Effect of cadmium and copper on survival and reproduction of *Daphnia pulex*

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Abstract

Acute and chronic toxicity tests were performed using *Daphnia pulex* with copper and cadmium as toxicants. The mean concentration causing 50% mortality in a 48 h acute test was 21 ug-l-' for copper and 78 ug-l-[1] for cadmium. In the 21 d chronic test, stimulation, recorded as increased offspring per animal (relative to that in the control), was observed for added copper concentrations of 0,003 ug.l-' to 0,3 ug-l-'. Impairment of reproduction occurred at an added copper concentration of 3 ug-l-'. In the case of the chronic test on cadmium, reproductive impairment at 21 d was observed over the added concentration range of 0,003 ug-l to 3 ug-l-'. The no observed adverse effect level (NOAEL) for chronic toxicity for copper was approximately 0,4 ug.l-' and for cadmium <0,003 ug-l-.

Introduction

The Department of Water Affairs and Forestry is in the process of establishing quality guidelines for the aquatic environment. Related to this activity is the need to develop and interpret toxicity bioassays for use in the whole effluent approach for the management of toxic effluents. For this purpose bioassays need to be tested and evaluated locally. Such evaluation also serves a purpose in placing overseas environmental quality criteria in perspective. Decisions will have to be made whether international environmental quality criteria should be adopted in South Africa, and to what extent they need modification appropriate to local conditions.

An important concept in toxicology is that the occurrence of poisoning is a matter of dose and exposure to a potentially toxic substance. The factor that determines whether a chemical agent is potentially harmful or safe is the relationship between the concentration of the chemical to which an organism is exposed, together with the amount absorbed, and the duration of the exposure (Rand and Petrocelli, 1985).

Daphnids are widely used in acute and chronic toxicity bioassays, both to quantify the toxic effects of single (Khangarot and Ray, 1989) or multiple (Enserinketal., 1991) substances, and to serve as biological indicators of effluent and receiving water quality (EPA, 199 la). Results from daphnid chronic toxicity tests are also used in estimating the no observed effect level (NOEL) (Kuhn et al., 1989) and the maximum acceptable toxicant concentration (MATC) (Gersich and Milazzo, 1990). The advantages of using these organisms as test species include their short life cycle, the ease of laboratory culturing, their wide distribution and ecological significance, their low space and water volume requirements, and their sensitivity to chemicals (Elnabarawy et al., 1986). A considerable body of information exists on the effects of chemicals on the survival, growth and reproduction of various Daphnid species (Sheedy et al, 1991).

Particularly relevant ecologically are the effects on growth and reproduction of aquatic organisms, as even small changes in the levels of some variables can disturb the balance in a biocoenosis quite drastically (Schober and Lampert, 1977). Survival and population growth of aquatic organisms exposed over longer time intervals are usually affected at concentrations much lower than the levels of specific chemicals that cause acute effects (Savino and Tanabe, 1989). Acute concentrations thus do not represent concentrations that are completely safe in aquatic habitats subject to pollution *(Standard Methods*, 1989). The establishment of a MATC or NOEL (more strictly NOAEL; the no observed adverse effect level) of chemical substances to aquatic organisms, has relevance to the setting and evaluation of criteria for the protection of aquatic life.

In the characterisation of toxicants one can often distinguish between pure toxicants showing oc-type toxicity, as would be expected of e.g. cadmium, and substances which act as growth stimulants at low concentrations (6-type toxicity), such as exhibited by micronutrients, e.g. copper. The oc-curve is the pattern commonly observed for the effect of a toxic substance, showing no departure from the organisms' response or state from normal at low concentrations, to a progressive inhibition above a threshold concentration. The 8-curve shows a single stimulatory peak at concentrations immediately below those that are inhibitory. The term hormesis was used by Stebbing to describe stimulatory effects caused by low levels of potentially toxic agents, although the concept was described by Schulz as early as 1888 (Stebbing, 1982).

In order to allow thorough evaluation and interpretation of bioassay results in actual cases of pollution, the response of indicator organisms to specific microcontaminants must be established. This study investigated 2 common industrial pollutant metals, copper and cadmium, as they affect survival and reproduction of *Daphnia pulex.* Both acute and chronic toxic effects were evaluated, this being essential to the interpretation particularly with respect to environmental criteria for these 2 metals.

Materials and methods

Culture technique

Test organisms were from a *D. pulex* culture which has been maintained at the Hydrological Research Institute, South Africa, for more than 3 years. Stock cultures were maintained in reconstituted moderately hard water (total hardness of 80 to 90 mg-l-' $CaCO_3$) as recommended by EPA (1991 b). *Daphnia pulex* cultures were fed on a suspension of commercial trout pellets, alfalfa and yeast, prepared according to the technique described by EPA (1985). The cultures were maintained in a controlled environment at 20°C, which has been recommended as the culture and test

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