Riverine macroinvertebrate responses to chlorine and chlorinated sewage effluents - Acute chlorine tolerances of *Baetis harrisoni* (Ephemeroptera) from two rivers in KwaZulu-Natal, South Africa

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Abstract

Chlorine is widely used in South African sewage treatment works, and despite its volatility is likely to have a considerable impact on riverine ecosystems. This paper considers the results of acute (96 h) toxicity responses to chlorine of riverine mayfly nymphs *Baetis harrisoni* collected from the small, relatively uncontaminated suburban Westville Stream, KwaZulu-Natal and from the more severely impacted Umbilo River, which flows through the industrial area of Pinetown, KwaZulu-Natal, South Africa. The 96 h LC_{50} value for total residual chlorine for nymphs from Westville Stream was 4.1 µg/l and from the Umbilo River 4.8 µg/l. This value is well below the general effluent standard of 100 µg/l (General and Special Standards, Regulation 991, 1984), but correlates with the acute effect value guideline of 5 µg/l (South African Water Quality Guidelines, No 7. 1996).

Keywords: ecotoxicology, water quality, mayfly

Introduction

Chlorine is not normally a constituent of natural waters as it is too reactive to persist in the aquatic environment for long (DWAF, 1996). However, large quantities of chlorine constituents are being introduced regularly into receiving waters (Johnson and Jolley, 1990; White, 1992). This is a consequence of the use of chlorine as an oxidizing agent and disinfectant in water purification and wastewater treatment; a control for fouling organisms in industrial cooling towers; and as a constituent of pulp and paper mill effluent. The presence of chlorine in natural waters can have potentially severe consequences for riverine flora and fauna (Dallas and Day, 1993).

To date, chlorine toxicity research has focused mainly on fouling organisms in industrial cooling water systems (Mattice and Zittel, 1976; Doherty et al., 1986; Rajagopal et al., 1997; Rajagopal et al., 2002; 2003) and the effects of paper mill effluent on a number of different organisms (Middaugh et al., 1997; Van den Heuvel et al., 2002). Besides experiments involving Daphnia (Taylor, 1993; Fisher et al., 1999) there appears to have been little research investigating the effect of chlorine toxicity on freshwater invertebrates (Arthur, 1975 and Gregg, 1975 cited in US EPA, 1984; Ward and Graeve, 1978, 1980), and none on South African indigenous riverine invertebrates.

The South African Water Quality Guidelines for Aquatic Ecosystems specifies an Acute Effect Value (AEV) of 5 µg/l for chlorine. These guidelines were, however, developed using international data and in the case of chlorine it is noted that the data used did not satisfy the minimum acute database requirement (DWAF, 1986). It is of interest then to refine the *Water Quality Guidelines* to reflect actual tolerances of indigenous organisms within the local environment. The aim of this study as a whole was to investigate the effects of chlorinated, treated sewage effluent on riverine macroinvertebrates. To carry out these investigations, both toxicological (this paper) and ecotoxicological (Palmer et al., 2003) approaches were followed. The toxicological aspect involved the selection of a macroinvertebrate, the mayfly *Baetis harrisoni* (Barnard), and the determination of its acute (96 h) LC_{50} response value to chlorine. However, wild populations that are constantly exposed to a pollutant may also become resistant, and for this reason *B. harrisoni* nymphs were used from both a relatively unpolluted stream in Westville and from the more severely impacted Umbilo River, both in Durban, KwaZulu-Natal.

Materials and methods

Description of study sites

The Westville Stream is located in the residential area of Westville, Durban, KwaZulu-Natal (Fig. 1). The stream does not flow through any industrial area and shows no indication of industrial pollution. The soil in this area is quite sandy though and there is some percolation from the septic tanks of neighbouring houses (Dickens, 1993). However, the stream's community diversity suggested it was relatively unpolluted, and had a thriving mayfly population.

The Umbilo River rises at the foot of Field's Hill and flows through industrial, commercial and residential areas of Pinetown, then past the Umbilo Wastewater Treatment Works and the residential areas of Queensburgh and Umbilo, before flowing into the Umbilo Canal which leads into the Durban Harbour, KwaZulu-Natal (Fig. 1). The water quality of the river is monitored by staff from the Umbilo Wastewater Treatment Works and is considered poor, with the main impact being caused by industrial effluent and to a lesser extent wastewater treatment effluent.

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