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Bioconcentration of trichlorfon insecticide in pacu (*Piaractus mesopotamicus*)

Ruy Bessa Lopes [a], Lourival Costa Paraiba [b,*], Paulo Sérgio Ceccarelli [c], Valdemar Luiz Tornisielo [d]

[a] *Laboratório de Ecotoxicologia, Centro de Energia Nuclear na Agricultura, Universidade de São Paulo, Cx. 96, 13400-970, Piracicaba, São Paulo, Brazil*

[b] *Embrapa Meio Ambiente, Rodovia Campinas Mogi-Mirim, Tanquinho Velho, Cx. 69, 13820-000 Jaguariúna, São Paulo, Brazil*

[c] *Centro de Pesquisa e Gestão de Recursos Pesqueiros Continentais, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, Cx 64, 13630-970, Pirassununga, São Paulo, Brazil*

[d] *Laboratório de Ecotoxicologia, Centro de Energia Nuclear na Agricultura, Universidade de São Paulo, Cx. 96, 13400-970, Piracicaba, São Paulo, Brazil*

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Abstract

Pacu (*Piaractus mesopotamicus*) is one of the most representative fish species of Brazilian fish culture, produced in most Brazilian States due to its importance for food diet and sport fishery. This research work investigated the bioconcentration of trichlorfon [*phosphonic acid*, (*2,2,2-trichloro-1-hydroxyethyl*)-*dimethyl ester*] insecticide in pacu under fish ponds culture conditions and a first-order kinetic insecticide dissipation in the water. Trichlorfon was applied at a rate of 4.62×10^4 mg to each of three nurseries containing 4.2×10^5 l of water. The fish ponds were built on the soil and supported 60 young pacus fishes. The concentrations of trichlorfon fitted to an equivalent non-linear kinetic type model, allows estimate the values of trichlorfon concentration in the water and fishes. These estimations together with the bioconcentration factor determined in the fishes, allowed establishing theoretical reference limit values for human consumption of fishes produced under cultivation systems with trichlorfon. This information will contribute to enlarge the database on pesticide use in Brazilian commercial fish farming, especially about the use of trichlorfon as chemotherapy for the control of fish ectoparasites.

Keywords: Epizooty; Fish ectoparasite; *Lernae*; *Argulus*; Aquaculture; Fish ponds

1. Introduction

Aquaculture is worldwide taking benefits from technologies developed to give support to this activity performance, which is in continuous expansion. Such technologies are concerned with environmental control of the production system, fish breeding and genetic improvement, fish food diet control, fish density and stock control, and the use of xenobiotics as therapeutic chemicals. In Brazil, the use of pesticides in fish culture is associated with the adoption of intensive fish production systems, for sport fishery and commercial fish farming.

The complexities of fish production systems increased the difficulty of the evaluation and prediction of injury effects to environment and aquatic-organisms caused by pesticides use in aquaculture. Consequently, it increased the difficulty of establishment of critical limit concentrations, estimate bioconcentration values under culture conditions and calculate pesticide half-life times in the media and aquatic-organisms.

According to Schnick (1999), xenobiotics have been used in aquaculture since the early 1930s as anesthetics,

* Corresponding author. Tel.: +55 19 38678767; fax: +55 199 38678740.
E-mail address: lourival@cnpma.embrapa.br (L.C. Paraiba).

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growth promoters, aquatic vegetation controller, predatory fauna eradicator, disinfectant and therapeutic for fish pests and diseases. In production systems that maintain high fish densities, several fish pathologies, like the epizooties caused by *Lernae* and *Argulus* ectoparasites, are treated with xenobiotics. Such chemotherapeutic agents actually constitute one of the main environmental problems derived from the intensive fish culture.

Trichlorfon [*dimethyl*, (*2,2,2-trichloro-1-hydroxyethyl*) *phosphonate*] is a selective organophosphate insecticide used to control a variety of arthropod pests including cockroaches, crickets, silverfish, bedbugs, fleas, cattle grubs, flies, ticks, leaf miners, and leaf-hoppers. It is available in granular, soluble concentrate and wettable powder formulations and is used in agriculture and veterinary, that acts onto arthropods as an inhibitor of acetilcolinesterase.

In United States (USA), trichlorfon is currently registered for non-agricultural uses such as commercial animal kennels, golf course turf, ornamental shrubs and plants, and ornamental and baitfish ponds, and is also registered for indoor non-food and no feed areas such as greenhouses, agricultural and farm premises, and non-food contact areas of food and meat processing plants. Registered residential uses of trichlorfon include uses such as perimeter treatment around dwellings, harvester ant mound treatment, and application to residential lawns. Trichlorfon is not a restricted use pesticide and products are marketed for homeowner use (http://www.epa.gov/pesticides/op/trichlorfon.htm) (EPA, 2001).

The National Agency of Sanitary Monitoring (ANVISA) of the Brazilian Government which regulate the use of pesticides, authorize the agricultural use of commercial products that contain trichlorfon in its formularization for cotton, potato, cacao, coffee, sugar-cane, cereals, fruits, horticulture, pastures and terrestrial animals, however it does not regulate the use of trichlorfon in cultivated fish (http://www.anvisa.gov.br/legis/portarias/10_85.htm#). ANVISA classified trichlorfon as an insecticide and zoo vermicide. In Brazil, trichlorfon is used in fish cultures to control *Lernae* and *Argulus*, two common ectoparasites found in several fish types. Nevertheless, it is used in Asia in the production of several fish species and in Europe and Chile to control epizooties in salmon and trout cultures.

Pacu (*Piaractus mesopotamicus*) is a demersal freshwater fish species. It was chosen for this research work, because of its importance for Brazilian food diet and sport fishery. This is one of the most representative native fish species of the Brazilian continental fish culture, once it is produced in about 80% of the commercial fish production systems, all over the Brazilian States and in 77% of the production systems of the State of São Paulo (Lopes, 2000). According to the Brazilian Institute of Environment and Natural Renewable Resources (IBAMA), the commercial production of pacu was as high as 9.244 T in 2002.

In fish importer countries, toxicological and kinetic studies have been used to help the legal registration of pesticides using in aquaculture and to define the fish maximum residue levels limits (MRLs) allowed for human consumption. Kinetic studies might predict transformations, transports and destinations of pesticides in the environment and aquatic organisms.

The pesticide bioconcentration factor (BCF) ($1\,kg^{-1}$) for an aquatic organism is defined by the quotient between the organism's pesticide concentration (C_f, $mg\,kg^{-1}$) and the water pesticide concentration (C_w, $mg\,l^{-1}$) and must be calculated when the system is in steady-state equilibrium, or else, by the quotient between organism's pesticide elimination rate (k_{fw}, h^{-1}) and the organism's pesticide accumulation rate (k_{wf}, $1\,kg^{-1}\,h^{-1}$). The comparison between different pesticide BCF values allows knowing the several pesticide cumulative potentials in the food chain and estimating the acceptable risk concentration for a specific pesticide in a determined aquatic medium.

A classical experimental procedure to calculate BCF consists in exposing a group of test-organisms to a constant water pesticide concentration until the steady-state equilibrium is achieved, that is the accumulation phase. This situation is followed by the organism's pesticide depuration or elimination phase, which consists of transferring the same organisms to pesticide-free water and determining the pesticide concentrations in the medium. One difficulty of this experimental procedure is to maintain a constant pesticide concentration in water, during the accumulation phase.

The kinetic models that describe the pesticide accumulation and elimination kinetics by aquatic organisms allow estimating the pesticide half-life time and the elimination time of 95%-pesticide from aquatic organisms; also, the pesticide half-life time and the dissipation time of 95%-pesticide from the aquatic medium, and the bioconcentration factor. These times might be used, for example, to determine the lack time necessary to wait before fishes from commercial fish production can be released for human consumption.

This research work aimed at determining the following parameters for trichlorfon, under experimental conditions similar to the commercial fish culture conditions: the bioconcentration factor, the half-life time in the water, the trichlorfon half-life time in the fish, the elimination time of 95%-trichlorfon from fishes and the dissipation time of 95%-trichlorfon from water. This information about trichlorfon will contribute to enlarge the database associated to the behavior and fate of pesticides used in fish cultures.

2. Materials and methods

2.1. The nurseries, the water and the fishes

This experiment was carried out in fish nurseries of the Research Center of Tropical Fishes (CEPTA) of IBAMA, located at Pirassununga Municipal District, State of São Paulo, Brazil. Three nurseries were built directly over the soil, measuring 30 m (length) × 10 m (width) × 1.40 m