IDENTIFICATION OF THE WATER QUALITY FACTORS WHICH PREVENT FINGERNAIL CLAMS FROM RECOLONIZING THE ILLINOIS RIVER

PHASE II

by

Richard E. Sparks and Michael J. Sandusky
ILLINOIS NATURAL HISTORY SURVEY
RIVER RESEARCH LABORABORY
Havana, Illinois 62644

and

Anthony A. Paparo
SCHOOL OF MEDICINE AND DEPARTMENT OF ZOOLOGY
SOUTHERN ILLINOIS UNIVERSITY
Carbondale, Illinois 62901

TECHNICAL COMPLETION REPORT

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ABSTRACT

Water samples taken from the Illinois River on 5 October and 22 April 1977 inhibited the beating of the cilia on isolated clam gills, within two hours of exposure. The April sample was significantly more toxic than the October sample. Sediment taken on 14 December 1970 from Quiver Lake, a bottomland lake which receives sediment from the Illinois River and where fingernail clams were abundant prior to a die-off in 1955-58, was toxic to isolated clam gills. A sediment layer from the 2.6-5.1 cm depth showed the greatest toxicity, the 0-2.5 cm depth the next greatest toxicity, and deeper layers showed significantly less toxicity. From 3 April to 8 May 1980, intact fingernail clams were exposed to raw Illinois River water (containing suspended sediment), clean well water, and raw river water subjected to three treatments: (a) sand filtration (b) sand filtration + carbon filtration (c) sand filtration + clinoptilolite filtration. After two weeks of exposure, clams in raw river water suffered significantly greater mortality (42.5%) than other clams. After six weeks of exposure, 62.5% of the clams in raw river water had died, the next highest mortality (47.5%) occurred in sand-filtered water, and mortality in the other two treatments did not differ significantly from the well-water controls (24% mortality). The clams probably survived better in the treated water for two reasons: (1) clinoptilolite and carbon each removed ammonia, which is found in Illinois River water and which is toxic to fingernail clams (2) the additional physical filtration provided by the charcoal and clinoptilolite removed additional sediment, which contains unidentified toxic factors. Surviving clams grew better in river water and treated river water than in clean well water, probably because they fed upon fine organic matter which passed through the filters. The latter results indicate that the unidentified toxic factor acts directly on the clams, rather than indirectly by affecting their food supply. The rapid assay, using fingernail clam gills, and the deletion bioassay, where toxic components are selectively removed from raw water samples and the corresponding reduction in toxicity measured, are promising means of identifying effective treatments for complex wastes and polluted streams.

Sparks, Richard E., Michael J. Sandusky and Anthony A. Paparo

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Technical Completion Report to Office of Water Research and Technology, Department of the Interior, March 1981

KEYWORDS--water pollution effects/ bioassay/ bioindicators/ animal physiology/ fingernail clams/ Sphaerium transversum/ Musculium transversum/ Sphaeriidae/ silt/ ammonia/ suspended solids/ suspended sediment/ Keokuk Pool/ Mississippi River/ Illinois River/ pollutant identification/ toxicity/ clams/ mussels/ mollusks/ bivalves/ water pollution treatment/ water quality/ zeolites/ clinoptilolite/ activated carbon/ filtration/ pollution abatement/ sediment/ water pollution sources/ food webs/ limiting factors/ secondary productivity/ aquatic productivity/ assay

INTRODUCTION AND BACKGROUND

Richardson (1921, 1928) conducted surveys of the bottom fauna in the Illinois River and found that fingernail clams and snails were abundant or common in a 180-mile section of the river between the mouth and the upper end of Peoria Lake (Figure 1) during the years 1913-1915. The clam population declined after 1915 from river miles 80.1 to 180.5 (river miles are measured upstream from the confluence with the Mississippi River) as a result of the increased sewage pollution from the Chicago Sanitary and Ship Canal which opened January 1, 1900, and diverted Chicago sewage from Lake Michigan to the Illinois River. Degradation of the bottom progressed downstream at a rate of 8 to 16 miles per year (Richardson 1921). The bottom fauna exhibited a recovery pattern from 1920 to 1925 (Richardson 1921, 1928), probably in response to the installation of sewage and industrial waste treatment facilities in the Illinois Valley.

After 1925 there is a gap in bottom fauna data until a 1964 survey by Starrett and Paloumpis (1964). Starrett and Paloumpis found no fingernail clams in the Illinois River above Beardstown (river mile 86.9), so the clams had died out in a 100-mile section of the river sometime between 1925 and 1964. Anderson (1977) surveyed the bottom fauna in the Illinois River in 1975. Distribution of fingernail clams in the Illinois River in 1975 was essentially the same as it was in 1964. However, there appeared to have been a drastic decrease or loss of snails in the lower Illinois River. Although Starrett and Paloumpis (1964) found no snails above Beardstown, they reported an average of $34/m^2$ from Beardstown to Grafton; no snails were collected in the 1975 study.

There are three lines of evidence indicating that the die-off of fingernail clams occurred in the 1950's. Paloumpis and Starrett (1960) observed a die-off of fingernail clams in three Illinois River bottomland lakes in the 1950's. To use Quiver Lake as an example: in 1952, sphaeriid clams, mainly *Musculium transversum*, occurred in numbers exceeding $20,000/m^2$. During the next four years, 1953-1956, populations of fingernail clams and certain snails declined to zero. A slight recovery occurred in the following

two years. However, in 1973, Sparks (unpublished data in the files of the Illinois Natural History Survey) found no sphaeriids, snails, or aquatic insects in Quiver Lake at the same stations.

A second line of evidence pointing to a 1950's die-off of benthic organisms is the abrupt decline in utilization of the Illinois Valley by lesser scaup ducks, which are one of the groups of diving ducks which feed on fingernail clams and snails (see Figure 2). Figure 2 shows that lesser scaup utilization of the Mississippi River, where fingernail clams are still common, showed a less severe decline in the 1950's than occurred in the Illinois Valley, followed by a recovery. Diving duck utilization of the Illinois River has never recovered to pre-1955 levels, indicating that fingernail clam populations have never recovered, since the diving ducks are quick to locate and utilize beds of clams.

The third line of evidence comes from an examination of fish stomachs by Paloumpis and Starrett in the 1960's. Fingernail clams are a favorite food of carp and other bottom-feeding fish, and the fish can often locate and feed upon beds of clams which go undetected by a biologist. Fingernail clams formed 50.2% by volume of the food items taken by carp collected below Beardstown, but no clams were found in carp collected above Beardstown (Starrett 1972). The clams had evidently died out in the Illinois River above Beardstown prior to the 1960's.

Although Anderson (1977) did not take any fingernail clams above mile 107 in 1975, other studies have shown that fingernail clams still occur in tributaries and in isolated pockets in the Illinois River. Biologists from the Metropolitan Sanitary District of Greater Chicago collected fingernail clams in the Calumet River and in the Chicago River and its south branch in 1975 (Metropolitan Sanitary District of Greater Chicago 1978). All locations were fairly close to inlets from Lake Michigan. Fingernail clams occur in the Des Plaines River above the entrance of the Chicago Sanitary and Ship Canal (personal communication, 1 June 1977. Mr. Thomas A. Butts, Illinois State Water Survey, Peoria, Illinois), and fingernail clams are regularly impinged on the intake screens at the R.S. Wallace Power Station located at river mile 162.5 on Lower Peoria Lake (personal communication, 1 June 1977, Mr. Guy R. McConnell, WAPORA, Inc.,

Charleston, Illinois). The fingernail clams taken at the power plant may have washed downstream from populations which managed to survive in areas of Peoria Lake where spring water enters through the river bottom. There are several areas in Peoria Lake, such as the vicinity of Spring Bay (miles 173.0-180.0), where spring water is known to enter the lake. Starrett (1971) found, during a mussel survey in 1966, that in this region of Peoria Lake there was an increase in the dissolved oxygen (2.0-6.0 mg/l dissolved oxygen) and a corresponding increase in the number of mussels collected. Between June and November, 1973, biologists from the environment consulting firm, WAPORA, took 1 fingernail clam in 21 Ponar dredge samples near Hennepin (mile 212.0) and 9 fingernail clams in 21 Ponar dredge samples near Havana (mile 118.6) (WAPORA 1974). The Illinois Natural History Survey has also collected fingernail clams in Quiver Creek, a tributary of the Illinois River near Havana. In the reach of the Illinois River from mile 89.0 to mile 145.3, which includes the Havana region, a bedrock valley overlain with sand deposits lies to the east of the Illinois River. Groundwater flows through the sand into the Illinois River at the rate of about 8.75 m^3/s (309 cfs) during low-flow conditions (Singh and Stall 1973). The good quality groundwater flowing into the river along the sandy eastern bluffs may make some areas marginally suitable for fingernail clams. However, the clams apparently are still not abundant enough here or in Peoria Lake to attract and hold large flocks of diving ducks (personal communication, 1 June 1977, Mr. Robert Crompton, Wildlife Field Assistant, Illinois Natural History Survey).

Since fingernail clams go through an entire life cycle in 33 days (Gale 1969), they are capable of quickly repopulating an area from which they have been eliminated. There is some factor in the Illinois River which currently prevents recolonization of the river from the residual populations remaining in Peoria Lake and the tributary streams.

The same unknown factor which is affecting fingernail clams in the Illinois River, may also be affecting clams in other Midwestern rivers. For example, the Illinois Natural History Survey documented a decline in the population and growth rate of fingernail clams in the Keokuk Pool, Mississippi River in 1976 and 1977. The reduction in the population of fingernail clams apparently had an impact on diving duck use of Keokuk Pool, since there was a 49% decrease in the peak population

of .34 mg/l (as un-ionized ammonia nitrogen, NH_3-N), which do occur occasionally in the upper reaches of the Illinois River.

The research described in this report is a follow-up to the earlier work. We completed the following tasks: (1) development of improved methods for maintaining fingernail clams in the laboratory; (2) determination of toxicity to clam gills of different layers of sediment from the Illinois River; (3) determination of effects of raw Illinois River water and sediment on intact clams; and (4) determination of effects on intact clams of raw Illinois River water treated to remove certain components, including ammonia and sediment. The following project objectives were <u>not</u> achieved: (1) analysis of shells and tissues of clams exposed to treated and untreated river water by microprobe techniques; (2) analysis of treated and untreated river water by x-ray diffraction; (3) testing of the effects of treated river water on clam gills; and (4) identification of the toxic factor in Illinois River water and sediment, which prevents fingernail clams from recolonizing portions of the river where they were formerly abundant.

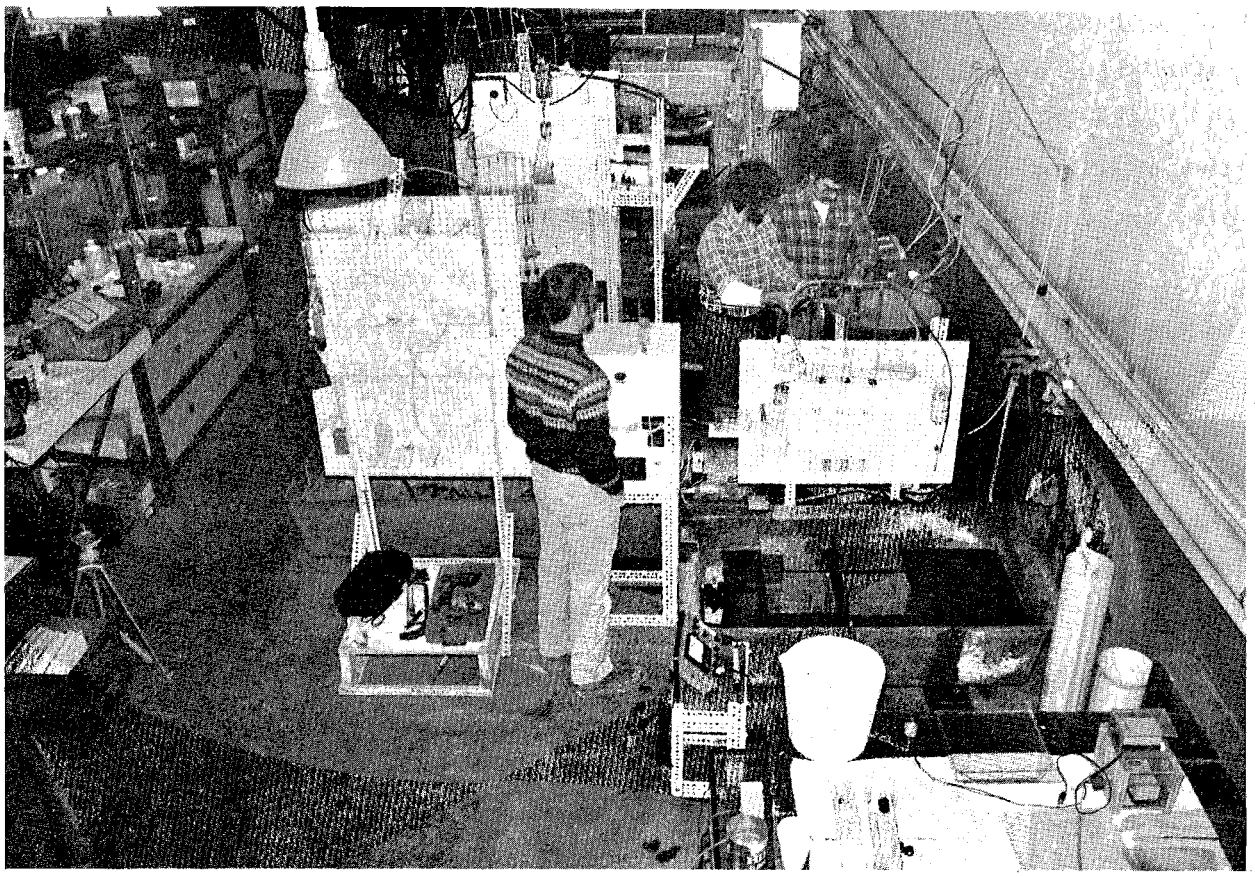

Figure 3. Bioassay Laboratory. The proportional diluter (right) supplied well water and algae to the stock aquaria.

A small sample of mud from the aquarium was passed through a 30-mesh sieve to separate organisms. Twenty small clams (*Musculium transversum*, 2-3 mm in shell length) were separated from detritus and other organisms under a microscope and placed in a 100-mm petri dish. Two petri dishes, containing 20 clams each, were placed on top of the mud in the stock tank, and removed at 2-week intervals to measure the shells and count the number of live clams.

dishes containing clams and sieved sediment were placed in bare aquaria containing no other clams or sediment, following a suggestion by Gale (1972:22) that the decomposing remains of dead clams may induce a resting state (no growth) in live clams kept in the same container.

Water temperatures and dissolved oxygen concentrations in the stock aquaria were measured 5 times a week, pH 2 or 3 times per week, and alkalinity once a week. Results are reported in Table 1.

ADDITION BIOASSAYS, USING CLAM GILLS

During Phase I of this project, water samples from the Illinois River and sediment samples from an adjacent backwater lake connected to the river were collected and tested on fingernail clam gills. Not all the results had been analyzed and graphed at the time the Phase I Report was prepared (Anderson et al. 1978), so the methods and results are presented in this report. Since sediment or river water were added to clean water, these tests are called *addition bioassays*.

Sediment

On 14 December 1976 a sediment core was taken from Quiver Lake, which opens into the Illinois River at Havana. Quiver Lake was the location where Paloumpis and Starrett (1960) documented a die-off of fingernail clams in 1955-58, and where Sparks failed to find any live clams in 1973. The core was extruded from the 10-cm diameter steel corer onto a plastic tray, and divided into the following segments: (1) surface to 2.5 cm depth (2) 2.6-5.1 cm depth (3) 5.2-7.6 cm depth (4) 7.7-10.2 cm depth. Each segment of the core was placed in a separate jar and shipped to Southern Illinois University for testing. At Southern Illinois University, the core segments were stored overnight in a refrigerator, warmed to room temperature the next day, and used immediately. Equal volumes of wet mud from each core segment were placed in 1 liter of invertebrate physiological solution, making four test solutions in all. After the effects on the clam gills were determined, a measured volume of test solution was passed through a membrane filter, air dried, and weighed. The sediment concentration (in mg per liter) was then calculated. The average particle size was measured under

screen of the pump. The pump was capable of grinding up and passing 3.8-cm solids, but the protective intake screen was approximately 1-cm mesh. A small pump circulated the water in the reservoir, to keep the sediments from settling out, and supplied a head box which delivered water by gravity flow to the test chambers and treatment systems described below. All parts of the delivery water system were made out of nontoxic materials, including glass, polyethylene, teflon, nylon and silicone rubber. The only exception was the metal impeller of the pump, but analyses by atomic absorption and flame emission spectroscopy showed no differences in metal concentrations between water samples taken simultaneously at the intake and in the reservoir.

Figure 4 shows how the raw river water was treated to *remove* certain components, hence these tests are called *deletion bioassays*.

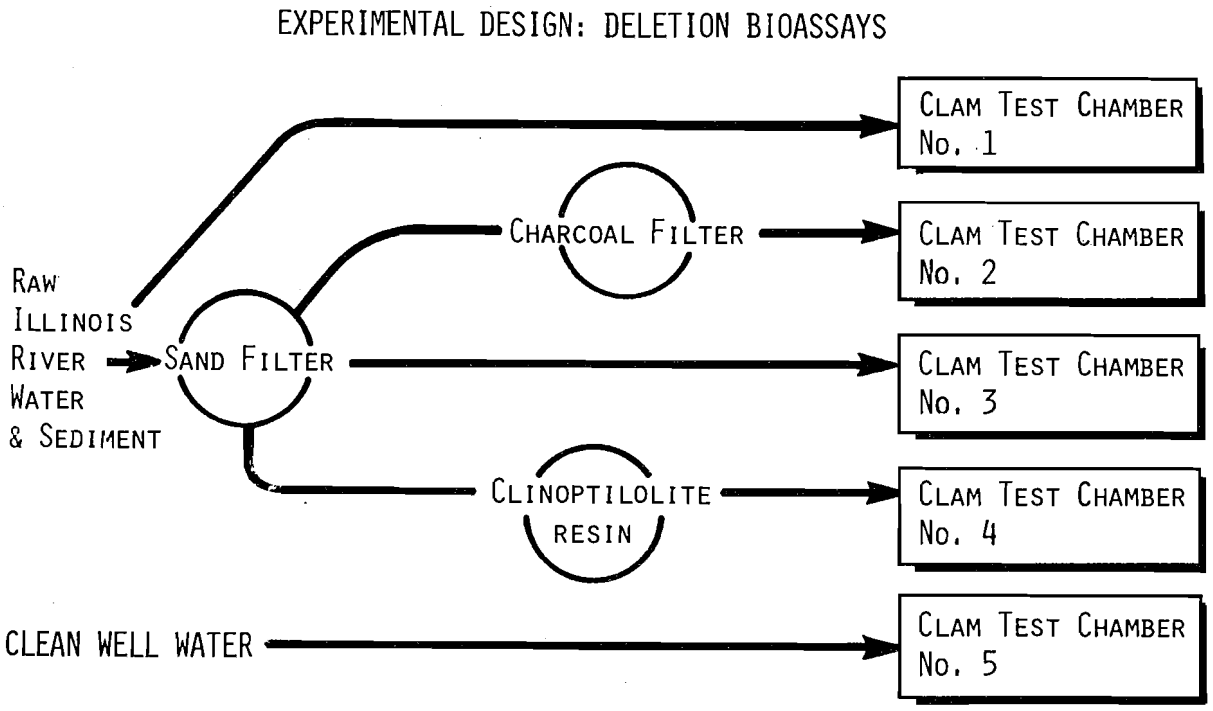

Figure 4. Schematic Diagram of Deletion Bioassay.

The outlet at the bottom of each garbage can was covered with plastic screen and a pad of fiberglass in the bottom of the can kept the media from plugging the outlet. Sand, charcoal, or clino was added next, and covered with another pad of fiberglass which could be removed easily and washed. Water flowed by gravity from the constant head box to the sand filter, then to the other filters or test chambers.

The test chambers were 37.8-liter glass aquaria with outlets to maintain the volume at 23 liters. The test chambers were immersed in a water bath to control water temperature. Water flow from the deletion apparatus into the test chambers was approximately 100 ml per minute and was checked 3 times a day. Sediment occasionally clogged the delivery tubes overnight, but because of the large volume of the test chambers in relation to the small size and oxygen requirements of the clams, oxygen levels in the test chambers did not decline. The maximum length of time the flows could have stopped was 12 hours, and we do not feel that these infrequent stoppages had any effects on the results of our deletion bioassays, which lasted 3-6 weeks.

During deletion bioassay number 1, a 50-ml pipette was used to deliver the concentrated algal suspension to each test chamber twice a day. However, high concentrations of algae could not be maintained in the test chambers with pipette feeding. An automatic feeding system (separate from the one used on the stock aquaria) delivered 100 ml of algal suspension to each test chamber every 5 minutes during deletion bioassay number 2. Algal concentrations were measured by procedures described in Standard Methods (American Public Health Association 1976:1024-26).

Clams from stocks number 8 (collected 21 June 1979) and 11 (collected 20 March 1980) were used in deletion bioassays 1 and 2, respectively. The procedures were the same as in the culture tests: (1) each test chamber held 2 petri dishes containing 20 clams each (for a total of 40 clams exposed to each test solution), (2) the clams were 2.4 to 3.0 mm in shell length, (3) clam survival and growth were checked at 2-week intervals, and (4) sieved sediment collected from the Mississippi River on the same date the clams were collected was added to the petri dishes at the beginning of the bioassay and at 2-week intervals thereafter.

Water temperatures and dissolved oxygen concentrations in the test chambers were measured 5 times a week, pH 2 or 3 times per week, and alkalinity

RESULTS AND DISCUSSION

RESULTS OF DIFFERENT CULTURE TECHNIQUES

Water chemistry and temperature in the stock aquaria are given in Table 1.

Clam Mortality

Clam stocks 7-11 maintained during this phase of the research had lower mortalities after 2 and 4 weeks in the laboratory than stocks 1-6 maintained during Phase I (Figures 6 and 7). The confidence limits

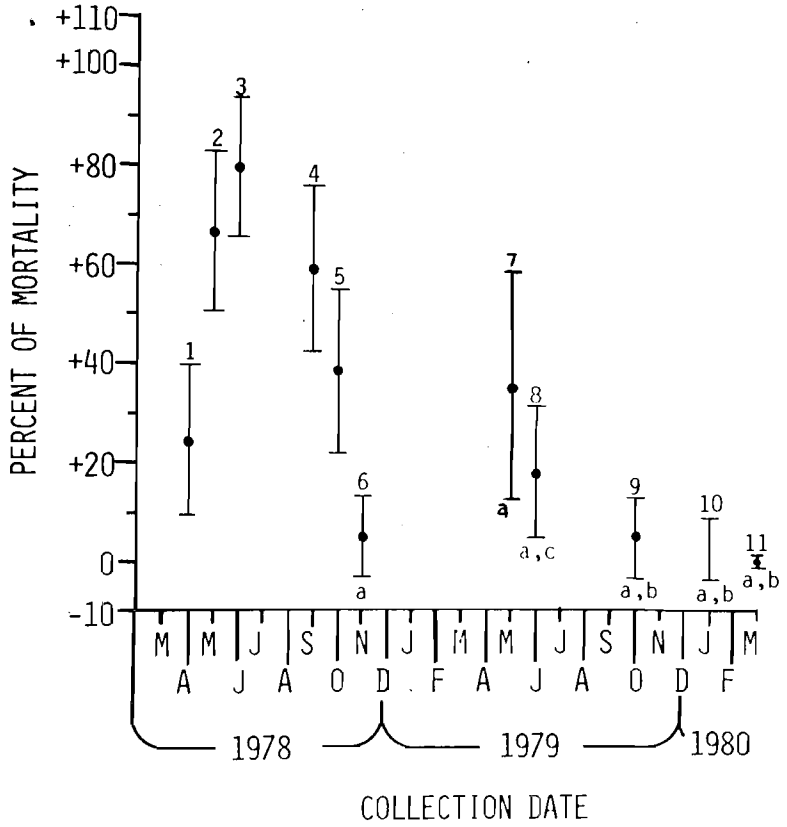

Figure 6. Stock Clam Mortality at Two Weeks. Brackets indicate 95% confidence limits. [a]Mississippi River silt added. [b]Algae added automatically every five minutes. [c]Algae added by pipette twice a day.

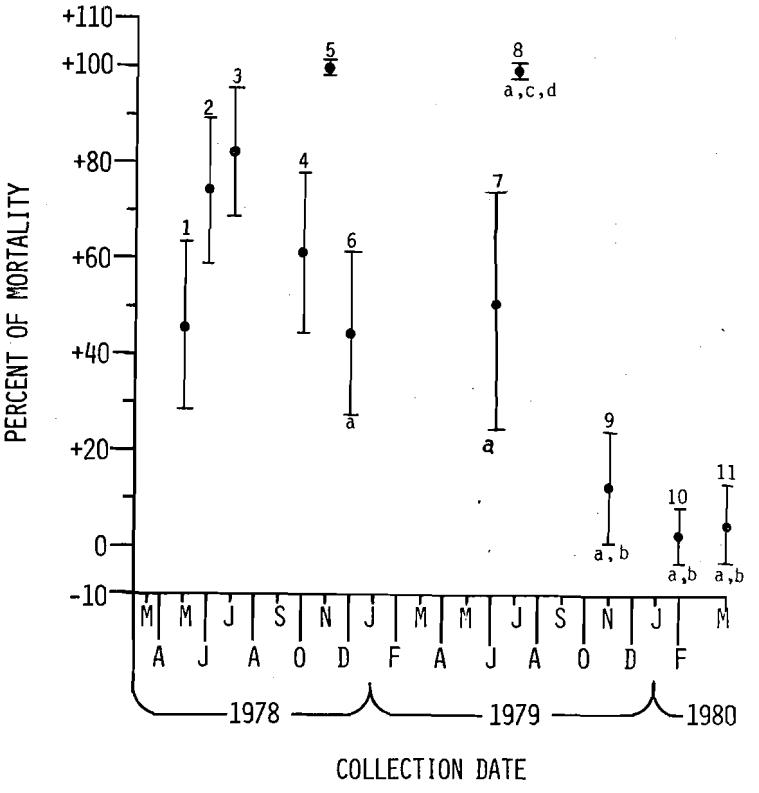

Figure 7. Stock Clam Mortality at Four Weeks. [a]Mississippi River silt added. [b]Algae added automatically every five minutes. [c]Algae added by pipette twice a day. [d]Clams affected by stoppage of water flow and aeration during a power failure which occurred between the 2-week and 4-week check.

for stock 7 were much wider than for the other stocks, because of the small initial sample size (20 clams in stock 7, 40 in the others), necessitated by the paucity of small clams in the bottom samples obtained from the Mississippi River on 4 June 1979.

Addition of Mississippi River silt to the petri dishes, starting with stock 6, improved clam survival, and automatic feeding of algal suspensions, starting with stock 9, further improved survival (Figures 6

TABLE 2

Growth and Survival of Stocks of Fingernail Clams*

	No. Alive	Mean Shell Length (mm)	Variance	Standard Deviation	Range (mm)	Mean Growth Increment (mm)
Stock 7[1] Collected 06/04/79						
Initial	20	2.5	0.04	0.20	2.2-2.9	--
2 Weeks	13	2.7	0.06	0.24	2.2-3.0	0.2
4 Weeks	10	2.7	0.05	0.22	2.2-3.0	--
Stock 8[1,3] Collected 06/21/79						
Initial	40	2.7	0.02	0.14	2.4-2.9	--
2 Weeks	32	2.8	0.01	0.07	2.6-2.9	0.1
4 Weeks	--	--	--	--	--	--
Stock 9[2] Collected 10/23/79						
Initial	40	2.5	0.01	0.11	2.3-2.7	--
2 Weeks	38	2.6	0.01	0.11	2.4-2.8	0.1
4 Weeks	34	2.6	0.02	0.15	2.4-2.9	--
Stock 10[2] Collected 01/03/80						
Initial	40	2.6	0.0246	0.1568	2.4-3.1	--
2 Weeks	39	2.8	0.0584	0.2416	2.5-3.6	0.2
4 Weeks	39	2.8	0.0685	0.2618	2.5-3.6	--
Stock 11[2] Collected 03/20/80						
Initial	40	2.4	0.0067	0.0821	2.3-2.6	--
2 Weeks	40	2.7	0.0270	0.1642	2.4-3.0	0.3
4 Weeks	38	2.7	0.0268	0.1638	2.4-3.0	--

*all stocks were maintained in silt
[1]algae delivered by pipette
[2]algae delivered automatically every 5 minutes
[3]electrical failure terminated test after 2 weeks

The size (μm), weight (mg/l) and particle concentration (particles/l x 10^6) for each sediment layer, following dilution to make up a test solution, are given below (mean ± standard deviation):

Layer	Size	Weight	Particle Concentration
0.0-2.5 cm	5.3 ± 1.2	53.8 ± 8.2	2.8 ± 0.9
2.6-5.1 cm	2.8 ± 0.9	44.1 ± 6.7	5.1 ± 1.9
5.2-7.6 cm	4.5 ± 1.1	61.2 ± 11.2	3.8 ± 1.2
7.7-10.2 cm	3.8 ± 0.9	78.1 ± 9.8	4.5 ± 0.6

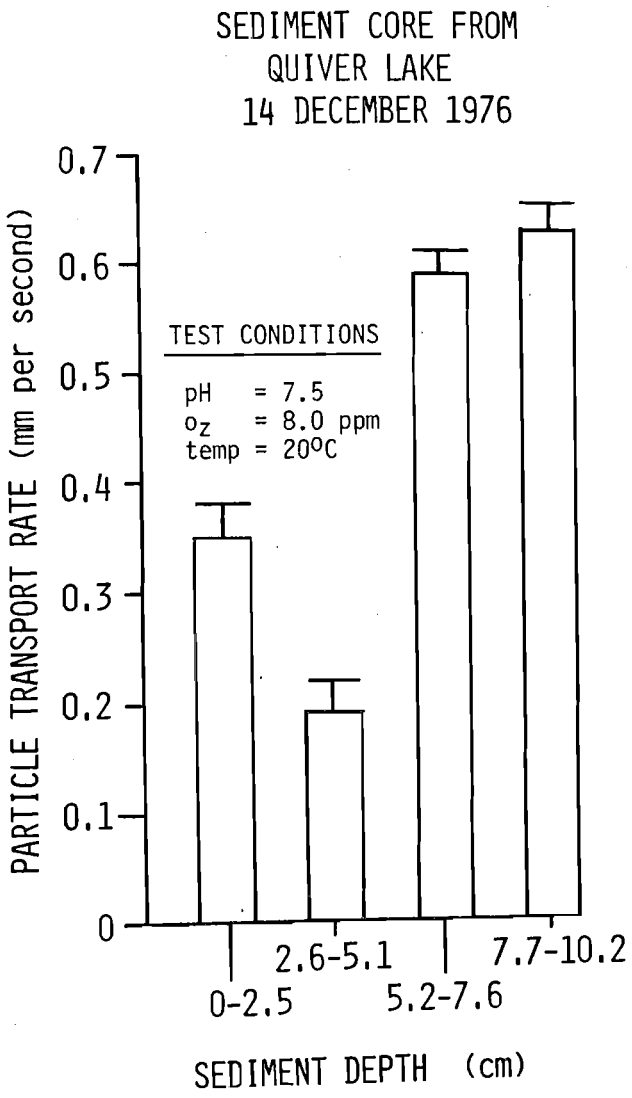

Figure 8. Response of Clam Gills to Four Layers of Sediment from Quiver Lake, Illinois River.

that the degree of inhibition differed significantly between water samples taken on different dates (Figure 9), because the input of toxicant to the river could vary; the volume of flow in the river (hence the dilution) varies; and physical/chemical factors, such as toxicant absorption or desorption from sediment, may vary.

DELETION BIOASSAYS, USING INTACT CLAMS

Deletion Bioassay Number 1

Deletion bioassay number 1 started on 29 June 1979. Water levels in the Illinois River during the bioassay are shown in Figure 10 and the water chemistry and temperature in Table 3. The test terminated

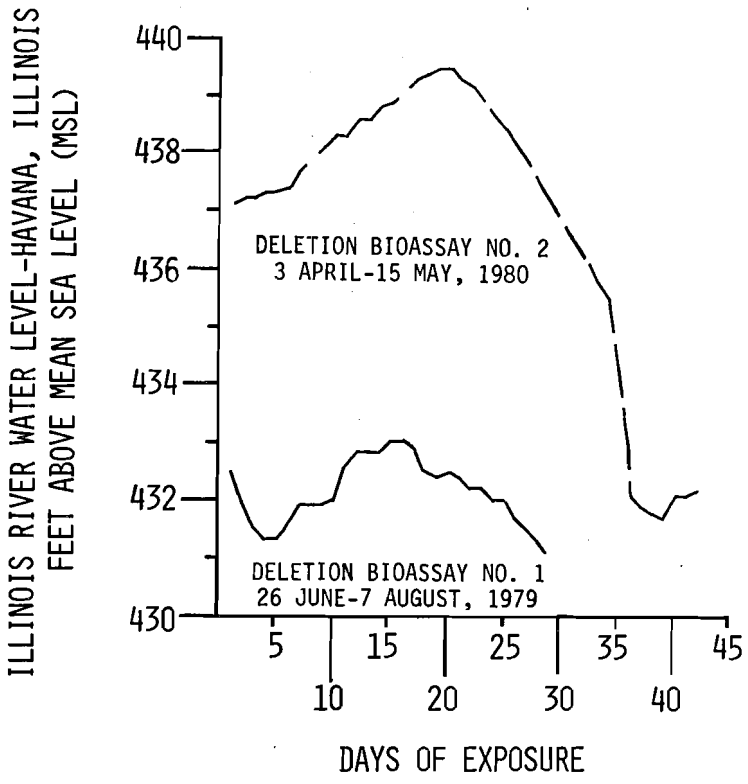

Figure 10. Water Levels in the Illinois River During Deletion Bioassays 1 and 2.

prematurely on 7 August 1979 when a pump delivering well water to the control chamber failed and could not be repaired or replaced immediately.

Clam Mortality. There were no significant differences in mortality between clams maintained in well water and in raw river water or treated river water (Figures 11 and 12, Table 4).

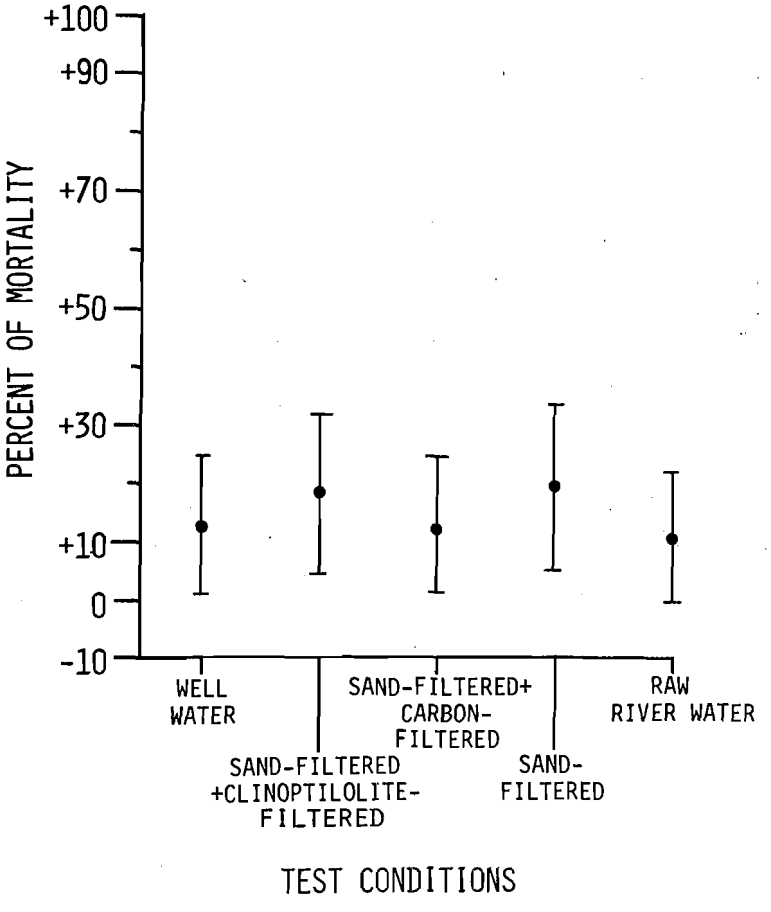

Figure 11. Mortality of Clams Exposed to Well Water, Raw Illinois River Water and Treated River Water for Two Weeks in Deletion Bioassay Number 1. Brackets show 95% confidence limits.

Clam Growth. Clams maintained in raw river water and sand-filtered water grew significantly more than clams exposed to other treatments (Figures 13 and 14, Table 4).

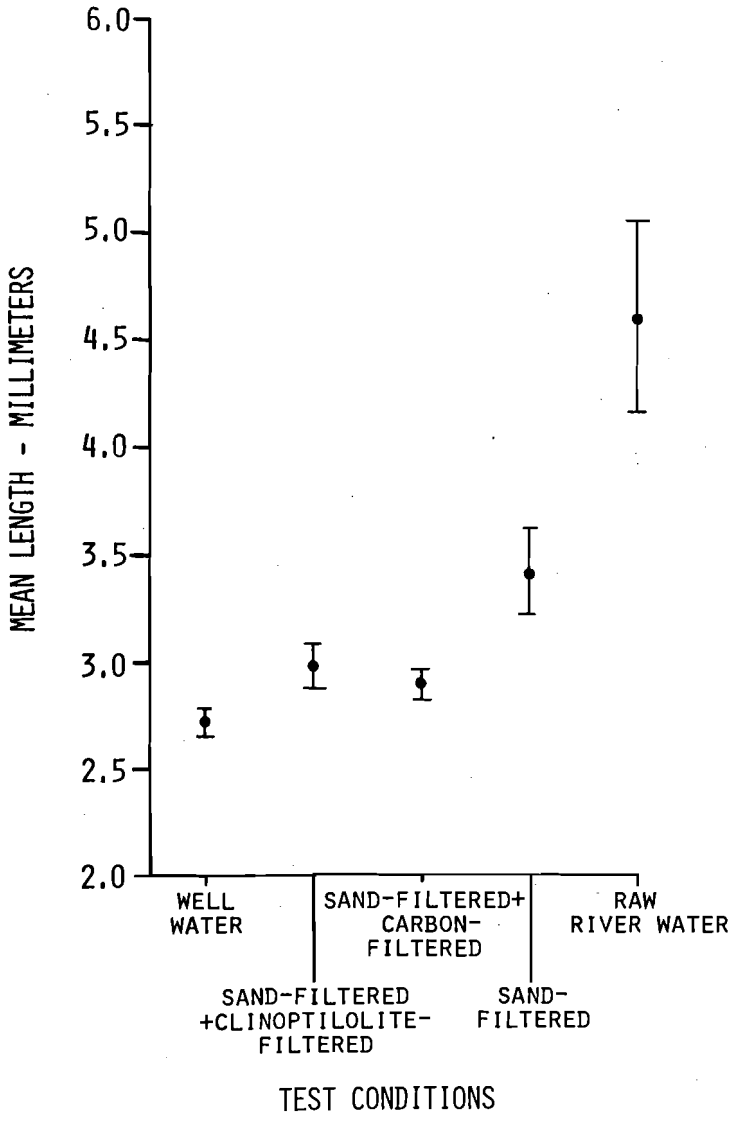

Figure 13. Shell Length of Clams Exposed to Well Water, Raw Illinois River Water and Treated River Water for Two Weeks in Deletion Bioassay Number 1. Brackets show 95% confidence limits.

TABLE 4

Results of Deletion Bioassay No. 1

	No. Alive	No. Missing	Mean Shell Length (mm)	Vari-ance	Standard Deviation	Range (mm)	Mean Growth Increment (mm)
Initial							
Control[1]	40	--	2.7	0.03	0.16	2.4-3.0	--
Sand-Clino[2]	40	--	2.7	0.02	0.15	2.4-2.9	--
Sand-Char[3]	40	--	2.7	0.03	0.16	2.4-3.0	--
Sand[4]	40	--	2.7	0.02	0.15	2.4-3.0	--
Raw[5]	40	--	2.7	0.02	0.15	2.4-3.0	--
2 Weeks							
Control	34	1	2.7	0.03	0.18	2.4-3.0	--
Sand-Clino	31	2	3.0	0.09	0.29	2.4-4.0	0.3
Sand-Char	34	1	2.9	0.04	0.21	2.5-3.2	0.2
Sand	29	4	3.4	0.29	0.54	2.8-5.0	0.7
Raw	33	3	4.6	1.58	1.26	2.5-6.5	1.9
4 Weeks							
Control	31	0	2.7	0.03	0.17	2.4-3.0	--
Sand-Clino	24	2	3.2	0.15	0.38	2.7-4.2	0.2
Sand-Char	28	2	3.0	0.06	0.25	2.5-3.6	0.1
Sand	21	7	4.2	0.52	0.72	2.8-5.6	0.8
Raw	24	2	3.2	0.15	0.38	2.7-4.2	0.2

[1]well water
[2]river water, filtered through sand and clinoptilolite
[3]river water, filtered through sand and charcoal
[4]river water, filtered through sand
[5]raw Illinois River water and silt

suspension delivered to the test chambers during bioassay number 2 were:

4 April	3032
16 April	3666
18 April	9197
24 April	324
7 May	2294
14 May	2909

One hundred ml of algal suspension was delivered to each test chamber every 5 minutes. The concentrations of algae delivered to the test aquaria during deletion bioassay number 2 are of the same order of magnitude as the total green algae (Chloroplyta) numbers found in Keokuk Pool, Mississippi River, by Gale and Lowe (1971:508).

Water chemistry and temperature in the test chambers during bioassay 2 are reported in Table 5.

Clam Mortality. Clams exposed to raw Illinois River water during deletion bioassay number 2 suffered significantly greater mortality than all other groups after 2 weeks and 4 weeks of exposure (Table 6, Figures 15 and 16). After 6 weeks, clams exposed to Illinois River water had significantly greater mortality than all groups except those clams exposed to sand-filtered Illinois River water (Figure 17). The control group of clams, exposed to unchlorinated well water, had the lowest mortality after 4 weeks and 6 weeks (Figures 16 and 17).

Clam Growth. Although mortality of fingernail clams exposed to raw river water was high, growth of the survivors after 2 weeks and 4 weeks of exposure was only slightly worse than clams in treated water (Table 6, Figures 18 and 19) and after six weeks, comparable to the clams in treated water (Table 6 and Figure 20). Clams in clean well water showed the poorest growth of all, so lack of food may still have been affecting the control clams despite automatic feeding of algae. Sediments continuously accumulated in test chambers receiving raw river water as well as in chambers receiving filtered river water, but no additional sediment accumulated in the well water control. As mentioned above, the

TABLE 6

Results of Deletion Bioassay No. 2

	No. Alive	No. Missing	Mean Shell Length (mm)	Vari-ance	Standard Deviation	Range (mm)	Mean Growth Increment (mm)
Initial							
Control[1]	40	--	2.6	0.02	0.15	2.4-2.9	--
Sand-Clino[2]	40	--	2.6	0.02	0.14	2.4-2.9	--
Sand-Char[3]	40	--	2.6	0.02	0.13	2.4-3.0	--
Sand[4]	40	--	2.6	0.02	0.13	2.4-2.9	--
Raw[5]	40	--	2.7	0.02	0.13	2.4-2.9	--
2 Weeks							
Control	37	1	2.7	0.02	0.15	2.5-3.0	0.1
Sand-Clino	35	0	3.6	0.24	0.49	2.5-4.3	1.0
Sand-Char	38	0	3.6	0.20	0.45	2.7-4.3	1.0
Sand	36	0	3.7	0.23	0.48	2.6-4.4	1.1
Raw	23	0	3.2	0.15	0.38	2.7-4.0	0.5
4 Weeks							
Control	34	1	2.8	0.02	0.15	2.5-3.0	0.1
Sand-Clino	33	0	4.0	0.35	0.59	2.7-4.8	0.4
Sand-Char	31	0	4.0	0.44	0.67	2.5-5.0	0.4
Sand	34	0	4.1	0.43	0.66	2.7-4.9	0.4
Raw	17	0	3.7	0.37	0.60	2.8-4.6	0.5
6 Weeks							
Control	29	0	2.8	0.02	0.14	2.5-3.0	--
Sand-Clino	30	0	4.4	0.32	0.56	3.6-5.4	0.4
Sand-Char	29	0	4.1	0.30	0.55	3.1-5.1	0.1
Sand	21	0	4.8	0.63	0.79	2.9-6.0	0.7
Raw	15	0	4.3	0.62	0.79	2.9-5.6	0.6

[1]well water
[2]river water, filtered through sand and clinoptilolite
[3]river water, filtered through sand and charcoal
[4]river water, filtered through sand
[5]raw Illinois River water and silt

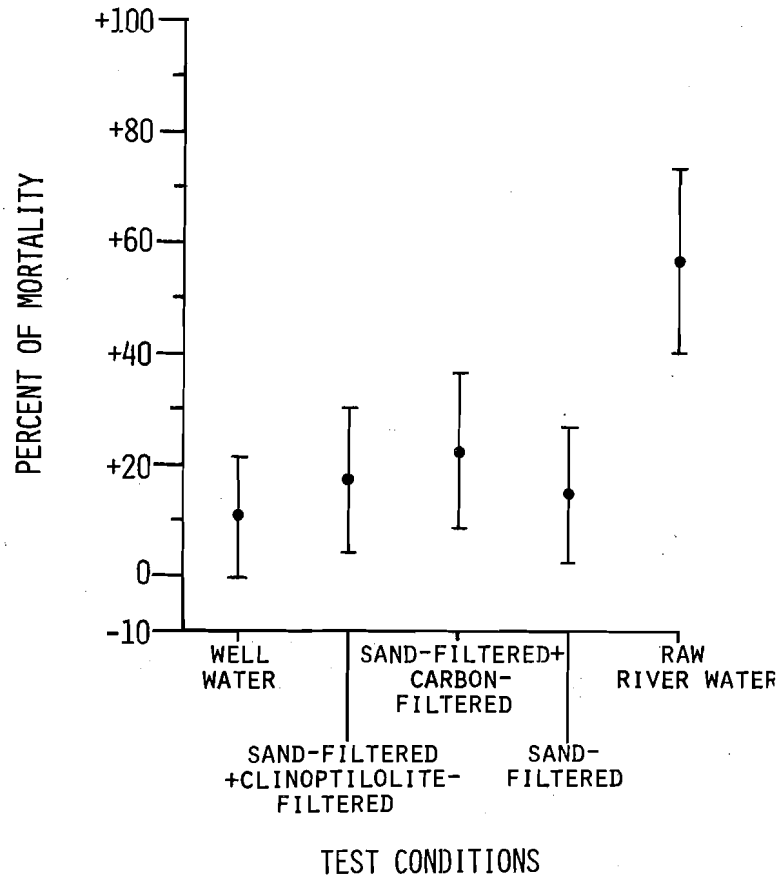

Figure 16. Mortality of Clams Exposed to Test Conditions for Four Weeks in Deletion Bioassay Number 2.

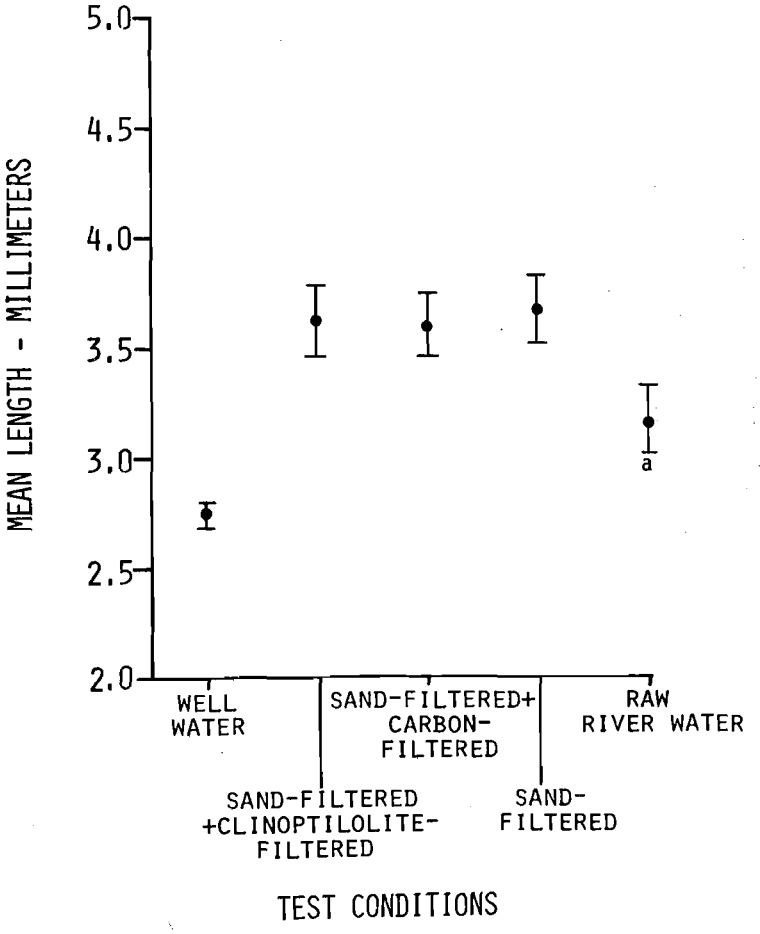

Figure 18. Growth of Clams Exposed to Test Conditions for Two Weeks in Deletion Bioassay Number 2. [a]See note in text (METHODS, page 17) regarding possibility of size-selective mortality.

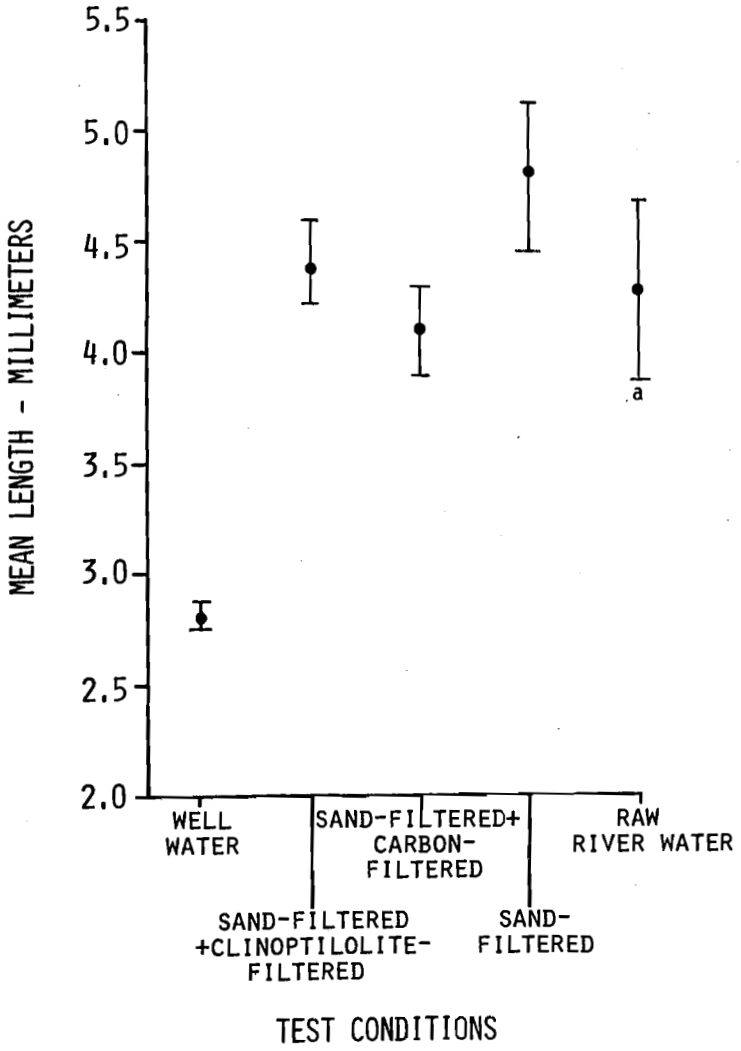

Figure 20. Growth of Clams Exposed to Test Conditions for Six Weeks in Deletion Bioassay Number 2.

SUMMARY

1. Illinois River water is toxic to fingernail clam gills. Water samples taken from the river on 5 October 1977 and 22 April 1978 inhibited the beating of the cilia on isolated clam gills, and the April sample was significantly more toxic than the October sample.

2. Illinois River sediment is toxic to fingernail clam gills. A sediment core was taken from Quiver Lake, a bottomland lake which receives sediment input from the Illinois River and where fingernail clams were abundant prior to a die-off in 1955-58. A sediment layer from the 2.6-5.1 cm depth showed the greatest toxicity, the 0-2.5 cm depth the next greatest toxicity, and deeper layers showed significantly less toxicity. Although the sediment layers were not dated, this pattern of toxicity is consistent with the observed die-off. Deeper, hence older layers of sediment, do not show the toxicity of the shallower, younger layers. The decline in toxicity in the surficial layer could result from a reduction in the input of toxicant, or greater dilution of a steady toxicant input by an increased sediment input.

3. Raw water from the Illinois River, containing suspended sediment, is toxic to intact fingernail clams. After six weeks of exposure, 62.5% of the clams in raw river water died. The next highest mortality (47.5%) occurred in sand-filtered water, while mortality in the other two treatments (charcoal and clinoptilolite filtration) did not differ significantly from the mortality of 24% in the well-water controls. The clams probably survived better in the treated water for two reasons: (1) clinoptilolite and charcoal each removed ammonia, which is found in Illinois River water and which is toxic to fingernail clams (2) the additional physical filtration provided by the charcoal and clinoptilolite removed additional sediment, which contains unidentified toxic factors.

4. The toxicant is fairly fast acting, since clams in raw river water suffered 42.5% mortality within two weeks, and ciliary inhibition on isolated clam gills occurred within two hours of exposure to raw river water.

5. The results of both the gill assay and the deletion assay show that the toxicity of the river varies with time, with April 1978 and April

RECOMMENDATIONS

This research has shown that Illinois River water and sediment are toxic to fingernail clams, but the research has not identified the specific toxicant or toxicants. The toxicant could be identified, using the gill bioassay developed in this research in conjunction with physical-chemical methods of partitioning water and sediment samples. We recommend the following approach: (1) take sediment cores from a series of lakes and pools along the entire Illinois River, where sediments are known to be accumulating, (2) use the gill bioassay (which provides results rapidly--within hours) to determine where the "hot spots" of toxicity are along the river, and which layer of sediment within each "hot spot" contains the greatest toxicity, (3) take a large volume sample of the most toxic sediment layer from the lake with the most toxic sediment and chemically extract and partition the components of the sediment, (4) test the extracts and partitioned components on fingernail clam gills to determine which component has the greatest toxicity, (5) analyze the most toxic component to provide specific chemical identification of the toxicant or toxicants, (6) verify the identification by measuring the toxicity of the pure chemical (obtained from a chemical supply house) to fingernail clam gills and intact clams, and (7) make recommendations to the state and federal environmental protection agencies regarding control of the toxic material and the prognosis for restoration of detritus-based food webs in the Illinois River.

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PUBLICATIONS RESULTING FROM THIS RESEARCH (con't.)

Sparks, R.E., and A.A. Paparo. 1979. A rapid toxicity test using the fingernail clam, Musculium transversum. *Rapid Methods Research Highlights*, February:1-2.