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Book reviews

Bioremediation and Natural Attenuation: Process Fundamentals and Mathematical Models, P.J.J. Alvarez, W.A. Illman, Wiley/Interscience, Hoboken, NJ (2006). (619 pp., US$ 99.95, ISBN 0-471-65043-9).

Groundwater, the authors note, represents 98% of the fresh water on earth. Unfortunately, it is challenged (i.e., contaminated) by hazardous wastes and chemical spills. Remediation is both a technical and a financial challenge for which in situ remediation has a primary role in certain cases. To this end, the authors have written this book in order ". . . to provide fundamental biological, chemical, mathematical, and physical principles related to the fate and transport of hazardous wastes in aquifer systems, and their connection to natural attenuation and bioremediation engineering".

The problem is large given that the United States generates an estimated 100 million tonnes of waste a year with 440,000 sites impacted by gasoline releases from leaking underground storage tanks and about 19,000 landfill sites used for disposal of municipal and industrial wastes. In addition, there are 180,000 unlined pits, ponds and lagoons, 20 million household septic systems, abandoned petroleum wells and surface spills. Common pollutants most frequently found at these sites include trichloroethylene, lead, benzene, toluene, chromium, arsenic, etc.

Remediation of contaminated sites is a national priority but an expensive one. Removal costs to treat contaminated sites average US$ 975 m^{-3} for incineration, US$ 350 m^{-3} for landfilling, US$ 125 m^{-3} for thermal desorption, US$ 237 m^{-3} for soil washing, and US$ 95 m^{-3} for above-ground bioremediation (these data are from a 1993 Bioremediation Report by King Publishing Group, Washington, DC, as cited in the book).

We are, however, dealing with a relatively new technology which began about 1952. Its originator was E.F. Gayle who proposed the microbial infallibility hypothesis. Gayle postulated that ". . . for any conceivable organic compound, there exists a microorganism that can degrade it under the right conditions".

The use of bioremediation developed rapidly since then and currently ". . . is an emerging technology that holds great promise for the cost-effective removal of a wide variety of environmental pollutants. Successful applications of bioremediation have been well documented for many sites contaminated with three major classes of hazardous wastes that are amenable to bioremediation: petroleum hydrocarbons (33% of all applications), creosotes (22%), and chlorinated solvents (9%). Bioremediation has also been applied to a lesser degree, to clean up sites contaminated with pesticides, munitions wastes, and other chemical mixtures".

> "Bioremediation offers several advantages and limitations compared to traditional site remediation approaches such as pump-and-treat or soil excavation followed by incineration. The principal advantages generally include lower cost and the ability to eliminate pollutants in situ, often transforming them into innocuous by-products such as CO_2 and water".

In the second chapter, which deals with Geochemical Attenuation Mechanisms, the authors discuss several abiotic processes that can contribute to (or inhibit) the natural attenuation of groundwater pollution. Discussed are processes that transform pollutants into less harmful compounds and processes that immobilize some contaminants within the aquifer matrix. In the discussion, the authors emphasize the geochemical principles responsible for abiotic natural attenuation, mechanisms, cooperation between different microbial species for enhanced biodegradation, biotransformation of metals, biodegradation kinetics, bioavailability and the application of biodegradation kinetics to fate and transport models.

Each chapter begins with an interesting (or historical) quotation, many of which are well known. In Chapter 1, the author cites "The Rhyme of the Ancient Mariner": "Water, water everywhere, nor any drop to drink". In Chapter 3, the quotation is from Pasteur: "The role of the infinitely small nature is infinitely large". This chapter discusses the ability of microorganisms to degrade and recycle environmental pollutants. Topics covered in this chapter entitled "Biodegradation Principles" include the following: the bacterial engine, requirements for biodegradation, acclimation, common biotransformation mechanisms, cooperation between different microbial species for enhanced biodegradation, biotransformation of metals, and bioavailability.

The analytical (mathematical/theoretical) phase of the book begins with Chapter 4 which is entitled "Fundamentals of groundwater flow and contaminant transport processes". The following two chapters continue in this theoretical vein: "Numerical modeling of contaminant transport, transformation, and degradation processes", and "Field and laboratory methods to determine parameters for modeling contaminant fate and transport in groundwater".

Having well discussed the mathematical basis of the topic, the authors return to the discussion of microbial mechanisms in Chapter 8, entitled "Bioremediation technologies", and in Chapter 9, entitled "Performance assessment and demonstration

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of bioremediation and natural attenuation". My assessment of these chapters is that they are a most excellent review of the topic and are a very good review of the state of current technology.

In contrast to the preceding chapters, these two chapters on bioremediation are short on mathematics but long on discussion being well illustrated with diagrams of treatment systems and presentation of real-life case studies. Prominent in the Reference section are citations of the excellent proceedings published by Battelle Press for their international conferences on in situ and on-site bioreclamation symposiums (these conferences were held every second year from 1991 to 1999).

In conclusion, my assessment is that this is an excellent book. The topic is important; both theory and state-of-the-art are well discussed and well described. I agree with the statement on the back cover of the book which says: "This book provides, under one cover, the current methodologies needed by groundwater scientists and engineers in their efforts to evaluate subsurface contamination problems, to estimate risk to human health and ecosystems through mathematical models, and to design and formulate appropriate remediation strategies".

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Hazardous Materials Characterization: Evaluation Methods, Procedures, and Considerations, D.A. Shafer, Wiley-Interscience, Hoboken, NJ (2006). (378 pp., US$ 74.95, ISBN 0-471-46257-8).

Hazardous materials are ubiquitous substances found in almost every work place. Knowledge of their potential hazards is essential. This book, to some extent, supplies that knowledge. However, as a text, it adds very little to the body of literature on hazardous materials that I am familiar with as most of the book is a discussion that is relatively simplistic (although in the author's defense, the material he supplies is probably relatively useful to the non-safety professional). The book appears to have been written for lower level supervisors, i.e., those in industry who do not have a scientific background. Indeed, I found the writing clear. Missing, however, (for one who has been involved with many research papers on hazardous materials published in this journal and elsewhere) were references to the literature. Indeed, the one extensive reference was a list of hazardous chemicals with their CAS Numbers. That list was 17 pages long but really supplies the reader with little information.

Chapter 4, entitled "Hazards Characterization and Site Evaluation," contains five excellent checklists:

1. Environmental Health and Safety (Hazardous/regulated materials, Hazardous/regulated wastes, Wastewater, and Air, and Environmental reporting);
2. Hazardous Materials Communication;
3. Respiratory Protection;
4. Confined Space Entry;
5. Ventilation.

In Chapter 9, the author does a decent job of describing the hazards of biological agents such as viruses, bacteria, fungi, and pathogenic parasites. Selected biohazards that were covered included anthrax, avian flu, blood borne pathogens, botulism, smallpox, and viral hemorrhagic fevers. He also included AIDs, which surprised me.

Other problems I found included the mention of a BLEVE which is a hazard resulting from fire impinging upon propane tanks. That certainly is a chemical hazard that deserves treatment, but unfortunately the amount of information given by the author was, in my opinion, inadequate. There were several pictures in the book, but almost all were limited to examples of responders in protective gear.

The book "breaks some new ground" in the final two chapters entitled: (1) Disaster site work and (2) Characterization of CBRNE terrorist threats and weapons of mass destruction (WMD). Given the impact on the health of responders to the September 11 terrorist attack in New York City and the subsequent world-wide concern for terrorism-caused incidents, these two chapters are extremely important. The author is to be commended for their inclusion.

The book ends with a complete 17-page glossary.

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L. Theodore, Nanotechnology: Basic Calculations for Engineers and Scientists, Wiley/Interscience, Hoboken, NJ, 2006 (US$ 82.50, 479 pages, ISBN 0-471-73951-0).

A citation from microbiology I recall notes ". . . the role of the infinitely small is infinitely large." What is true for microbes is also true for particles—nanoparticles. Nanotechnology is a rapidly developing field and the topic of a second book that