

THE ARSENIC CONTENT OF WATER, PLANKTON, SOIL AND FISH FROM PONDS TREATED WITH SODIUM ARSENITE FOR WEED CONTROL

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ABSTRACT

Arsenic analyses were made of over 1,000 samples of water, plankton, soil and fish from a 22-acre, a 26-acre, and eight 0.25-acre earthen ponds that were treated with different amounts of sodium arsenite.

The concentrations of arsenic in the waters from the 22- and 26-acre ponds treated with 4.0 p.p.m. As_2O_3 in the fall of 1954 declined to 0.05 p.p.m. As_2O_3 by January, 1955. The concentration of arsenic in the water of the 22-acre pond that was again treated with 4.0 p.p.m. As_2O_3 in April, 1955, declined to 0.8 p.p.m. As_2O_3 one week after application; after this pond was drained and refilled one time during the winter of 1955, no arsenic was found in the water.

Four 0.25-acre ponds received arsenic in 1955. Even after these ponds were drained and refilled three times, considerable amounts of arsenic were retained by the bottom soils and were slowly released into the water each time they were refilled. Six weeks after the third refilling, up to 0.3 p.p.m. As_2O_3 was found in the water and up to 714.3 p.p.m. As_2O_3 on a dry weight basis was found in the plankton.

The 0.25-acre ponds received an application of approximately 4.0 p.p.m. As_2O_3 July 24, 1956. Seventy-two hours after treatment, the arsenic appeared uniformly mixed throughout the water, averaging 4.2 p.p.m. As_2O_3 . The concentration of arsenic declined rapidly to 1.7 p.p.m., and finally to 0.2 p.p.m. As_2O_3 at the termination of the experiment on October 10, 1956.

From July to October, the amount of plankton varied from 5.9 to 10.6 milligrams dry weight per liter. Arsenic content of the plankton from ponds treated with sodium arsenite increased gradually, and after 30 days ranged between 3,690 and 7,200 p.p.m. As_2O_3 of the dry weight; 76 days after treatment the arsenic content ranged between 1,636 and 3,600 p.p.m. As_2O_3 .

The arsenic content in the top inch of bottom soils from arsenic-treated ponds increased gradually, and at the termination of the experiment ranged between 14 and 54 p.p.m. As_2O_3 . As the arsenic in the soil increased, the percentage of arsenic that could be removed by leaching with distilled water also increased.

Fish from each pond were analyzed for arsenic when the concentration in the water had declined to less than 1.0 p.p.m. As_2O_3 . While small amounts of arsenic were found in the digestive tracts of some of the fish, little or no arsenic was detected in the flesh.

INTRODUCTION

The control of filamentous algae and undesirable plants in ponds is a major problem confronting fishery biologists. The presence of these plants in ponds interferes with the harvest of fish, causes overcrowding and stunting of smaller fish, and robs the water of nutrients that could be utilized by the more desirable phytoplankton. In addition, some plants provide breeding places for anopheline mosquitoes, which are vectors of malaria.

Sodium arsenite has been used for many years for aquatic "weed" control. Domogalla (1926) used this chemical to control aquatic vegetation in a recreational area. Surber (1929) was the first to use sodium arsenite as a tool for fisheries management. In his report Surber stated that preliminary experiments with sodium arsenite indicated that this chemical could be used effectively at low cost for the control of submerged aquatic plants without apparent harm to either large or small fish and without seriously diminishing the supply of natural fish food.

Wiebe, Grow and Slaughter (1931), reported that there was no detectable arsenic in hatchery-reared bass, but bass from ponds treated with sodium

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arsenite contained from 0.58 to 0.96 milligrams of As_2O_3 per kilogram of fish (live weight). According to Rosenfels and Crafts (1939), light soils fixed the lowest and heavy soils the highest percentage of a given application of sodium arsenite, while light soils required the least and heavy soils the most arsenic to sterilize them. Kerr (1939) stated that, because of the cumulative effects and slow leaching properties of arsenic, the quantity of arsenic in the soil may remain toxic to soil organisms for years.

Although much work has been done on methods of application of sodium arsenite, rates and times of application, and various techniques required to kill troublesome plants and algae, insufficient information is available on the arsenic content of water, plankton, soil, and fish from such treated areas. In order to obtain such information the following experiments were conducted.

ARSENIC CONTENT OF LARGE PONDS TREATED WITH SODIUM ARSENITE

A modified Gutzeit method of analysis was employed for all arsenic determinations. The Gutzeit generator, roll cotton, lead acetate solution, and mercuric bromide paper were prepared as described in Standard Methods (1955). However, 1:6 hydrochloric acid solution, 2 grams of 20-30 mesh arsenic-free zinc, and 10 ml. of the freshly collected, untreated sample were substituted for the sulfuric acid solution, the 5 grams of zinc, and the concentrated-oxidized sample.

In the fall of 1954, a 22- and a 26-acre pond were treated with sodium arsenite (4.0 p.p.m. As_2O_3). After 24 hours, samples of water collected from the surface and from depths of 2.5, 5.0, and 7.5 feet averaged 2.6 p.p.m. in the 22-acre pond and 3.2 p.p.m. in the 26-acre pond. Sixteen days later the As_2O_3 content of the water in the 22- and 26-acre ponds had dropped to 0.6 and 1.3 p.p.m., respectively. In January, 1955, the arsenic content of the water was 0.05 p.p.m. As_2O_3 in both ponds.

On April 1, 1955, just prior to retreatment with sodium arsenite, of the 22-acre pond for algae control, there was 0.05 p.p.m. As_2O_3 in the surface waters. One day after treatment with approximately 4.0 p.p.m. As_2O_3 the water contained 3.0 p.p.m. As_2O_3 . This arsenic concentration dropped rapidly, and one week after treatment was 0.8 p.p.m. As_2O_3 . However, on August 15 (4.5 months after treatment), the arsenic content of the surface water was still 0.15 p.p.m. As_2O_3 . This pond was drained and refilled during the fall. On January 25, 1956, no arsenic was detected in the pond water.

ARSENIC CONTENT IN SMALL PONDS TREATED WITH SODIUM ARSENITE

In the summer of 1956, determinations were made of the arsenic in water, plankton, soil, and fish taken from eight 0.25-acre earthen ponds. Four of these eight ponds received applications of sodium arsenite in 1955. Prior to the 1956 application of sodium arsenite, the As_2O_3 content of the water, plankton, and soil from the treated ponds that were drained and refilled two times, and from ponds that had been drained and refilled three times ranged from 0.0 to 0.3 p.p.m. in the water, from 0.0 to 714.3 p.p.m. in the plankton, and from 0.0 to 38.0 p.p.m. in the soil (Table I).

TABLE I
THE CONTENT OF ARSENIC IN WATER, PLANKTON, AND SOIL 24 HOURS PRIOR TO THE 1956 TREATMENT WITH SODIUM ARSENITE

No. of Pond	1955 As_2O_3 Treatment p.p.m.	No. of Times Pond Drained and Filled between 1955 and 1956 Experiments	As_2O_3 Concentration 6 Weeks after Refilling in 1956 (p.p.m.)			
			Water	Plankton	Bottom Soil at Water Depth	
					2 Ft.	4 Ft.
F-14	8	2	0.0	0.0	0.0	0.0
F-21	8	3	0.3	62.7	T	4.0
F-15	16	2	0.1	714.3	2.0	38.0
F-20	16	3	0.3	352.4	0.0	20.0

Following the draining at the end of the 1955 experiments, F-14 and F-15 were refilled with water, allowed to stand for three months, and then drained. They remained empty for four months, and then were filled in May for the 1956 experiments. These ponds were thus drained and refilled two times between the 1955 and the 1956 arsenic treatments.

Two other ponds, F-20 and F-21, were drained and refilled in the fall of 1955, allowed to stand for three months, again drained and refilled. These ponds were then stocked with minnows, fed with cereal meals for four months and then drained. They were refilled in May for the 1956 experiments. These ponds were thus drained and refilled three times between the 1955 and 1956 arsenic treatments.

It was evident that in these ponds treated with sodium arsenite a considerable amount of arsenic was held in the bottom soils and, except for one pond, the arsenic was not entirely removed by draining and refilling the ponds as much as three times in a seven-month period. Following refilling for the second or third time, arsenic from the pond bottom was released into the water and, as will be discussed later, was subsequently taken up in considerable quantities by the plankton.

Prior to the 1956 application of sodium arsenite, these ponds were stocked with bluegill sunfish and fertilized according to recommended rates and procedures (Swingle and Smith, 1947).

ARSENIC CONTENT OF WATER FOLLOWING THE 1956 TREATMENT WITH SODIUM ARSENITE

The ponds were treated with an estimated 4.0 p.p.m. As_2O_3 July 24, 1956. This sodium arsenite was applied from a drum with an attached valve-hose arrangement as described by Lawrence (1958). The average arsenic concentration in the surface waters (24 hours after treatment with sodium arsenite) was 5.2 p.p.m. As_2O_3 , whereas at 4 feet it was 1.5 p.p.m. As_2O_3 . Seventy-two hours after treatment the arsenic appeared uniformly mixed throughout the upper 4 feet of pond water, and averaged 4.2 p.p.m. As_2O_3 .

The concentrations of arsenic in the waters declined gradually, and within 30 days after treatment averaged 2.0 p.p.m. As_2O_3 (Table II). At the termination of the experience on October 10, 1956, the arsenic concentrations of all treated ponds ranged from 0.2 to 1.7 p.p.m. As_2O_3 .

No arsenic was found in the water from the ponds that did not receive arsenic treatments in either 1955 or 1956.

From the analyses during the 1956 test period, it was found that, with one exception, there was much similarity in the arsenic content of the waters from ponds that received approximately 8.0 and 16.0 p.p.m. As_2O_3 in 1955 and from ponds that were drained and refilled two to three times between the two test periods. The water from Pond F-20 (Table II) that received 16.0 p.p.m. As_2O_3 in 1955, and 4.0 p.p.m. As_2O_3 in 1956 and which had been drained and refilled three times prior to the 1956 treatments averaged two times the arsenic concentrations of the companion pond (F-15, Table II). The increase in soluble arsenic may have resulted from organic acids released by decay of cereal meals used as feed for fish from January through April of 1956.

ARSENIC CONTENT OF PLANKTON FOLLOWING THE 1956 TREATMENT WITH SODIUM ARSENITE

The average production of plankton from July to October in all the ponds ranged between 5.9 and 10.6 milligrams dry weight per liter. The highest plankton productions, 10.4 and 10.6 milligrams, were found in the ponds that were not treated in 1955, but received 4.0 p.p.m. As_2O_3 in 1956. In ponds that received treatments of arsenic in both 1955 and 1956, the average plankton production ranged from 5.9 to 7.9 milligrams, while in the check ponds that received no arsenic in either year the average plankton production was 7.8 and 9.6 milligrams.

In Ponds F-9 and F-10 that were untreated in 1955 but treated with 4.0 p.p.m. As_2O_3 in 1956, the arsenic concentrations in the plankton reached a peak of 6,955 p.p.m. As_2O_3 within 27 days after treatment and slowly declined to 2,172 p.p.m. (Table II). The arsenic concentrations in the plankton from Ponds F-14 and

TABLE II
THE CONTENT OF ARSENIC IN WATER, PLANKTON AND SOIL FROM PONDS TREATED WITH SODIUM ARSENITE IN 1955 AND 1956

Pond	1955 Treatment		1956 Treatment		As ₂ O ₃ Content of Water		Peak As ₂ O ₃ Content of Plankton	Number of Days after Treatment	As ₂ O ₃ Content at Termination of the Experiment		As ₂ O ₃ Content of Soil at Termination of the Experiment
	As ₂ O ₃ p.p.m.	As ₂ O ₃ p.p.m.	As ₂ O ₃ p.p.m.	As ₂ O ₃ p.p.m.	30 Days after Treatment	72 Days after Treatment			p.p.m.	p.p.m.	
F-9	0.0	4.0	1.9	0.5	6,955	27	2,172	17.2	25.2		
F-10	0.0	4.0	2.1	0.5	4,321	33	1,635	22.0	13.8		
F-14	8.0	4.0	2.0	0.2	5,555	27	2,981	45.5	21.5		
F-21	8.0	4.0	1.9	1.0	8,200	41	2,048	43.6	34.7		
F-15	16.0	4.0	1.5	0.4	5,610	39	3,372	54.0	25.5		
F-20	16.0	4.0	2.8	1.7	7,487	60	3,600	34.0	24.5		

F-21 that received 8.0 p.p.m. As_2O_3 in 1955, and 4.0 p.p.m. As_2O_3 in 1956, reached a peak of 8,200 p.p.m. As_2O_3 within 41 days after treatment, and slowly declined to 2,048 p.p.m. The arsenic concentrations in the plankton from the ponds F-15 and F-20 that received 16.0 p.p.m. As_2O_3 in 1955, and 4.0 p.p.m. As_2O_3 in 1956, reached a peak of 7,487 p.p.m. As_2O_3 60 days after treatment and then slowly declined to 3,600 p.p.m.

Only a trace of arsenic was detected in the plankton from ponds that were not treated with arsenic in 1955 and 1956.

ARSENIC CONTENT OF SOILS FOLLOWING THE 1956 TREATMENT WITH SODIUM ARSENITE

The arsenic concentrations are expressed as p.p.m. As_2O_3 on dry weight basis in the top 1 inch of soil at the 2-foot and the 4-foot depths of water. The samples of soil were air-dried in the laboratory and then pulverized. One weight of soil was leached with 10 weights of distilled water followed by three 10 weight leachings with 10 percent hydrochloric acid. These four leachings were analyzed separately. After sodium arsenite was applied in 1956 the content of arsenic increased gradually, and at the termination of the experiment it ranged between 13.8 and 54.0 p.p.m. (Table II). This increase of arsenic was about two times as great at the 2-foot depth as at the 4-foot depth of water.

The average arsenic in the soils from ponds treated only in 1956 averaged 14.2 p.p.m. As_2O_3 .

As the concentration of arsenic in the soil increased, the percentage that could be removed by leaching with distilled water increased. Distilled water leachings of soils containing less than 15.0 p.p.m. As_2O_3 yielded undetectible or only a trace of arsenic, whereas leaching of soils containing 50 or more p.p.m. As_2O_3 yielded 3 or more p.p.m. As_2O_3 .

Analyses of soil samples taken from July to October, 1956, indicated that the amount of arsenic in the soil was proportional to the amount of sodium arsenite that had been applied in 1955 and 1956. The arsenic that was leached from soils in ponds that received various amounts of arsenic were as follows:

Total p.p.m. As_2O_3 added as sodium arsenite in 1955 and 1956	Total p.p.m. As_2O_3 leached from bottom soils
4.0	14.2
12.0	26.7
20.0	29.3

No arsenic was found in the extract of soils from the ponds that were not treated with arsenic in either 1955 or 1956.

ARSENIC CONTENT OF FISH FOLLOWING THE 1956 TREATMENT WITH SODIUM ARSENITE

The bluegill sunfish that were analyzed for arsenic were recovered by seining when the As_2O_3 concentration in the pond water had declined to less than 1.0 p.p.m. The arsenic in the contents of the digestive tract of bluegills from the treated ponds ranged from 2.1 to 6.6 p.p.m. As_2O_3 (wet weight). However, no detectible arsenic or only a trace amount of arsenic was found in the tissue of the digestive tract, liver or muscle. Fish from untreated ponds contained no detectible arsenic.

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A COMPARISON OF SPAWNING ENVIRONMENTS FOR THE CHANNEL CATFISH, "*ICTALURUS PUNCTATUS*" (RAFINESQUE)

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ABSTRACT

During the spawning seasons of 1958 and 1959 an experiment was conducted to compare the spawning success of channel catfish in three types of environments. The environments employed included a 0.6-acre pond, 16 concrete block holding pens 6 feet wide, 12 feet long and up to 3½ feet deep, and six aquaria of 50 gallon capacity along with four concrete holding house tanks.

The spawning fish were from three to four years old and were in what was considered to be average flesh. The highest percentage of spawning fish was noted in the pond environment both years. Spawning success was noticeably less in the spawning pens and was lowest in the aquaria or holding tanks. A few fish in the pens were injected with a hormone preparation, chorionic gonadotropin, while all fish held in the aquaria or holding tanks were treated with either fish pituitary or chorionic gonadotropin injections.

Results of the experiment indicated that the least restrictive environment gave the highest percentage of spawning success for the brood stock employed. Also, hormone injections during the spawning season did not appear to be a substitute for the development of a brood stock of mature, well-fed and healthy fish prior to spawning time.

INTRODUCTION

Interest in the channel catfish, *Ictalurus punctatus* (Rafinesque), as a sport and food fish has increased greatly in recent years. Long a popular fish in west-central states and in the southwest, the species has caught the attention of fish culturists in the southeast of late. Swingle (1958) and Prather (1959) have pointed to some of the possibilities of channel catfish as a commercial species or as a combination sport and commercial fish. Johnson (1959) states that in ricefield culture of fresh-water fishes, the channel catfish is in the greatest demand and commands the highest price of any species being cultured in these waters.

Methods of propagating the channel catfish have been known to fish culturists for more than thirty years (Doze, 1925). Since this early description of propagation, other workers have described findings that contributed to the development of hatchery techniques of propagating channel catfish (Clapp, 1929; Mobley, 1931; Morris, 1939; Lenz, 1947, and Toole, 1951). While differing as to details, these workers followed a basic concept of pairing spawning fish either in a spawning pond or a spawning pen to obtain eggs which were then incubated by the fish or by a mechanical device.

Only recently have there been new developments in improving spawning techniques for channel catfish. Clemens and Sneed (1957) were successful in spawning channel catfish under controlled conditions in glass aquaria by the