method is used to solve the advection-diffusion equation having source or sink term with initial and boundary conditions. The solution profile of normalized field variable for both conservative and non-conservative systems are calculated numerically using the Bellman method and the results are presented through graphs for different particular cases. A comparison of the numerical solution with the existing analytical solution for standard order conservative system clearly exhibits that the method is effective and reliable. The important part of the study is the graphical presentations of the effect of the reaction term on the solution profile for the non-conservative case in the fractional-order as well as standard order system. The salient feature of the chapter is the exhibition of stochastic nature of the considered fractional-order model.

In Chapter 4, shifted Legendre collocation method is used to solve the fractional-order advection-diffusion equation having a nonlinear type source/sink term with initial and boundary conditions. The solution profiles of the normalized solute concentration for both reaction-advection-diffusion and reaction-diffusion systems are presented through graphs for different particular cases. The salient feature of the chapter is the pictorial presentations of the effect of fractional order spatial and time derivatives and also advection term on the solution profile. A drive has been taken to compare the numerical solution of our proposed method with the existing analytical solution through error analysis which is exhibited through figure and table.

Chapter 5 is concerned with the investigation of one-dimensional space-time fractional-order Burgers-Fisher and Burgers-Huxley equations. In this chapter the shifted Legendre collocation method is used to solve the one-dimensional nonlinear reaction-advection-diffusion equation having spatial and temporal fractional-order derivatives with initial and boundary conditions. The solution profiles of the normalized solute concentration of space-time fractional-order Burgers-Fisher and Burgers-Huxley equations are presented through graphs for different particular cases. The main purpose of the chapter is the graphical exhibition of the effect of the temporal, spatial fractional-order derivatives and the reaction term on the solution profile of the space-time fractional-order Burgers-Fisher and Burgers-Huxley equations. The other purpose of the chapter is the error estimation of the proposed method. A drive has been taken to validate the effectiveness of the proposed method through tabular presentation of comparison of numerical results with analytical results for the existing problems through convergence analysis.

In Chapter 6, the shifted Legendre collocation method is extended to solve the nonlinear fractional-order partial differential equations and the proposed method has been applied to solve the nonlinear (2+1)-dimensional space-time fractional reaction-advection-diffusion solute transport models. The variations of solute concentration for both space-time fractional reaction-advection-diffusion equation and space-time fractional reaction-diffusion equation are presented through graphs for different particular cases. The main feature of the chapter is the graphical exhibitions of the effects of the reaction term, advection term and fractional-order parameters on the solution profile. A drive has been taken to validate the efficiency of our proposed method through comparing the numerical results with the analytical results of a particular existing form of the concerned model in integer-order system through error analysis which are displayed in tabular and pictorial form.

The objective of Chapter 7 is to finding the solution of aerosol transport equation and investigation of solution profiles. In this chapter the shifted Legendre collocation method is used to solve the two-dimensional fractional-order aerosol equation with initial and boundary conditions. The solution profile of the equation is presented graphically for different cases. The important feature of the chapter is graphical exhibitions of the effect of the size of the aerosol particles and also the temporal derivative on the solution profile. The salient feature of the chapter is the demonstration of lower variation of mass concentration with the change in time level in fractional order systems than that in integer-order system. A drive has been taken towards the tabular and pictorial presentations of a comparison of the numerical solution of our proposed method with an analytical solution of an existing problem through error analysis which conforms super-linearly convergence rate of the proposed method to validate its efficiency and effectiveness.

Chapter 8 concludes the entire thesis and future work has been presented.