ECOTOXICITY STUDIES IN JAMAICAN ENVIRONMENT I. TOXICITY, BIOACCUMULATION, ELIMINATION AND TISSUE PARTITIONING OF ETHOPROPHOS BY THE FISH *TILAPIA* IN BRACKISH WATER MICROCOSM

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Abstract

The present study was conducted on the toxicity of ethoprophos to sexually mature red hybrid *Tilapia*. The NOEC and LOEC were 1 and 4 mg/L of ethoprophos; the 24-h LC_{50} and LC_{95} values were 8.41 and 21.00 mg/L. Bioconcentration of the insecticide from NOEC and LOEC in the surrounding water by the fish peaked (3.25 " 0.412 and 12.50 " 1.831 µg/g, respectively) eight to twelve hours after exposure. Bioconcentration from LOEC was 3.8-fold greater than at NOEC. The contaminated fish (after 24-h exposure to LOEC) eliminated 83 % of the ethoprophos residues within 12-h exposure to uncontaminated water. The order of partitioning of ethoprophos in the different tissues of the fish was gonads > liver> gut > gills > skin-muscle-bone.

1. INTRODUCTION

Widespread use of insecticides in Jamaica has contaminated its surface, ground and coastal waters, and aquatic fauna [1]. Studies on the fate of two widely used insecticides, endosulfan [2] and ethoprophos [3] revealed that up to 30% of the residues may run-off from mountainous slopes in the watershed with frequent rainfall, causing undetermined ecotoxic effects. In fact, a rapid survey of major rivers in Jamaica revealed the presence of ethoprophos in at least two of these rivers [4]. The present study was, therefore, conducted to determine the toxicity to and bioconcentration and tissue partitioning of ethoprophos in the fish *Tilapia*.

2. MATERIALS AND METHODS

Sexually mature red hybrid tilapia (*T. mossambica* x *T. nilotica*), 10 - 13 cm long, were obtained from a commercial fish farm and acclimatized to brackish water by exposing them to water of 0.25 and 0.5% salinity for five days each in the laboratory. The acclimatized fish were exposed to different concentrations of ethoprophos (Mocap10G) for 24 or 72 hr in aquaria with 15 L of brackish water at 0.5% salinity or 15% sea water and estuarine sediment and algae. The water was constantly aerated and food was provided daily. Each experiment had three replicates of 15 fish each.

Non-observable (NOEC), least observable (NOEC) and acute toxic effects were studied by exposing the fish 1, 4.0, 5.5, 7.0, 8.5 and 10.0 mg/L of ethoprophos. Toxic symptoms (darting, shuddering, sideswimming and death) were recorded every 8 hr for a 24-hour period. Probit analysis was used to determine the different toxicity levels.

Uptake was studied by exposing the fish to 1 mg/L or 4 mg/L of insecticide. At regular intervals, two fish were removed from each replicate, rinsed in distilled water twice, dried with paper towels, weighed and frozen for residue extraction. Elimination and tissue partitioning of residues were conducted by exposing two sets of fish to 4 mg/L of ethoprophos for 24 hr. One set of fish were dissected to separate the gut, gills, gonads, liver and skin-muscle-bone while the other was exposed to uncontaminated water for 72 hr for studying elimination of the residues. At regular intervals, two fish from each of the three replicates were removed, weighed and frozen as described earlier.

Frozen fish or tissue samples were thawed and homogenized in petroleum ether. Residues were partitioned in acetonitrile and cleaned using florisil according to the method described by Robinson and Mansingh [5]. Residues were determined by a Shimadzu 9A gas chromatograph equipped with a FPD. Analytical conditions were: glass column, 1.6 m by 2 mm packed with OV-17; carrier gas, nitrogen, at a flow rate of 30 - 35 mL/min; temperature settings: column 250EC, injector and detector 280EC. Detection levels ranged from 0.001 - 0.002 ng, recovery ranged from 75.8 - 80.4% from homogenized fish tissue and 89.2 - 91.7% from water. The reproducibility of results was 95.5 " 1.5%.

3. RESULTS AND DISCUSSION

The NOEC (no observable effect concentration), LOEC (least observable effect concentration), LATEC (least acute toxic effect concentration), LC_{10}, LC_{50} and LC_{95} of ethoprophos against the fish *Tilapia* are presented in Table 1. The LC_{50} values are well within the range of 0.27 - 13.8 mg/L reported by [6, 7] for different species of fish and suggests relatively low toxicity of ethroprophos to *Tilapia* when compared with other insecticides.

TABLE I. TWENTY FOUR HOUR NOEC, LOEC, LATEC, MATEC AND ATEC VALUES OF ETHOPROPHOS TO TILAPIA FISH

Toxicity concentration	Concentration (mg/L)	Fiducial limit	Slope	Proposed toxicity terminology
NOEC	1 - 2	-	-	NOTEC
LOEC	3 - 4	-	-	LOTEC
LC_{10}	4.13	2.410 - 5.202	4.141 " 0.934	LATEC
LC_{50}	8.41	7.205 - 10.232	4.141 " 0.934	MATEC
LC_{95}	21.00	15.072 - 47.518	4.141 " 0.934	ATEC

It may be pointed out that the difference between LOEC and LC_{10} is much less than between NOEC and LOEC or LC_{10} and LC_{50}. This may be attributed to the short experimental period of 24 hours for evaluating sublethal toxic effects. Furthermore, it is difficult to define NOEC and LOEC because (1) the toxicity of an insecticide is dependent upon the chemical properties of the insecticide and genetic heterogeneity of the target population, (2) the threshold of toxicity may not be behaviorally noticeable, (3) the toxic symptoms may be mild or pronounced, but recoverable, (4) these symptoms may be manifested by a few or more than half of the individuals in a population, (5) the symptoms may be abolished after a short or long period and (6) a few (< 10%) individuals may succumb after manifestation of pronounced toxic effects. How can all these effects be caused by a single LOEC?

It is, therefore, proposed that chronic and lethal or acute toxicities, and the concentrations causing such effects, be classified as NOTEC or no observable toxic effect (on 90% of the individuals) concentration, LOTEC or least observable mild and recoverable toxic effect (on < 50% of the individuals) concentration, MOTEC or mild, observable and recoverable toxic effect (on > 50% of the individuals) concentration, POTEC or pronounced observable and recoverable toxic effect (on > 25% of the individuals) concentration, LATEC or least acute toxic effect concentration (LC_{10}), MATEC or median acute toxic effect concentration (LC_{50}) and ATEC or acute toxic effect concentration (LC_{95}). The quantitative and arbitrary LOEC in Table 1 includes MOTEC and POTEC as well.

The uptake of ethoprophos was significantly ($P < 0.001$) faster and higher from LOEC than from NOEC (Fig.1). The rate of accumulation was most rapid during the first hour of exposure to both concentrations. Thereafter, at NOEC, it increased gradually to 3.25 " 0.72 Fg/g at 8 hr and fluctuated insignificantly ($P > 0.05$) for the next 64 hr. At LOEC, however, bioaccumulation continued to be steep for 4 hr (10.4 " 1.39 Fg/g) but gradual for the next 16 hr when the bioconcentration reached 12.5 " 2.41

Fg/g and fluctuated insignificantly ($P > 0.05$) afterwards. The bioconcentration factor (BCF) of ethoprophos in the fish was 2.4, and is a reflection of its high water solubility in water [8].

Fish, transferred to uncontaminated water after 24 hr. of exposure to LOEC, eliminated 82% of the initial concentration of ethoprophos in the first 12 hours, and a further 4% during the next 60 hours (Fig. 1). This rapid rate of elimination of the insecticide may be attributed to its high water solubility and its rapid transportation to gills and kidneys, as suggested by Tooby and Durbin's [9] for highly soluble insecticides.

The partitioning of ethoprophos was highest in the gonads > liver > gut > gills > skin, muscles and bones (Fig. 2). Gonads do bioconcentrate high levels of residues due to high lipid content [10] and are, therefore, adversely affected by the toxicants which is manifested in low fecundity [11, 12]. Accumulation in liver exposes the residues to detoxification [13], while those in gut and gills can be eliminated fairly fast.

The low BCF of ethoprophos, which is well below the critical value of 100 [14], and the rapid elimination of the accumulated residues by *Tilapia*, suggest that the insecticide may pose only limited danger to the fish, particularly since the LOEC levels are unlikely to be reached in the environment.

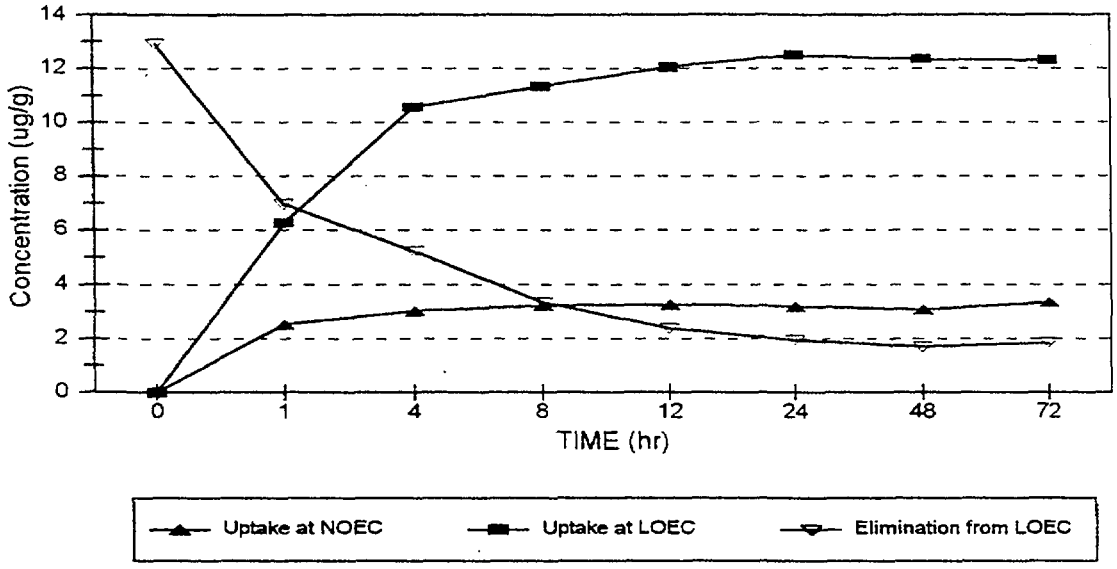

FIG. 1:Bioaccumulation of ethoprophos by hybrid Tilapia from non-observable and least-observable toxic effect concentration and elimination from whole body after 24 hr of exposure to least-observable toxic effect concentration under steady state conditions.

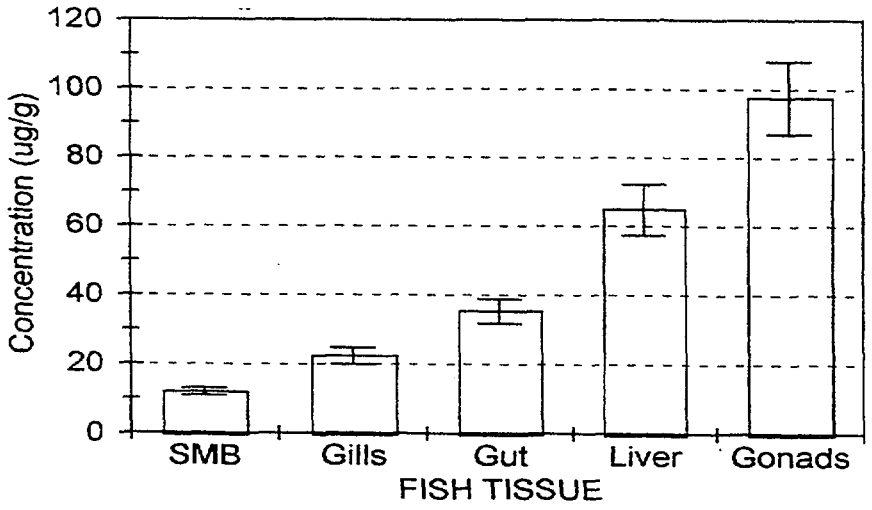

FIG. 2:The partitioning of accumulated ethoprophos in body tissues of hybrid Tilapia after 24 hr of exposure to least observable toxic effect concentration

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