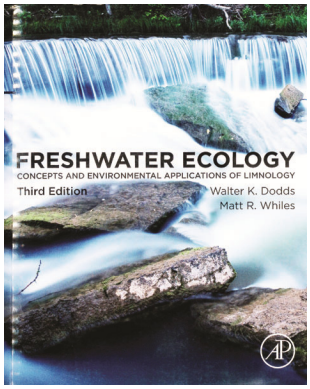

Freshwater Ecology: Concepts and Environmental Applications of Limnology, 3rd Edition. Walter K. Dodds and Matt R. Whiles. Academy Press, an Imprint of Elsevier, 125 London Wall, London EC2Y 5AS, United Kingdom. 2019. xvi + 981 pages. Price: US$ 125.00. Paperback ISBN: 9780128132555, eBook ISBN: 9780128132562.

Aquatic ecosystems are the destination of precipitation (surface and subsurface water) in the hydrological cycle, and are broadly categorized as lentic and lotic ecosystems. Lentic ecosystem refers to stationary or relatively still water bodies (such as lakes, ponds, etc.), while lotic ecosystem refers to flowing water (such as streams and rivers)[1]. These ecosystems encompass ecological, social and economic processes (ecosystem functions) that interconnect biotic components and provide goods and services for the society. Degradation of these vital ecosystems has been the primary cause for increasing water insecurity, raising the need for integrated solutions to freshwater management[2,3]. This makes it necessary to understand the hydrological and biological entities for determining the level of services provided by the ecosystem, and linkages of ecosystem structure with its functional capabilities, which are essential to frame appropriate management strategies towards mitigation of impacts[1].

The publication under review lucidly presents basic science with the environmental applications for easy reading and comprehension of all facets of aquatic ecosystems from the basic chemical and physical properties of water, to the advanced and unifying concepts of community ecology with the ecosystem relationships found in continental waters. The third edition integrates recent advances in aquatic ecology, including how to balance ecological and human health needs, GMOs, molecular tools, and a host of other environmental issues with emphasis on toxins, pollutions, etc. The current edition incorporates advances that have occurred and new topics that have gained prominence with respect to the environmental effects. Particularly a new section has been added with more emphasis on toxins and pollutions. The publication is exhaustive spanning across 25 chapters in 998 pages with 892 new and updated references and 46 new illustrations (compared to the second edition). The publication is useful to students of aquatic ecology and decision makers of freshwater resources in an era of water scarcity with changes in the climate due to global warming. An attempt to engage student interest and facilitate learning is evident through a variety of innovative pedagogical approaches adopted in each chapter with sidebars, biography (of notable contemporary limnologists) boxes, method boxes. The textbook also has an appendix on experimental design in aquatic science and a glossary. Chapters will cater to a variety of experience levels, as the concepts are supported with interesting and appropriate examples. Each chapter at the end contains excellent learning tools of a summary of highlighting basic concepts as well as questions for thought.

Water is elixir of life, has no substitute and is extremely valuable. The majority of planet Earth is covered by water, but only a very small proportion (2.79%) is associated with the continental areas for societal use. Chapter 1 elucidates the need for studying continental aquatic systems and a brief description of a global water budget with respect to water availability to humans. Aquatic ecosystems provide us with numerous benefits in addition to direct use. The natural capital accounting of the global values of wetlands ($3.2 trillion per year) and rivers and lakes ($1.7 trillion per year) indicate the vital importance of freshwater systems to humans[4] and the values are derived mainly from flood control, water supply and waste treatment.

Water is one of the best *solvents* and can dissolve both gases and ions. The physical properties of water such as viscosity and inertia of water with scale, temperature and relative velocity related to aquatic ecology are discussed in chapter 2. Light, temperature and movement of water are tied intimately to the rate at which chemicals move through the water determines the survival and growth of most aquatic organisms, which are explained in chapter 3. The hydrological cycle describes the movement of water across the land and, in combination with other geological processes, determining many of the physical characteristics of the habitat. Chapter 4 provides details on the hydrologic cycle and hydrodynamics apart from the presentation of the physical geology of aquatic habitats closely tied to terrestrial habitat – groundwaters and chapter 5 presents physiography and hydrology of wetland habitats. The links between terrestrial and aquatic ecosystems as well as among different aquatic ecosystems need to be understood[2] in order to comprehend how water moves across the surface of the continents. As the earth warms in response to increases of greenhouse gases (primarily CO_2), it would alter the variability and distribution precipitation and evapotranspiration influencing the sustenance of freshwater habitats. Chapter 6 presents physiography of flowing waters including streams, characteristics of stream flow, geology, and how streams move materials. Humans have constructed many lakes and ponds to meet the societal demand. Physiography of lakes and reservoirs is presented in chapter 7.

Plants, animals and microbes interact with the environment to alter water quality and perform ecological services, such as decomposition and nutrient cycling. Biodiversity of invertebrates, microbes and fishes is useful to indicate chronic pollution problems. Chapter 8 presents varieties of aquatic organisms, provides basic taxonomic principles, introduces different ways to classify organisms and outlines the survival strategies of organisms in the respective habitat.

Primary producers capture much of the energy that flows through freshwater food webs, and microbes are responsible for the bulk of the biogeochemical transformational fluxes in aquatic systems.

A deformed adult Pacific tree frog, *Pseudacris regilla*. Photograph by Goodman and Johnson, *PLoS ONE*, 2011; www.ncbi.nlm.nih.gov/pmc/articles/PMC3102088

Chapter 9 describes the microbes and plants found in freshwaters. Chapter 10 discusses animals, some of the most fascinating organisms found in aquatic habitats because of their diversity and behaviour. Aquatic animals provide an important indication of the health of freshwater ecosystems because they integrate stresses and sensitive species are generally not found in polluted habitats[5,6]. Spatial segregation of habitats also influences species evolution, which ultimately drives diversity. Evolution of organisms and biodiversity of freshwater is presented in chapter 11, including measures of diversity and the reasons for variability of diversity among and within habitats.

The way chemicals move through the environment is an essential aspect of ecosystem function. Chapter 12 focuses on aquatic chemistry controlling nutrient cycling, forms a conceptual foundation for treatment of all biogeochemical discussions in this book. Understanding nutrient cycling requires careful study of the concept of oxidation–reduction state (redox). Next chapter (Chapter 13) discusses organic and inorganic forms of carbon and fluxes of carbon in the environment (including the carbon cycle), which is essential to understand food webs and the structure of aquatic ecosystem. In addition to carbon, other nutrients such as sulphide, ammonium and nitrate, are central to the way that aquatic ecosystems function, which are discussed in chapter 14 and concludes with a discussion on interrelations among cycles and revisits the ability of redox to control nutrient cycling. Chapter 15 discusses adaptation to extreme and unusual habitats. For example, physiological adaptations to high temperature include lipids with higher melting points and stabilizing features of proteins and nucleic acids. The next chapter (16) presents human stressors such as physical disturbance as well as organic and inorganic toxic pollution. High concentrations of toxic compounds accumulate in the tissues of organisms at the top of food webs, which is referred as bio-magnification of pollutants. The impacts of pollutants and other habitat alterations on aquatic communities have been assessed through bio-assessment protocols.

Nutrients often limit primary production or heterotrophic activity and serve as the base of food webs in aquatic systems. Exposition of nutrient dynamics aids in understanding ecosystem production, nutrient pollution, and interactions among heterotrophs, autotrophs and their environment. Chapter 17 presents the relative concentration of nutrients needed in different systems along with the crucial concept of nutrient limitation including the mechanism of acquisition and assimilation of nutrients. Excess nutrient input to aquatic ecosystems occur due to anthropogenic activities with the sustained inflow of untreated or partially treated sewage, agriculture run off, industrial effluents, etc. The nutrient enrichment stimulates primary producers, making an ecosystem more productive, which is known as Eutrophication. Chapter 18 discusses 'trophic state', the level of ecosystem productivity and problems associated with eutrophication. The concluding section of this chapter describes methods for controlling eutrophication with several case studies.

Interactions among microorganisms are based on behavioural responses that are mediated by motility and responses to chemicals. Chapter 19 describes aspects of the ecology of microbes; begins with a discussion of motility, provides a general classification of interaction types and then discusses species interactions (exploitation, competition, mutualism, commensalism, amensalism and neutralism) in microbial communities and how macroscopic organisms interact with microscopic organisms. Chapter 20 presents herbivory, detrivory, omnivory and predatory animals, followed by adaptations in response to being prey or predator. Other ways that species interact (including indirect interactions, succession, mutualism and the effects of keystone species) also have consequences in determining community structure. Chapter 21 focuses on interactions among larger organisms. Chapter 22 discusses complex community interactions including disturbance (flooding, etc.), succession, interactions, aquatic food webs and theoretical community ecology. Fish dominate food webs as the top predators in aquatic ecosystems and indicators of water quality apart from being model organisms for physiological and behavioural research. Chapter 23 presents the biogeography of fish communities and factors that influence growth, survival and reproduction of fishes.

Ecosystems are thermodynamically open, hierarchically organized communities of producers, consumers and decomposers together with the abiotic factors that influence species growth, reproduction and dispersal. Chapter 24 discusses general methods of approaching ecosystems (including trophic energy transfers, nutrient budgets and the link between biodiversity and ecosystem function) and then focus on ecosystem properties in groundwater, rivers, streams, lakes and wetlands. Ecological processes, management and evolution operate at the broad scales such as watershed, etc., and are monitored through latest spatial techniques (remote sensing data with geographic information system). In this regard, chapter 25 presents scaling, landscape, macroecology and macrosystems in freshwaters.

The publication certainly fills a void in the subject domain and will be useful in the teaching as well as in research as reference. The chapters are concise and self-contained units conforming to a wide variety of organizational schemes that will be useful while teaching freshwater ecology. The publication provides a stimulating mix of ecological concepts with the basic knowledge of organisms dwelling in fresh water ecosystem. Understanding tenets of the ecology of freshwater resources will lead to more sound decisions regarding aquatic habitats as well as provide a comprehensive foundation for further explorations.

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