Fate and Transport of Contaminants in the Environment

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College Publishing
12309 Lynwood Drive
Glen Allen, Virginia 23059
Phone (800) 827-0723 or (804) 364-8410
Fax (804) 364-8408
Email collegepub@mindspring.com
www.collegepublishing.us

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J O H N   C .   W A L T O N ,   P H . D . ,   P . E .

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A C K N O W L E D G M E N T S

This book is dedicated to my wife, June, and our four children: Claire, Arthur, Mariah, and Rory. Many graduate students have contributed to the work, especially Gautam Agrawala, Omar Al Qudah, Drew Hall, Arturo Woocay, Masud Rahman, David Casey, Huanmin Lu, Sazzad Bin–Shafique, Floyd Johnson, Juan Clague, Sergio Solis, Reneé Hilton, Humberto Garcia, and Rob Rice. I would also like to thank the technical reviewers of the text who provided many constructive criticisms.

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INTRODUCTION

Migration of chemicals in the environment is important to a variety of disciplines. Biologists are concerned with movement of limiting nutrients such as nitrogen and phosphorus that are essential for plant growth. Toxicologists are concerned with estimating human and environmental risk from exposure to toxic chemicals. Climatologists need to understand the sources and sinks for greenhouse gases. Regulatory agencies must evaluate estimated future release of and exposure to hazardous materials and compare them to regulatory and health standards. Geologists, ecologists, and meteorologists are interested in biogeochemical cycles and how they are influenced by anthropogenic activities. Scientists, engineers, and regulators are concerned with cleanup of contaminated sites and minimizing risk to humans and the environment.

This textbook evolved from an interdisciplinary class taught to students with diverse backgrounds who typically had an advanced grasp of some of the material covered and relatively little background in other portions. Engineering students are comfortable with mathematics but often have limited backgrounds in chemistry, biology, and/or geology. Biology and geology students may have difficulty with quantitative treatment requiring differential equations. The goal of this textbook is to introduce an interdisciplinary, non-specialist audience to fundamental concepts of how chemicals migrate in the environment and how this migration is estimated in risk assessments. Mathematical treatment beyond the elementary level is sometimes presented with the intent of pushing students with greater interest or more complete backgrounds toward more complete understanding. This material is not essential to the text and can be skipped (or simply not included in tests) by choice of the instructor.

The text should also be useful for people without specialized knowledge who work with fate and transport in the environment and/or as an introduction to the field. Mathematical treatment up to partial differential equations is present but not required to follow most of the material presented. Increasingly, most calculations of fate and transport are performed by practitioners with specialized computer codes. The focus of this text is on fundamental principles and relatively simplified calculations that explain the concepts and fundamental assumptions underlying most codes predicting contaminant transport, rather than a guide to computer codes.

The text contains a series of chapters providing coverage of background concepts preceding chapters covering the major environments of groundwater, surface water, and the atmosphere. Depending upon the training of the students or reader, some of these chapters could be skipped and/or reordered. The mathematical treatment of contaminant transport in all media is remarkably similar. The essential similarities between the models used in surface water, groundwater, and air pollution are emphasized in order to provide unifying concepts and bolster understanding of concepts. Generalized transport phenomena concepts are introduced in the first two chapters followed by more specific and detailed application in the media specific chapters.

The text is supplemented with student exercises that can be assigned with homework or worked on in class in cooperative groups. All figures included in the text, figures associated with homework solutions, and supplementary materials are available to the instructor in color to facilitate classroom presentation and explanation of the material. Please visit the author's Web site at www.windowoutdoors.com to access these materials. For instructors a fully worked solutions manual to every problem in the text is available. To receive these solutions please contact the publisher at the address or email provided on the copyright page.