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Interaction of potash and decis in the ecophysiology of a freshwater fish *Oreochromis mossambicus*

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Abstract

Interaction of potash and decis in the ecophysiology of a freshwater fish, *Oreochromis mossambicus*, was studied. It was found that 300, 550 and 700 mg L^{-1} of potash were sublethal (LC_0), median lethal (LC_{50}), and toxic (LC_{100}) to *O. mossambicus* for 96 h exposure, respectively. For decis, 96 h $LC_{100,}$ LC_{50}, and LC_0 was 0.4, 0.25, and 0.1 mg L^{-1}, respectively. Sublethal concentrations of potash and decis were exposed to fishes individually and in combination for 28 days. The results revealed that the combined effect of these chemicals was more highly toxic to food intake, growth, and conversion efficiencies than the individual chemicals. The marker enzymes (acid phosphatase, alkaline phosphatase, aspartate transaminase, alanine transaminase) were also analyzed in blood, liver and muscle. The enzyme activities were decreased in liver and muscle. On the other hand, serum exhibited increased activities of marker enzymes. The results were tested statistically and interpreted accordingly.

Keywords: *Oreochromis mossambicus*; Potash; Decis; Survival; Feeding energetics; Phosphatases; Transaminases

1. Introduction

Agriculture, as the single largest user of freshwater on a global basis and as a major cause of degradation of surface and groundwater resources through erosion and chemical runoff, has resulted in global effects on water quality. Among anthropogenic chemicals, pesticides and fertilizers may cause serious problems because they are designed especially to kill organisms (both noxious target organisms and other nontarget ones) and to improve crop growth. They are released into the natural environment intentionally. It has been widely documented that their concentration in the natural environment is often high enough to kill certain organism and affect the structure and function of natural communities (Hatakayama et al., 1991, 1994; Rani et al., 1997, 1998).

Extensive use of agricultural chemicals leads to the contamination of the freshwater system where *Oreochromis mossambicus* are native inhabitants. This species is often used as sentinel organism to investigate the biological effects of pollutants in the aquatic environment. In recent years, *O. mossambicus* has served as a bioindicator and integrator of contaminants, on various reasons, viz., wide distribution in the fresh water environment, free-swimming nature, ability to respond against environmental pollution, and importance as an economic food source for human beings (Pelgrom et al., 1995).

Fertilizers and pesticides applied simultaneously in agricultural operations have more effect on the metabolism and enzyme systems of target species than in the case of individual chemicals. Moreover, chemical fertilizers have synergistic effects on the physiology of nontarget species. The combination of chemicals results in greater toxicity than what would be expected on the basis of simple addition of their individual actions. Studies on the toxicity of mixtures are referred as interaction studies. Palanivelu et al. (2002) are of the opinion that interaction of chemicals may influence the absorption and distribution of one chemical by another or combination of their actions or effects.

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One of the marked effects of chemical poisoning is death. Quite often the chemical concentration in the environment may not be enough to kill the organism, but sublethal concentrations often result in altering the physiology. Toxicity bioassay is the basic tool for detection, evaluation, and abatement of water pollution. On the basis of toxicity determination, one can judge the quality of water and the environment. Feeding energetics is an important factor governing growth and reproduction. The nature and extent of pollution effect on an organism are reflected in feeding energetics. Growth represents a net outcome of a series of processes such as digestion, assimilation, metabolism, and excretion (Beamish et al., 1975). Brett and Groves (1979) produced a hypothetical model for average partitioning of dietary energy for organisms, which starts with an intake of 100 calories of which 20 calories are lost as feces and 7 calories as nitrogenous waste. The cost of digestion and assimilation of the food is 14 calories for specific dynamic function, leaving a net energy of 59 calories to be used by the organism. This net energy is apportioned between maintenance activities, metabolism, growth, and reproduction. Energy metabolism and growth compete for net energy. Thus, if metabolism is elevated, growth will be limited unless the intake of food is increased, and hence parameters related to food utilization can be used as stress indicators.

When organisms are exposed to foreign chemicals, there may be inhibition or acceleration of the catalyzed reaction rate. The mechanism of these effects can involve changes in enzyme activity, or it may be due to a direct effect of the chemicals on enzyme molecules (Heath, 1987). Thus, the measurement of cellular enzymes of the organism is an indicator of stress which can be used to assess the effect of toxicants. Majority of workers have studied the effect of individual chemicals on various physiological responses in fishes (James et al., 1992; Palanichamy et al., 1985a, b; Palanivelu and Balasubramanian, 1997; Rani et al., 1998). However, the influence of combinations of pesticide and fertilizer on ecophysiology of fish has not received much attention (Palanivelu et al., 2002, 2004, 2005b; Rani et al., 1997, 1999). These compounds exert their impact at multiple levels including molecules, tissues, organs, individuals, populations, and communities and a variety of ecotoxicological tests have been designed to assess these effects (Cairns and Niederlehner, 1995).

Fish–pollutant relationships have received considerable attention in the study of fish ecophysiology. In adverse conditions, these chemicals affect the nontarget species, for which bioassays and biomarker assessments are essential to establish toxic limits of fertilizers and pesticides. Furthermore, these studies serve as a tool to evaluate ecotoxicological hazards.

2. Materials and methods

Juveniles of *O. mossambicus* ranging in weight from 7.8 to 9.2 g were collected from local pond, near Chennai, Tamil Nadu, India and used for experiments after a week of acclimation to laboratory conditions. In a preliminary experiment, the sublethal concentration of potash and decis for *O. mossambicus* over 96 h exposure was determined by exposing them as groups of 10 individuals to different concentrations of potash and decis individually. After acclimation to the laboratory conditions, acute toxicity study was carried out by following the standard EPA/ROC (1998) guidelines to determine the lethal (LC_{100}), median lethal (LC_{50}), and safe sublethal (LC_0) levels of potash (caustic potash-HKO) and decis (deltamethrin-(S)–alpha-cyano-m henoxybenzyl(1-R,BR)-3 (2,2-dibromovinyl)-2, 2-dimethylcyclopropane carboxylate) for *O. mossambicus*. The 96-h LC_{50} value of mortality for each exposure concentration was recorded and tested by probit analysis as described by Finney (1971). Potash (caustic potash 45%) and decis (delatamethrin 98%) were obtained from local manufacturers. The lethal, median lethal, and sublethal concentration were found to be LC_{100} (700 mg L^{-1}), LC_{50} (550 mg L^{-1}), and LC_0 (300 mg L^{-1}) for potash and LC_{100} (0.40 mg L^{-1}), LC_{50} (0.25 mg L^{-1}), and LC_0 (0.10 mg L^{-1}) for decis (Figs. 1 and 2). The highest concentrations of potash and decis that showed 100% survival of fish were 300 and 0.10 mg L^{-1}, respectively, which were considered as the sublethal levels. Hence these concentrations were taken for toxicity studies.

To investigate the sublethal effects of potash and decis individually and in combination, feeding energetics was studied in *O. mossambicus*. Ten fish were exposed to test concentrations of potash (300 mg L^{-1}), decis (0.10 mg L^{-1}), and their mixture (300 mg L^{-1} potash + 0.10 mg L^{-1} decis). A control chamber was also set up where the fish were maintained in chemical-free water. The fish were maintained in large glass aquarium tanks of 30″ × 25″ × 20″ with sublethal concentrations of fertilizer and pesticide individually and in combination. For each group, three chambers were set up to replicate the results. The test individuals were fed about 10 g of fresh goat liver a piece once a day for a period of 2 h (10:00–12:00 A.M.). Control food was dried in a hot air oven to weight constancy and water content of the food was estimated. Unfed remains were carefully collected using a pipette without causing disturbance to the fish. Toxicant

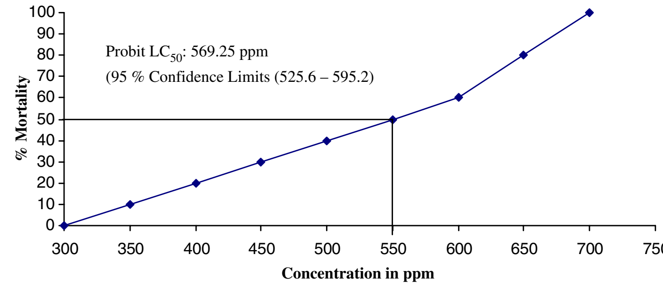

Fig. 1. Percentage mortality of *O. mossambicus* exposed to various potash concentrations for 96 h and its median lethal concentration (LC_{50} with 95% confidence limits calculated by probit analysis).

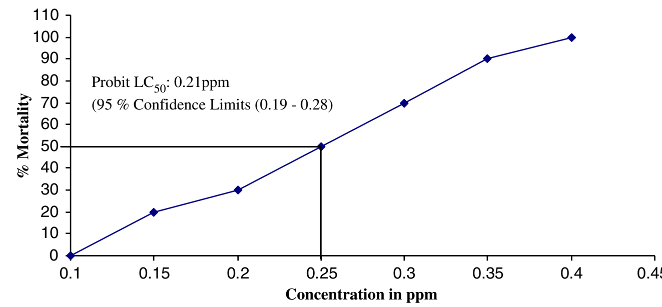

Fig. 2. Percentage mortality of *O. mossambicus* exposed to various decis concentrations for 96 h and its median lethal concentration (LC_{50} with 95% confidence limits calculated by probit analysis).