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Differential sensitivity of three cyanobacterial and five green algal species to organotins and pyrethroids pesticides

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Abstract

In this work, five organotins and pyrethroids pesticides were tested to examine their effects on the three cyanobacteria *Anabaena flos-aquae*, *Microcystis flos-aquae*, *Mirocystis aeruginosa* and on the five green algae *Selenastrum capricornutun*, *Scenedesmus quadricauda*, *Scenedesmus obliqnus*, *Chlorella vulgaris*, *Chlorella pyrenoidosa* through 96 h acute toxicity tests. The results indicated that: (1) the decreasing order of the average acute toxicity to cyanobacteria and green algae of five dissimilar organotins and pyrethroids pesticides was: fentin hydroxide>cyhexatin>azocyclotin>fenbutatin oxide>beta-cyfluthrin. (2) Wide variations occurred in response to the tested pesticides among the eight individual species of cyanobacteria and green algae. The sensitivity of various species of algae exposed to fenbutatin-oxide varied over one order of magnitude, exposed to cyhexatin/fentin-hydroxide/beta-cyfluthrin varied over two orders of magnitude and exposed to azocyclotin varied three orders of magnitude. (3) In contrast with the sensitivity of cyanobacteria and green algae, cyanobacteria were much less sensitive to beta-cyfluthrin than green algae. The pollutants may result in a shift of green algal and cyanobacterial group structure, especially in a shift from dominance by green algae to dominance by cyanobacteria, and may sustain cyanobcterial blooms during the special period. Thus, the decreasing order of the aquatic ecological risk was: beta-cyfluthrin>fentin hydroxide>cyhexatin>azocyclotin>fenbutatin oxide. There was a strong variance between toxicity and ecological risk, i.e. "low toxicity" does not automatically imply "low ecological risk". The toxicity of pyrethroids pesticides was lower than that of organotins pesticides, whereas the aquatic ecological risk of pyrethroids pesticides was higher than that of organotins pesticides.

Keywords: Organotins pesticides; Pyrethroids pesticides; Toxicity; Sensitivity; Cyanobacteria; Green algae

1. Introduction

The organotins are a group of acaricides that double as fungicides. Of particular interest is cyhexatin, one of the most selective acaricides known, introduced in 1967. Fenbutatin-oxide has been used

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extensively against mites on deciduous fruits, citrus, greenhouse crops, and ornamentals. The organotin pesticides inhibit oxidative phosphorylation at the site of dinitrophenol uncoupling, preventing the formation of the high-energy phosphate molecule adenosine triphosphate (ATP). These trialkyl tins also inhibit photophosphorylation in chloroplasts, the chlorophyll-bearing subcellular units, and could therefore serve as algicides. Over the past two decades many synthetic pyrethroids have become available. These are very stable in sunlight and are generally effective against most agricultural insect pests when used at the very low rates. Their modes of action are apparently worked by keeping open the sodium channels in neuronal membranes (Ware, 2001). However, its usage may enter freshwater ecologicals by spray drift, leaching, run-off, or accidental spills and present potential risks for aquatic flora (Van den Brink and Ter Braak, 1999; Wang and Freemark, 1995). Alterations of the species composition of an aquatic community as a result of toxic stress may affect the structure and the functioning of the whole ecological (Campanella et al., 2000; Wong, 2000; Verdisson et al., 2001). Algae and cyanobacteria (blue-green algae) are known to be comparatively sensitive to many chemicals (Real et al., 2003). Their ecological position at the base of most aquatic food webs and the essential roles in the nutrient and phosphorus cycling are critical to all ecologicals (Källqvist and Svenson, 2003; Sabater and Carrasco, 2001). Some information on the toxicological aspects of pesticides on green algae has been reported. However, little is known on the toxicological aspects of pesticides on cyanobacteria (Abou-Waly et al., 1991; Sabater and Carrasco, 2001). Cyanobacteria can produce algal toxins, which has important implications for humans and aquatic organisms (An and Kampbell, 2003). Tests on a certain species of algae are of limited applicability in assessing the effects of environmental contaminants on algal communities, which are composed of an array of species with different sensitivities (Sanchez and Tarazona, 2002). A few works have been published about the comparative sensitivity of pesticides toward various green algae (Ma et al., 2004a,b). Yet, there were few reports concerning the differential response of various cyanobacteria and green algae. In the present work, five organophosphates and pyrethroids pesticides were tested to examine their effects on three cyanobacteria *Anabaena flos-aquae*, *Microcystis flos-aquae*, *Mirocystis aeruginosa* and five green algae *Selenastrum capricornutun*, *Scenedesmus quadricauda*, *Scenedesmus obliqnus*, *Chlorella vulgaris*, *Chlorella pyrenoidosa*, and the differential sensitivity of cyanobacteria and green algae are compared.

2. Materials and methods

2.1. Chemicals

All of tested pesticides were purchased from People's Republic of China. Their CAS, REG. NO. and their respective formulations were shown in Table 1. The tested pesticides were dissolved by 99.5% acetone. The concentration of the acetone in the medium was kept minimizing and was less than 0.05%. The US Environmental Protection Agency recommends the allowable maximal limits of 0.05% solvent for acute tests and 0.01% for chronic tests, this level was not significant with regard to toxicity (Jay, 1996).

2.2. Test organisms

The toxicity tests were carried out with the freshwater cyanobacteria *A. flos-aquae*, *M. flos-aquae*, *M. aeruginosa*, and green algae *S. capricornutun*, *S. quadricauda*, *S. obliqnus*, *C. vulgaris*, *C. pyrenoidosa*, which obtained from the institute of hydrobiology, the Chinese academy of science.

2.3. Nutrient media

The medium for cyanobacteria and green alga growth inhibiting test were HGZ and HB-4 medium, respectively. The culture medium was sterilized at 121 °C, 1.05 kg cm^{-2} for 30 min (Kong et al., 1999), which was described in detail in the works of Ma et al. (2003a,b).

2.4. Test methods

Cyanobacterial or green algal cells were propagated photoautotrophically in a 250 mL Erlenmeyer flask containing 100 mL liquid HGZ or HB-4 medium and