UTILIZATION OF ANHYDROUS AMMONIA IN FISHERIES MANAGEMENT

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ABSTRACT

This study completes a segment of a project to evaluate the use of anhydrous ammonia as a fisheries management technique in small impoundments. Objectives were to determine the feasibility of using anhydrous ammonia for fish eradication, for pond fertilization, and for vegetation control. Treatments in 15 pounds in Central Texas indicate that anhydrous ammonia fulfills these objectives. Anhydrous ammonia was selected because of known toxicity to fishes and because ammonia is a naturally occurring compound. Thus, the use of anhydrous ammonia as a total or selective population control agent will not leave a persistent nondegradable residue in a pond. Treatment rates varied from 13 to 40 ppm of anhydrous ammonia. Higher treatment rates caused total kills while lower treatment rates appeared selective for certain species. Phytoplankton and zooplankton populations were decimated and recovered slowly. As expected, profound changes in ammonia, pH, CO_2, and alkalinity occurred following treatments.

INTRODUCTION

Management of fish populations in small impoundments often requires the use of materials which are toxic to fish. The well-known purpose of using fish toxicants is to eliminate or reduce undesirable fish populations to facilitate restocking. Insecticides, partcularly rotenone, have been used for many years to control fish populations. Anhydrous ammonia was selected for this study because of its potential as a fish toxicant and because of possible coherent benefits of fertilization and vegetation control. Furthermore, introduction of anhydrous ammonia into a pond will not leave a persistent non-biodegradable residue.

The toxicity of ammonia to fish is well known. Wallen, Greer, and Lasater (1957) rated ammonia as seventh in toxicity among the 86 chemicals tested in turbid water. Duodoroff and Katz (1950) cite numerous investigations giving results of lethal concentrations of ammonia around 2 to 7 ppm with the highest ranging around 25 ppm as NH_3.

Ammonia gas is soluble in water to the extent of 100,000 ppm at 20°C. It reacts with water to form ammonia and hydroxyl ions. McKee and Wolf (1963) cite the combined reversible equations for this equilibrium reaction as being:

$$NH_3 + H_2O = NH_4OH = NH_4^+ + OH^-$$

Belding (1927) found that fish exposed to ammonium hydroxide indicated symptoms of: irritation, rapid-irregular and frenzied movements, loss of equilibrium, and depressed respiration. Brockway (1950) speculated that the mechanism of ammonia toxicity to fish was a reaction in which the hemoglobin of the blood loses the ability to unit with oxygen or to liberate carbon dioxide and that the fish suffocated. Jones (1964) cites that the relation between the toxicity of ammonia solutions and the concentration of undissociated ammonia or ammonium hydroxide suggests that ammonia acts on fish as a true internal poison entering the body by way of the gills, but that the exact nature of the mechanism is not known.

METHODS AND MATERIALS

The anhydrous ammonia was metered into all ponds through a ⅜-inch diameter hose from trailer-mounted tanks. The hose outlet was suspended 2 feet above the pond bottom. Introduction of the ammonia was made in the deepest water areas of the pond with approximately one point of introduction per surface acre. Application rates varied from 13 to 40 ppm. Pond sizes varied from 0.1 to 4.4 surface acres.

In four ponds (Ponds 1, 2, 3, and 4) pre-and post-periodic measurements were made of the water temperature, pH, alkalinity, NH_3, and CO_2. However, only pH and temperature were taken in the remaining 11 ponds at the time of treatment. All ponds were observed visually for the first 24 hours after treatment and once per week for 4 weeks after treatment. Fish were collected for identification. Between 2 and 4 weeks after ammonia treatment, each pond was checked for any remaining fish population by seining and/or draining. The seine used for this purpose was a 50-foot bag seine with ¼-inch mesh. Two ponds (Ponds 5 and 13) were treated with 5 pounds of 5 percent rotenone powder per acre foot of water 2 weeks after the treatment with anhydrous ammonia as a further check to discover any remaining fish.

RESULTS

Physical and Chemical

The immediate major chemical changes which appeared to be caused by ammonia treatment were increases in pH, ammonia nitrogen, carbonates, and hydroxides. Carbon dioxide and bicarbonate amounts decreased temporarily (Table 1). Prior to treatment in Ponds 1 through 4, the ammonia nitrogen ranged from 0.4 to 1.5 ppm. Introduction of 20 to 40 ppm of ammonia caused proportional or even greater increases in ammonia nitrogen 24 hours after treatment. In Pond 1, the introduction of 28.8 ppm of ammonia increased the ammonia nitrogen from 0.4 ppm before treatment to 37.7 ppm 24 hour after treatment (Table 1).

Pretreatment measurements of pH ranged from 6.9 to 8.0 and increased to a range of 9.4 to 10.0 twenty-four hours after treatment.

Generally, in Ponds 2, 3, and 4, all measured chemical and physical characteristics returned to approximate pretreatment values 30 days following treatment. However, increased pH and ammonia levels persisted in Pond 1 for 8 months after treatment. Ponds 2 through 4 were treated in March with water temperatures varying upward after treatment. Pond 1 was treated in November with water temperatures varying downward after treatment.

Fish

Generally, the fish in a treated pond would begin to surface and die 1 to 3 hours after introduction of anhydrous ammonia. Although frenzied activity and irregular movement of the fish was evident, the irregular activity observed in all treated ponds was much less than observed in past experiences where rotenone was used as the fish toxicant.

Data are insufficient to indicate specific toxicity levels for the different species of fish used in the test. However, it appears that shad, sunfishes, and catfishes, including bullheads, are among the most susceptible (Table 2).

A "complete" kill of black bullheads (*Ictalurus melas*) was obtained in Pond 9 at a treatment rate of 20 ppm. The more tolerant species ap-

TABLE 1. Comparison of physical and chemical data of test ponds before and after treatment with anhydrous ammonia.

	pH	NH_3 (ppm)	Phenol Alkalinity (ppm)	Total Alkalinity (ppm)	CO_2 (ppm)	OH (ppm)	CO_3 (ppm)	HCO_3 (ppm)
Pond 1*								
Before Treatment	6.9	0.4	..	..	6.1	..	..	..
24 Hours After Treatment	9.6	37.7	68.5	117.4	0.0	19.6	96.8	0.0
2 Weeks After Treatment	9.0	19.1	24.8	72.8	0.0	0.0	49.6	23.2
3 Months After Treatment	7.6	5.0	0.0	46.2	7.5	0.0	0.0	46.2
8 Months After Treatment	7.9	1.5	1.3	24.9	4.9	0.0	2.6	22.3
Pond 2**								
Before Treatment	7.9	0.7	0.0	28.0	1.0	0.0	0.0	28.0
24 Hours After Treatment	9.9	31.3	8.8	106.0	0.0	70.0	36.0	0.0
1 Month After Treatment	7.6	1.1	0.0	17.0	1.5	0.0	0.0	17.0
Pond 3†								
Before Treatment	7.2	1.5	0.0	22.0	4.0	0.0	0.0	22.0
24 Hours After Treatment	9.9	42.0	115.0	145.0	0.0	85.0	60.0	0.0
1 Month After Treatment	7.2	1.5	0.0	27.0	7.0	0.0	0.0	27.0
Pond 4‡								
Before Treatment	8.2	1.2	0.0	23.0	2.0	0.0	0.0	23.0
24 Hours After Treatment	10.0	33.0	85.0	115.0	0.0	55.0	60.0	0.0
1 Month After Treatment	7.3	1.1	0.0	21.0	4.0	0.0	0.0	21.0

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* Pond 1 Treatment Rate = 28.8 ppm; Surface Area = 4.40 Acres; Volume = 32.70 Acre Feet.
** Pond 2 Treatment Rate = 30.0 ppm; Surface Area = 0.25 Acres; Volume = 1.33 Acre Feet.
† Pond 3 Treatment Rate = 35.0 ppm; Surface Area = 0.20 acres; Volume = 0.67 Acre Feet.
‡ Pond 4 Treatment Rate = 40.0 ppm; Surface Area = 0.17 Acres; Volume = 0.31 Acre Feet.
.. Samples Not Taken.

TABLE 2. Summary of the effect of anhydrous ammonia treatment on fish in 15 Texas farm ponds.

Pond	Surface Area (Acres)	Ammonia Treatment Rate (ppm)	Species Killed	Species Surviving	Method of Checking For Live Fish
1	4.4	28.8	*Umbra limi* *Campostoma anomalum* *Notropis atrocaudalis* *Notropis lutrensis* *Pimephales vigilax* *Notemigonus crysoleucas* *Carpiodes carpio* *Ictalurus melas* *Fundulus notatus* *Gambusia affinis* *Aphredoderus sayanus* *Chaenobrythus gulosus* *Lepomis cyanellus* *Lepomis macrochirus* *Lepomis megalotis* *Lepomis microlophus* *Micropterus salmoides*	None	Trawl and Seine
2	0.3	30.0	*Ictiobus bubalus* *Ictalurus punctatus* *Lepomis macrochirus* *Lepomis cyanellus* *Notemigonus crysoleucas* *Gambusia affinis*	*Lepomis cyanellus* *Gambusia affinis*	Seine Drain
3	0.2	35.0	*Lepomis macrochirus* *Lepomis cyanellus* *Ictalurus melas* *Gambusia affinis*	*Gambusia affinis*	Seine

Pond	Surface Area (Acres)	Ammonia Treatment Rate (ppm)	Species Killed	Species Surviving	Method of Checking For Live Fish
4	0.2	40.0	*Cambarus* spp. *Rana* spp. *Palaemonetes kadiakensis*	None	Seine
5	3.0	30.0	*Dorosoma cepedianum* *Pomoxis annularis* *Chaenobrythus gulosus* *Micropterus salmoides* *Lepomis megalotis* *Lepomis microlophus* *Cyprinus carpio* *Notemigonus crysoleucas* *Ictalurus melas* *Lepisosteus osseus* *Anguilla rostrata*	*Lepisosteus osseus*	Seine Rotenone Gill Nets
6	1.2	30.0	*Ictalurus melas* *Lepomis cyanellus*	None	Seine
7	0.4	30.0	*Lepomis cyanellus*	None	Seine
8	0.7	30.0	*Lepomis macrochirus* *Lepomis cyanellus* *Ictalurus melas* *Notemigonus crysoleucas* *Gambusia affinis*	*Gambusia affinis*	Seine

Pond	Surface Area (Acres)	Ammonia Treatment Rate (ppm)	Species Killed	Species Surviving	Method of Checking For Live Fish
9	0.4	20.0	*Ictalurus melas* *Lepomis cyanellus* *Lepomis macrochirus* *Notemigonus crysoleucas* *Gambusia affinis*	*Gambusia affinis*	Seine
10	0.6	20.0	*Pomoxis annularis* *Micropterus salmoides* *Lepomis macrochirus*	None	Drain
11	2.0	20.0	*Ictalurus melas* *Ictalurus natalis* *Notemigonus crysoleucas*	*Ictalurus melas* *Ictalurus natalis* *Notemigonus crysoleucas*	Gill Nets Seine
12	1.2	20.0	*Micropterus salmoides*	*Micropterus salmoides*	Gill Nets Seine
13	0.1	40.0	*Pimephales vigilax* *Gambusia affinis* *Carassius auratus*	None	Drain
14	0.1	13.0	*Carassius auratus* *Notemigonus crysoleucas* *Ictalurus punctatus* *Gambusia affinis*	*Carassius auratus* *Notemigonus crysoleucas* *Gambusia affinis*	Drain
15	0.8	20.0	*Ictalurus melas* *Lepomis cyanellus*	None	Seine

peared to be the long-nosed gar (*Lepisosteus osseus*), the golden shiner (*Notemigonus crysoleucus*), and mosquito fish (*Gambusia affinis*).

Only long-nosed gar appeared to have survived a treatment of 30 ppm in a three-acre pond. Although many gar were killed during the treatment, a set of 600-feet experimental gill net (1- to 3-inch mesh size) caught nine long-nosed gar weighing from ½ to 4 pounds 2 weeks after the treatment. Spot checks with rotenone and numerous seine hauls collected no other fish from this pond.

Mosquito fish populations survived treatments of 30 ppm or lower, but an entire population was killed in a small pond (Pond 13) at a treatment rate of 40 ppm. Generally, populations of macro-invertebrates such as crayfish (*Cambarus* spp.) and fresh water shrimp (*Palaemonetes kadiakensis*) were decimated at higher treatment rates.

All data relative to fish toxicity are summarized in Table 2.

Vegetation

Three of the 15 ponds treated during this study had dense growths of vegetation. Pond 12 had an infestation of *Chara vulgaris and Najas quadalupensis* covering 80 percent of the pond area. Pond 10 had an infestation of *Najar quadalupensis* over 50 percent of the pond area. Pond 1 had an infestation of *Brasenia schreberi* covering 20 percent of the pond area. Within 2 to 4 weeks after the introduction of anhydrous ammonia the vegetation in the above ponds disappeared completely. Six months after treatment, only *Chara* had re-established itself again in Pond 12.

Fertilization

Productivity measurements were not conducted during this segment of the project. However, visual observance of all ponds revealed the development and persistence of dense plankton blooms in all ponds treated during the spring or summer. Normally, the dense blooms appeared within 2 weeks after ammonia treatment and persisted in each pond for 30 days or more. Weekly post-treatment analysis in Pond 1 indicated almost complete decimation of the phytoplankton and zooplankton communities with very slow recovery. Recovery of the plankton populations in this pond could have been delayed by the low winter temperatures following treatment. In the summer (July) following the fall ammonia treatment of Pond 1, there was a three-fold increase in phytoplankton members.

CONCLUSION

The results of the first segment of this study indicate that anhydrous ammonia can be used for fish eradication and also appears to have fertilization and vegetation control qualities. It is an inexpensive, readily available material whch can be easly applied to ponds. Treatment of a pond with anhydrous ammonia drastically alters its ecology. The absence of a persistent residue should allow the pond to return to a productive state.

Data from this segment were insufficient to qualify toxicity levels for a given species. Future experimentation will be directed toward determining: (1) species specificity, (2) physiological effect of ammonia upon fish and other aquatic organisms, and (3) effect upon the benthic and planktonic communities.

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SURVIVAL OF YOUNG OYSTERS IN AREAS OF DIFFERENT SALINITY IN MOBILE BAY

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The oyster drill, *Thais haemastoma,* is the most serious predator of young oysters in Alabama. Mortalities as high as 95 percent have been attributed to drills in some areas (May, 1968). The distribution of *T. haemastoma* within the state is regulated by salinity. It is generally accepted that average salinities in excess of 15 ppt favor drill populations (Chapman, 1959) and that their activity diminishes if salinity is below 10 ppt. (Galtsoff, 1964). Drills are abundant in higher salinity areas of lower Mobile Bay and Mississippi Sound but are restricted or absent in areas of the northern half of the bay with average salinities less than 15 ppt.

Bottom salinities in Mobile Bay were studied by Austin (1954), Nelson (1967) and McPhearson during 1965 and 1966 (in Ryan, 1969). Additional data were gathered by us from 1967 to the present. All these data generally agree that a difference of about 3 to 10 ppt exists between the two areas throughout the year with the salinity in the northern area generally averaging below 15 ppt while the southern area is usually above 20 ppt (figure 1).

During August and September, 1968, oyster shells were planted for cultch in two areas of different salinity in lower Mobile Bay. Survival of spat and young oysters from a September-October set was observed biweekly from September, 1968 through May, 1969 by counting the average number of spat per shell from randomly dredged samples of 25 shells taken from each area.

The high survival of young oysters in the lower salinity areas was attributed to the lack of drills. Over 85 percent of the oysters in the higher salinity area were killed by oyster drills during the 9 month period (figure 2).

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