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**Mathematical Modelling of Water Pollution Dynamics:
Equations, Assumptions, and Application**

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Abstract

Water pollution is a complex environmental problem influenced by the transport, transformation, and accumulation of pollutants within aquatic systems. Mathematical modelling of water pollution dynamics provides a systematic framework for understanding these processes and predicting changes in water quality under different environmental conditions. This study focuses on the development and application of mathematical models that describe the spatial and temporal behaviors of pollutants in rivers, lakes, and other aquatic environments. The models are formulated using differential equations based on fundamental principles of mass balance, pollutant transport, advection, diffusion, reaction, and degradation. Key assumptions include homogeneous or spatially varying flow conditions, known pollutant input rates, defined reaction and decay coefficients, and appropriate boundary and initial conditions. Depending on the characteristics of the water body, both ordinary and partial differential equation models can be employed. The major objective is to analyse how pollutant concentrations change with time and distance and to identify the factors that significantly influence water quality. Model simulations can be used to estimate pollutant dispersion, determine critical pollution sources, evaluate natural attenuation processes, and assess the effectiveness of pollution-control strategies. Applications of these models support environmental monitoring, wastewater management, risk assessment, and sustainable water-resource planning. Overall, mathematical modelling provides a valuable decision-support tool for understanding water pollution dynamics and developing effective strategies for protecting aquatic ecosystems and public health.

Keywords: Water pollution, mathematical modelling, differential equations, pollutant dynamics, advection-diffusion, reaction kinetics, water quality, environmental modelling, pollutant transport, sustainability.