Phytoplankton dynamics and periodicity in two cascading warm-water reservoirs from 1989 to 1997 – taxonomic and functional (C-S-R) patterns, and determining factors

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Abstract

The composition and abundance of distinctive planktonic autotrophs (ca 60 taxa) were examined at roughly fortnightly intervals in two sizeable reservoirs (Midmar and Albert Falls) on the uMngeni River, KwaZulu-Natal, between 1989 and 1997. The dynamics of community structure and abundance were examined in both taxonomic and functional (C-S-R) terms in relation to physical abiotic variables (thermal stratification, light climate, water level) and biotic influences of predation (zooplankton abundance).

Annual periodicity was exhibited by most taxa apart from *Cryptomonas*, although patterns tended to be indistinct and inter-annual repeatability was generally weak – in line with year-to-year and between-system environmental variability. Water level fluctuation, with concomitant change in stratification intensity and hydraulic mixing and accompanying changes in water clarity associated with suspended sediment levels was clearly a major (direct and indirect) determinant of phytoplankton composition and abundance. The influence of top-down controls as inferred from phytoplankton-zooplankton relationships was fundamentally different in the two reservoirs – potentially stimulatory in Midmar, but clearly regulatory in Albert Falls, where episodic collapses of *Daphnia* populations resulted in chlorophyll values well into the eutrophic level range. In addition to annual patterns, changes in chlorophyll content implied progressive long-term changes in trophic status, especially in Albert Falls, with the emergence of various 'new' taxa (and/or higher peak densities of others).

Consideration of phytoplankton dynamics in terms of functional groups offers certain advantages over conventional phyletic taxonomic analyses, although algal response forecasting by either approach appears potentially constrained by hydrological variability. Site-specific bio-monitoring, possibly using new rapid technologies, is likely to be necessary for ongoing management purposes until predictive capabilities under regionally characteristic conditions improve. Despite limitations, functional classification proffers faster advances to this end than conventional taxonomic appraisal.

Keywords: algae, plankton, dynamics, community assemblage, reservoir limnology, water quality, bio-monitoring

Introduction

By virtue of high taxonomic diversity, and rapid response of most of its constituent members to environmental actuators and drivers (nutrients, light, temperature, turbulence, and pollutants), phytoplankton (in its collective sense of all planktonic autotrophs including cyanobacteria) has become widely recognised as a reliable 'bio-indicator' of water quality for a variety of purposes (Dubelaar et al., 2004). Man-made lakes (river-impoundments or river–reservoirs, colloquially referred to as "Dams") are the predominant source of freshwater for all uses (irrigation, industry, etc.), including human consumption (drinking water) in South Africa (DWA 1986). Despite this, little information exists concerning the composition and periodicity of their phytoplankton (Allanson et al., 1990). Investigations into this topic in South Africa commenced on natural coastal lakes – the pristine L. Sibaya (Hart and Hart, 1977), and subsequently Princess Vlei, an anthropogenically perturbed system (Harding, 1992). Studies published on this collective topic for South African reservoirs have been limited in number and/or temporal extent. These mostly involve 'extreme' environments such as the hypertrophic Hartbeespoort Dam (NIWR, 1985; Chutter and Roussouw ,1992), the eutrophic Roodeplaat Dam (Pieterse and Röhrbeck, 1990) and Loch Lomond (Vos and Roos, 2005), as well as certain water-bodies with high sediment turbidity – Lake le Roux (Allanson and Jackson, 1983) and Spioenkop (Hart, 1999). Extended algal studies of planktonic algae in the slow- flowing Vaal River Barrage have also involved eutrophic waters with elevated salinity (Roos and Pieterse, 1996; Pieterse and Janse van Vuuren, 1997). General concerns regarding water quality in SA impoundments have been largely subsumed in determinations of chlorophyll content – an integral measure of autotroph abundance – rather than in systematic analyses of its constituent members. Substantial regional databases containing such information exist (e.g. Graham et al., 1998) but appear not to have been interrogated regarding intrinsic temporal detail.

Water treatment costs and protocols are well known to vary according to its constituent suspended particles – biogenic autotrophs, and, commonly in South Africa – suspended mineral sediments. These attributes influence the filtration efficiency and capacity of water treatment plants, and may impose the need to combat objectionable tastes and odours (e.g. Graham et al., 1998; Barrell et al., 2004). Internationally, there is increasing prominence and concern about the growing and almost ubiquitous presence of toxins including geosmin, microcystin and cylindrospermopsin derived from cyanophytes (Baker et al., 1994; Shaw et al., 1999; Steffensen et al., 1999; Frank and

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