A comparison of the fate and effects of prochloraz in artificial and natural sediments

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Abstract

The current draft EC regulatory guidance document for the authorisation of plant protection products, directive EEC 91/414, contains provision for testing the potential toxicity of pesticides to sediment dwelling organisms. Development of an appropriate method is currently in progress, by a German regulatory and industry working group. The compounds which are expected to trigger sediment toxicity data are likely to be those which are relatively persistent, with a high \( K_{ow} \), with the potential for significant adsorption to sediments, and may have previously demonstrated toxicity to aquatic organisms. The current proposal from this working group involves an artificial sediment, prepared in accordance with OECD guideline 207, as used for earthworm toxicity tests. The implications of using this sediment on the distribution, fate and availability of the compound under test are considered. This paper presents toxicity data for \( Chironomus riparius \) generated using radiolabelled Prochloraz® in systems using this artificial sediment and two natural sediments. The fate of prochloraz was also investigated in the same systems and compared with data generated from sediment/water studies carried out in accordance with regulatory guidelines. At the maximum Predicted Environmental Concentration (PEC) of 195 \( \mu g/l \) nominal, prochloraz had no effects on the survival and development of \( Chironomus riparius \). The fate of the compound in the systems used was enhanced possibly as a result of photodegradation.

1. Introduction

The potential effect of pesticides on benthic communities has been the focus of much research in recent years. Of particular concern are persistent products with high \( K_{ow} \) values which may be readily adsorbed to suspended or bottom sediments. Development of a laboratory toxicity test, to assess the potential toxicity of pesticides, to sediment dwelling organisms, utilising the larval stage of \( Chironomus riparius \), is in progress (Barrett & Dohmen, 1992). The current proposal recommends the use of an ‘artificial sediment’ matrix, prepared in accordance with OECD guideline 207, (OECD 1984) as used for earthworm toxicity tests. The use of such a substrate would have several advantages over natural sediment, for example it would be standardized and reproducible, which for a regulatory toxicity study is an advantage, allowing inter- and intra-laboratory comparison of data to be made. However, the influence of such a substrate on the distribution, fate and bio-availability of the compound under test should be considered as this may influence the toxicity observed.

The objective of this work was to investigate how the fate and effects of one fungicide, prochloraz, were affected in a test system using both natural and artificial sediment. Prochloraz, a fungicide registered for use in cereal and orchard crops, was selected for this work since previous regulatory fate studies conducted in natural sediment water systems had indicated a relatively long half life, and strong adsorption to sediment (Phillips, 1995 unpublished). Results from laboratory aquatic toxicity tests with fish and aquatic invertebrates had also indicated the product to be moderately toxic with LC and EC\(_{50}\) values of less than 10 mg/l (Tomlin, 1994).
2. Test materials

2.1. Test species

A species of Chironomidae, Chironomus riparius was used in the study. First instar larvae were obtained from laboratory cultures, maintained as described by Barrett & Dohmen (1992).

2.2. Test sediments

Three different sediment types were used. Two natural sediments with different organic matter contents and an artificial sediment. All the sediments had previously been shown to support growth and development of the test species (Barrett, unpublished data). Their physical and chemical properties are summarized in Table 1.

The Iron Hatch and Millstream pond sediments were obtained from sites at Wareham, Dorset. They were collected using a drag net of 25 cm cross section and 100 mesh. Surficial sediment to a depth of ca. 5 cm was collected, sieved through a stainless steel 2 mm sieve and deep frozen at -18 °C for two weeks prior to use in order to kill natural fauna which could predate on the test species, or compete with it for food. This has been shown to be an adequate period of freezing to remove competitor species (Thirkettle & Barrett, 1994).

The artificial sediment was prepared according to OECD guideline 207 (OECD 1984) for testing toxicity of chemicals to earthworms. In terms of dry weight it comprised 10 percent fine sphagnum peat, 20 percent kaolinite clay and 70 percent fine quartz acid washed sand. The components were combined and mixed in a food mixer with sufficient water to produce a moist, crumbly substrate with a moisture content of ca. 40%. Sufficient CaCO3 was added to adjust the pH to 6.0 ± 0.5.

2.3. Water

The overlaying water used above all sediments was a reconstituted water Elendt ‘M4’ (Elendt & Bias, 1990) the same as used in the culturing of the test species.

2.4. Test vessels

Glass cylindrical units, 26.5 cm (tall) with an internal diameter of 12.3 cm were used. These had a specially designed lid incorporating a down tube to provide aeration, a net covered opening to allow food to be added, and anaesthesia of emergent flies with carbon dioxide prior to collection (Fig. 1).

2.5. Test chemical

Radiolabelled, 14C-prochloraz (technical grade) was used for the study (Fig. 2). This compound is described as stable in aqueous environments and lipophilic in nature with a log $K_{ow}$ of 4.38 (Tomlin, 1994).

The specific activity of the compound used was 103 $\mu$Ci mg$^{-1}$ with a purity of 96 percent determined by thin layer chromatography (TLC) prior to the start of the study.

3. Test methods

3.1. Preparation of the test vessels

Prochloraz is known to adsorb to glass surfaces the internal surfaces of the vessels were pre-treated with Surfasil$^{TM}$, a proprietary brand of siliconizing agent, to reduce adsorptive losses. This was applied undiluted...