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Abstract. Fifteen ponds were treated with toxaphene concentrations that varied from 0.01 to 0.1 parts per million. Preliminary studies revealed wide variations in the chemical and physical features of the ponds. Approximately 3,500 pounds of fish were killed. Carp, gizzard shad, and quillback were the most numerous; other species included largemouth bass, bigmouth buffalo, black crappie, black bullhead, bluegill, yellow bass, and channel catfish. Detoxification studies were conducted on five ponds. The first pond detoxified within 90 days; two remained toxic to fishes for 270 days. Factors important to the duration of toxicity are discussed.

The chemical insecticide toxaphene has recently been utilized for the eradication of undesirable fish populations by various fisheries workers (Hemphill, 1954; Hooper and Grzenda, 1955; Rose, 1956; and Tanner and Hayes, 1955). In several respects toxaphene is considered superior to rotenone or other derris bearing compounds as a fish toxicant. Cold water temperatures do not reduce the physiological effectiveness of toxaphene to a point where it is nontoxic. Thus, eradication projects are not restricted to summer months. Over extended periods of time there is apparently no difference in species tolerance to the compound. Toxaphene is also capable of attaining a higher percent of kill because of its longer duration of toxicity.

Toxaphene is best described as a highly residual chlorinated camphene having the empirical formula $C_{10}H_{10}C_8$. The technical or commercial grade is a cream-colored, waxy solid with a mild piney odor and contains 67 to 69 percent chlorine. It is highly soluble in common organic solvents but insoluble in water (Parker and Beacher, 1947). The toxaphene used in this study was an emulsified concentrate marketed by William Cooper and Nephews, Chicago, Illinois, under the trade name of Cooper-Tox No. 6. It contained six pounds of technical grade toxaphene per gallon.

Description of Study Area

The Banner Strip Mine Area is located in Warren County approximately five miles north of Indianola, Iowa. It is a typical southern Iowa open pit coal mine. Top-soil and shale were removed until coal deposits were exposed. The coal was excavated leaving a series of deep pits. These basins were eventually filled with water

either by runoff or ground water seepage. The mine has been abandoned since 1930.

The water area consists of 15 ponds ranging in size from one-eighth to 15 acres. All water levels are relatively stable except Pond 1 which is periodically flooded by the Middle River (Figure 1).

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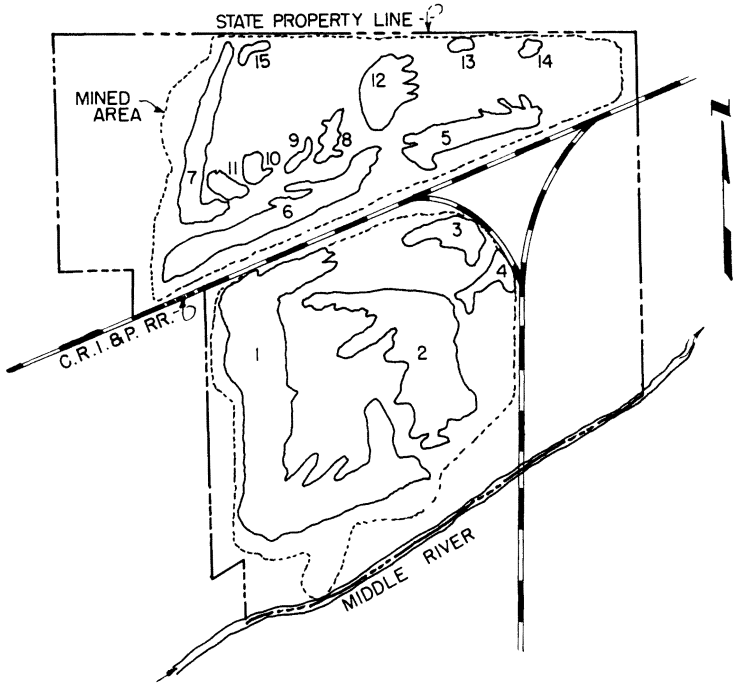

Figure 1. Location of the recreational ponds in the Banner Strip Mine Area.

Water chemistry of strip mine ponds may vary considerably. This is dependent upon the relationship of ground water seepage and the location of coal deposits. Preliminary studies revealed a wide variation in the physical and chemical characteristics of the Banner Ponds. Four of the 15 ponds were stratified chemically and thermally during the summer months; pH ranged from 4.0 to 7.5; methyl orange alkalinity ranged from 0.0 p.p.m. to 120 p.p.m. Turbidity measurements with a standard Secchi disk ranged from 2.5 to 18.5 feet. Data on the water chemistry of individual ponds are listed in Table 1.

Table 1

The Chemical and Physical Characteristics and Concentration of Toxaphene Used in the Eradication of Fish Populations in the Banner Strip Mine Area

Pond No.	Surface Area (Acres)	Average Depth (Feet)	pH	Methyl Orange Alkalinity (p.p.m.)	Light Penetration (Secchi ft.)	Stratified	Concentration (p.p.m.)
1	15	18	7.0	72	7.5	Yes (9-12 ft.)*	0.04
2	4.7	18	7.0	74	4.5	Yes (7-9 ft.)*	0.04
3	2.8	7	7.0	72	2.5	No	0.04
4	1.1	5	7.0	72	2.5	No	0.04
5	3.5	18	4.0	9	18.5	Yes (14-16 ft.)*	0.01
6	2.0	7	4.5	19	9.0	No	0.01
7	3.5	6	7.5	120	2.0	No	0.04
8	1.0	8	4.5	None	9.0	No	0.01
9	0.15	3	7.0	76	2.5	No	0.04
10	0.15	3	7.0	76	2.0	No	0.04
11	0.25	10	7.5	120	3.5	No	0.075
12	4.1	16	4.0	None	18.5	Yes (12-14 ft.)*	0.025
13	0.5	8	7.5	120	6.0	No	0.1
14	0.15	8	7.0	96	6.5	No	0.1
15	0.5	5	7.0	76	2.5	No	0.01

*Location of thermocline listed in parenthesis.

Method of Treatment and Results

Each pond was treated with a predetermined amount of toxaphene. Concentrations used were 0.01, 0.025, 0.04, 0.075, and 0.1 p.p.m. (Table 1). Three portable spraying units mounted in car-top boats were used to apply the material to the surface of the water. Within 75 hours fish were observed either dead or in distress. Mortality continued for approximately six days.

Approximately 3,500 pounds of fish were eradicated during the operation. Fish were found in every pond, but populations in the more inaccessible impoundments were minimal. Pond 1 contained the greatest number of fish. This was undoubtedly due to the periodic restocking of this pond during flood stages on the Middle River. Carp (*Cyprinus carpio*), gizzard shad (*Dorosoma cepedianum*), and quillback (*Carpiodes cyprinus*) were the most abundant fishes. Other species killed during the treatment included largemouth bass (*Micropterus salmoides*), big-mouth buffalo (*Ictiobus cyprinellus*), black bullhead (*Ictalurus melas*), black crappie (*Promoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), yellow bass (*Roccus mississippiensis*), and channel catfish (*Ictalurus punctatus*).

Duration of Toxicity

One of the major unsolved problems in the use of insecticidal chemicals for fish toxicants is the length of time water will remain toxic. Waters that are taken out of fish production for several years or more are lost to the sportsman. Most of these insecticidal compounds are highly residual and may be retained in soil or water for considerable time. In working with toxaphene, biologists have reported a wide variation in the duration of toxicity.

The factors primarily responsible for rapid detoxifications are not completely understood. Hemphill (*op. cit.*) stated that detoxification is more rapid in alkaline waters. In four Michigan lakes detoxification occurred more rapidly in shallow basin lakes (Hooper and Grzenda, (*op. cit.*). Rose (*op. cit.*) reports a rather short duration of toxicity in shallow Iowa prairie lakes with high turbidity.

Detoxification studies on the ponds in the Banner Area were conducted in relation to pH, alkalinity, turbidity, and rate of application. Five ponds with different physical and chemical characteristics were selected for special study. Ten fathead minnows (*Pimephales promelas*) were placed in holding pens several feet under the water surface. Live minnows were placed in the pens at 30 day intervals beginning 60 days after treatment until all ponds had detoxified. These fish were observed every 24 hours until a total time of 96 hours had elapsed. If no mortality occurred at the end of this period the pond was considered non-toxic.

Three of the five test ponds were quite similar in chemical and physical characteristics. Ponds 1, 11, and 13 were generally char-

acterized by alkaline, turbid, hard waters. Concentrations applied to these ponds were 0.04, 0.075, and 0.1 p.p.m. respectively. Ponds 5 and 12 were greatly different from the first group in chemical composition. Waters were relatively free from inorganic turbidity, soft, and highly acid. Toxaphene was applied in these ponds at a concentration of 0.01 and 0.025 p.p.m. Pond 11 was first to detoxify, 90 days after treatment. Detoxification occurred 150 days after treatment in Ponds 1 and 13. At the beginning of winter ice cover, Ponds 5 and 12 still remained toxic. Approximately two weeks after the spring thawing both ponds detoxified. This was slightly over 270 days after treatment.

Results of the experiments suggest that a single chemical or physical characteristic may not be responsible for detoxification. Rather, detoxification is the result of interactions between a combination of factors. In ponds of similar chemical characteristics the shallow silt-laden waters were first to detoxify. Hence, turbidity seems to be one of the primary factors. At the extreme chemical ranges tested, there is also a relationship between water chemistry and detoxification. In all cases the hard water ponds were first to become non-toxic. The alkaline ponds also detoxified more rapidly than the acid ponds.

The rate of application appears to be relatively unimportant to the duration of toxicity when concentrations are within the median tolerance limits of fish life. Regardless of the rate at which toxaphene was applied, the duration of toxicity was more related to chemical and physical characteristics of the pond than to the concentrations.

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