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ROTENONE AS A TOXICANT FOR FISHERIES MANAGEMENT IN MICHIGAN

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Rotenone ($C_{23}H_{22}O_6$), an alkaloid, primarily used as an insecticide, is obtained from the roots of certain plants of the family Leguminosae. Gardeners commonly use rotenone to control such things as bean beetles and cabbage worms. Since prehistoric times native inhabitants of the tropics and subtropics around the world have used extracts from rotenone-containing plants to catch fish. Depending upon the part of the world from which it comes, rotenone may be known as tuba, derris, cube or timbo. Much of the commercial supply is obtained from Derris elliptica, a plant found in southern Asia. In southeastern United States Tephrosia virginiana, devil's shoestring or goat's rue, contains rotenone and was used by the Indians as a fish poison. At the suggestion of Dr. Carl L. Hubbs, ichthyologist at the University of Michigan, rotenone was first used in fisheries management. In July 1934, Mr. Milton B. Trautman treated two small ponds on the estate of Mr. W. O. Briggs near Birmingham, Michigan. An aqueous suspension of powdered derris root (5% rotenone) was used to remove excessive numbers of goldfish (Carassius auratus) and carp (Cyprinus carpio). Since then, rotenone has been commonly used by fish managers to remove diseased, slow-growing, or undesirable fish from lakes and streams. Commercial formulations containing rotenone synergists and emulsifiers were soon developed for use in fisheries work.

Fish subjected to rotenone suffocate. Respiratory failure is caused by a constriction of the gill capillaries. Toxicity of rotenone to fish starts at 0.0025 mg/l (= ppm) but an average minimum lethal dose is about 0.05 mg/l. Fisheries workers generally use a concentration of 0.5 mg/l or greater of a 5% rotenone formulation. Professor Justin W. Leonard, now of the University of Michigan formerly director of research for the Michigan Department of Natural Resources, in 1938 worked out the first minimum lethal doses for some of the common fishes. He demonstrated that some fish, such as the goldfish (Carassius auratus) and the mudminnow (Umbra limi) are less susceptible to rotenone than others. From Leonard's study, and others that followed, it became apparent that the toxicity of rotenone decreased when exposed to light, heat, oxygen, alkalinity, and turbidity.

Although obviously extremely toxic to fish, rotenone is only slightly toxic to birds and moderately toxic to mammals and other invertebrates. In the low concentrations used in fisheries management, livestock may safely drink the treated water (although it is not recommended) and such things as dogs and snakes, frogs and ducks, are not harmed. In toxicity tests for mallards, the lethal dose for 50% of the birds was 2,000 mg/kg body weight and for pheasants 1,414 mg/kg. The acute oral lethal dose for rats has been reported as 132 mg/kg, for dogs 3,000 mg/kg, and for man 2,850 mg/kg. At this rate, a man weighing 150 pounds would have to consume almost one-half pound of rotenone to have a lethal dose.

Rotenone has been used in municipal water supplies without any adverse effects. Probelms of odor and taste caused by decomposing fish or the solvent used with commercial rotenone products are easily removed with activated carbon. Rotenone

does not persist in the environment. Treated water will detoxify within a few days to a month. Waters with high alkalinity (pH), high temperatures, and abundant light and air, detoxify rapidly.

Long-term exposure of rats to low concentrations of rotenone did not result in any serious adverse results. A commercial rotenone product containing 2.5% each of rotenone and sulfoxide (a synergist) was fed to rats in drinking water at a level of 100 mg/l for 70 weeks. Average weight of the experimental animals was then less than the control group but there were no other symptoms. In addition, the commercial product in water was exposed to sunlight and air until the test for rotenone was negative and the solution was no longer toxic to fish. This formulation containing rotenone "breakdown" products was then fed to rats in drinking water at a level of 100 mg/l for one year. Again, a slight decrease in weight was observed in the experimental rats in comparison with the controls, but no gross or microscopic pathology was detected.

Humans may eat fish killed by rotenone without being harmed; however, inhalation of rotenone powder by people working with it has caused headaches, sore throat, and other cold symptoms. Contact with the powder may cause irritation of eyes and a skin rash. Liquid formulations reduce risks to safety and health. Treated waters may be detoxified by using chemical oxidants such as permanganate or chlorine. Methylene blue has been used to revive warmwater fish that have been poisoned by rotenone.

In general, the invertebrate animals are much less sensitive to rotenone than fish, with the exception of the microcrustacea which are nearly as sensitive. Phytoplankton, the microscopic plants in the water, are affected very little by the rotenone. At the concentrations of rotenone used to kill fish, in almost all cases, the microcrustacea or zooplankton populations are severely reduced and will not be completely reestablished for several months. The effect of rotenone on the benthic organisms is extremely variable. Whether these bottom-dwelling invertebrates are injured or not depends upon such things as the water temperature, alkalinity and turbidity, and the concentration of the toxicant. In some situations, after treatment the more resistant species of invertebrates become more abundant than their original populations, presumably because of decreased competition. Reinvasion and increase in the numbers of the resistant species of invertebrates insures an available food supply for the fish which are subsequently stocked.

The commercial rotenone formulation which is used in fisheries management in Michigan has been approved by the United States and the State Departments of Agriculture. In 1962 the Federal Insecticide, Fungicide and Rodenticide Act was extended to cover fish toxicants. To be registered by USDA the application and claims must be substantiated by test data. In addition, the State of Michigan Department of Public Health has acknowledged that rotenone, as used in fisheries management, is not a hazard to public health and may be used, with certain precautions, in public water supplies.

As the agriculturist needs the plow to prepare the land for new crops, so the fisheries manager needs rotenone to prepare lakes for new fish populations. Both need to manage some parts of the environment for the benefit of man. Rotenone is an essential tool for the fisheries manager.

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