

# 1 Eutrophication and the Ecosystem

## 1.1 Background

Eutrophication of surface waters is generally recognised as a matter for environmental concern. Eutrophication is characterised by increased algal growth, with an increased incidence of toxic cyanobacteria blooms and a decrease in the abundance of species.

Some of the manifest problems brought about by prolific algal biomass include: turbid waters; anoxic conditions; bad smell and chironomid and *Culex* midge plagues (Vollenweider 1990; Moss et al. 1996a; Carpenter et al. 1998). Such eutrophication problems (“eutrophication” *sensu lato*) are generally considered to be the consequence of enhanced nutrient loadings (“eutrophication” *sensu stricto*) (Likens 1972; Vollenweider 1990; Reynolds 1992; Moss et al. 1996a; Carpenter et al. 1998). Therefore, the management of eutrophicated water bodies is usually primarily focused on the reduction of nutrient loading, supported by a policy of reduced environmental releases of phosphorus from laundry detergents, sewage and agriculture.

However, it became apparent over the past decade, that reduced grazing of algae by daphnids can be a crucial factor determining whether or not nutrient enrichment will lead to eutrophication problems (Moss et al. 1991; Moss et al. 1996b; Reynolds 1994). Biomanipulation of eutrophicated shallow water bodies, thereby improving ecological conditions for daphnids, became a regular tool applied in eutrophication management practice (Benndorf 1990; McQueen 1998; Harper et al. 1999).

Biomanipulation is mainly focussed on the improvement of biological conditions leading to a higher survival rate for daphnids as part of the aquatic foodweb. Examples of biomanipulation measures include: reduction of predation by planktivorous fish and improvement to the submerged vegetation as a shelter for daphnids against predation. More recently, the palatability of suspended particles as a factor determining the grazing efficiency of daphnids has become a topic of interest. High concentrations of resuspended inorganic particles hamper daphnid grazing, while at the same time stimulating algal growth due to increased nutrient releases (Kirk and Gilbert 1990; Ogilvie and Mitchell 1998). Top-down control by daphnids under eutrophicated conditions may also be reduced by the presence of unpalatable algal species (mainly cyanobacteria) that may gain competitive advantage over the heavily grazed palatable algal species.

This book covers another important aspect regarding the improvement of environmental conditions for daphnids, which is necessary for successful eutrophication management, i.e. optimisation of the abiotic water conditions. Bales et al.

(1993) suggested that the sensitivity of daphnids to saline conditions may be a significant reason for the higher susceptibility of brackish waters to eutrophication. From this perspective, ecotoxicologically reduced daphnid grazing due to micropollutant loadings could be a crucial factor leading to problems associated with eutrophication (Hurlbert et al. 1972; Hurlbert, 1975; Gliwicz and Sieniawska, 1986).

The toxic effects of pesticides and other chemicals on the viability of cladoceran populations reduce their capacity to graze the surplus algal growth caused by increased nutrient availability. In ecotoxicological semi-field studies, it has been observed that cladocerans are amongst the most sensitive species when it comes to toxicant exposure, consequently resulting in a reduction in the top-down control of the algal growth (Day 1989; Yasuno et al. 1993). Based upon the analysis of sediment cores, Stansfield et al. (1989) argued that a switch from submerged plant dominance to phytoplankton dominance (eutrophication) in a series of shallow lakes, i.e. the Norfolk Broads, U.K, during the 1950s and 1960s, was likely to have been due to the poisoning of cladocerans (viz. *Daphnia*) as a result of liberal organochlorine pesticide use.

The aim of this book is to provide a better understanding of the ecotoxicological aspects of eutrophication processes in shallow, temperate fresh waters, so that these processes may become a recognized factor in the restoration of eutrophicated water bodies.

Some basic limnological ecology, which is fundamental to the further contents of this book, is presented in the first chapter. Chapter 2 provides more information on daphnids, encompassing their ecology, grazing efficiency and any subsequent consequences for the control of algal densities. Chapter 3 concerns daphnid ecotoxicology, and provides information on toxicity induced reduction of daphnid grazing effectiveness (so called “toxic anorexia”) in experimental settings. Variation in daphnid grazing effectiveness in the field situation is described for two Dutch lakes in Chap. 4. The applicability of an ecotoxicological assessment of eutrophicated water bodies is discussed, and practical tips given, in Chap. 5.

## 1.2 Eutrophic and Eutrophicated Waters

### *Nutrients or Algae*

In order to acquire a better understanding of the causes of eutrophication in fresh water ecosystems, it is helpful to make a distinction between “**eutrophic**” waters (classification of water according to its intrinsic nutrient status, eutrophication *sensu stricto*) and “**eutrophicated**” (or “eutrophied”) waters (perception of manifest water quality problems related to ecological malfunctioning such as turbid water, bad smell and high algal density, eutrophication *sensu lato*).

The total phosphorus concentration of fresh surface waters is generally used as an indicator for the trophic status of that water body. Phosphorus is one of the essential nutrients for algal growth. It is considered to be the prime limiting element determining the biological productivity (algal productivity, and subsequent higher order productivity) in many freshwater aquatic systems.