1985

Evaluation of the toxicity of contaminated sediments in the James River, Virginia

Morris H. Roberts
Virginia Institute of Marine Science

Charles J. Strobel
Virginia Institute of Marine Science

EVALUATION OF THE TOXICITY OF CONTAMINATED SEDIMENTS IN THE JAMES RIVER, VIRGINIA

by

Morris H. Roberts, Jr. and Charles J. Strobel
Virginia Institute of Marine Science
Gloucester Point, VA 23062

Final Report

submitted to

Richmond Regional Planning Distric Commission
2201 West Broad Street
Richmond, VA 23220

28 August 1985

INTRODUCTION

The Virginia State Water Control Board, in cooperation with the Department of Chemical Oceanography of the Virginia Institute of Marine Science has recently conducted periodic chemical surveys of organic pollutants in the sediments of the upper James River. The August 1983 survey showed elevated concentrations of polycyclic aromatic hydrocarbons (PAH) at Stations 4 and 7 (Figure 1 and Table 1). Although the reported concentrations were approximately one order of magnitude lower than those reported in contaminated areas of the Elizabeth River, they were deemed high enough to warrant further study based on reported toxicity of Elizabeth River sediments (Hargis et al. 1984; Roberts et al. 1985).

The purpose of the present study was to determine if the sediments from these two sites were contaminated to the extent that they would be acutely toxic to fish.

MATERIALS AND METHODS

The test organisms for this study were the fathead minnow, Pimephales promelas and the bluegill sunfish, Lepomis macrochirus. Both warm water species are widely used in toxicity studies. All fish were purchased from a commercial fish farm and acclimated to laboratory conditions before use in tests.

Test sediments were collected in February 1985 from Stations 4 and 6A in the James River (Figure 1). All samples were collected from the edge of the channel. Station 4 was located right at day marker 168, downstream from

Goode Creek in depths ranging from 1 to 3 meters. This station has been monitored for PAH since August 1983. Station 6A was located along the opposite shore, approximately 400 meters downstream from day marker 166, or about 150 meters downstream from an Exxon oil terminal. The water depth at this station was approximately 10 meters. This station was chosen because of its proximity to the oil terminal. Attempts were made to sample at Stations 7 and 6, but the sediments consisted of coarse sand and gravel. There were no prior sediment PAH data for Station 6A. Control sediment was collected adjacent to a marsh along the Mattaponi River near Walkerton, VA.

Sediments from all sites were collected from a boat using a stainless steel Smith MacIntyre grab sampler. A portion of each sample was removed, placed in a solvent washed glass container, sealed, placed on ice and returned to the laboratory for analysis. The remainder of the test sediments were placed in 55 gallon plastic trash cans and stored at about 4 ^{o}C until used. A small sub-sample of sediment was removed from each container for grain size analysis.

The acute toxicity of both the total suspended solids and dissolved fractions of sediments from each station were examined. Stock test suspensions were 1:4 v/v mixtures of the sediment and carbon-filtered fresh water. The mixtures were agitated for 30 minutes in a fiberglass-coated cement mixer and allowed to settle for 60 minutes after which the supernatants were siphoned off. This was designated the 100% suspended solids fraction. To prepare the dissolved phase, each mixture was agitated for 30 minutes, and then allowed to settle for 2 to 24 hours (2 hours for the fathead test, 24 for the bluegill test). The supernatant was then

pumped through a 10um and a 1um filter to produce the dissolved fraction.

Fish were exposed to contaminated sediments in 10 gallon aquaria. For the definitive tests, each tank contained 30 liters of either 100, 56, or 32% dilutions of the suspended or dissolved fractions of the experimental sediment suspension, 100% suspended or dissolved fractions of the control sediment suspension, or clean water without sediment. Preliminary screening tests demonstrated that there was no need to study concentrations lower than those listed above. There were two replicates of each concentration. Treatments were randomly placed in two large waterbaths.

Ten fish were randomly introduced to the test tanks. Because of the high oxygen demand by the sediments, all tanks were continuously aerated. Fish were fed Zeigler #2 starter trout chow at 3% body weight per day. Each experiment lasted 10 days. Temperature, dissolved oxygen and pH were measured daily. Tanks were examined for dead fish at least twice daily. At the end of each test all fish were weighted and total lengths measured.

Sediments and sediment suspensions were analyzed for PAH by gas chromatography by the VIMS Department of Chemical Oceanography. Methods of analysis have been described elsewhere by Bieri et al. (1981). Grain sizes of the sediments were measured by the method of Folk (1974).

RESULTS AND DISCUSSION

Sediment samples from the collections at Stations 4 and 6A used for toxicity tests were found not to be contaminated by PAH above background (Table 1). The low PAH concentrations produced in the test suspensions were therefore reasonable. The sediment from Station 4 was fairly sandy and

would be expected to be low in PAH. Both the control sediment and that collected from Station 6A were comprised of fine mud (Table 2).

There were virtually no mortalities for either fish species exposed to suspended or dissolved phases of sediments from either station (Table 3). Thus, the experimental sediments were not acutely toxic. The PAH concentrations in the test suspensions were well below that found to be toxic in sediments from the Elizabeth River (Roberts et al. 1985). The exposure procedures used for the tests reported here differ from those used previously in that the contaminated materials were in suspension in the water rather than lying on the bottom of the exposure chambers. As a result, contaminants should be more bioavailable.

The overall mean weight and length of the experimental fish were 1.15 g and 46.3 mm for fathead minnows, and 0.67 g and 36.55 mm for bluegills. Fish in all treatments did not differ significantly in size.

The dramatic difference in PAH concentration at Station 4 in August 1983 compared to all subsequent collections is curious. This difference may reflect the dynamic nature of the river sediments in the upper James River. Another possible explanation is local variability. To evaluate this possibility, several replicate samples were collected in April 1985 at Station 4 by members of the VIMS Department of Chemical Oceanography. All samples were collected within the swing of an anchored boat. Results of analyses show these replicates vary by a factor of 30 from low to high (Table 1). The sediments were collected from a fairly narrow region of the James River. The source of variability in PAH concentration within such a small area is not understood.

Based on both chemical and biological results it is concluded that

sediments from the areas sampled were not contaminated to an extent that aquatic life was being acutely or subacutely harmed. The dynamic nature of the system may allow contaminated "hot spots" to develop periodically. The magnitude of this problem is presently unclear; and therefore, periodic monitoring is an essential part of any effort to assure adequate water quality in the upper James River. There is a clear need to develop a biological assay which will be both sensitive and reliable in measurement in degradation of biological water quality before an acutely lethal condition develops.

LITERATURE CITED

Bieri, R.H., P. DeFur, R.J. Huggett, W. MacIntyre, P. Slone, C.L. Smith, and C.W. Su. 1981. Organic compounds in surface sediments and oyster tissues from the Chesapeake Bay. Final Report to the US Environmental Protection Agency, Grant No. R8060102010, 179 pp.

Folk, R.L. 1974. Petrology of Sedimentary Rocks. Hemphill Publ. Co., Austin. 120 pp.

Hargis, W.J., Jr., M.H. Roberts, Jr. and D.E. Zwerner. 1984. Effects of contaminated sediments and sediment-exposed effluent water on an estuarine fish: acute toxicity. Mar. Environ. Res. 14:337-354.

Roberts, M.H. Jr., W.J. Hargis, Jr., C.J. Strobel and P.F. DeLisle. 1985. Acute Toxicity of Sediments Contaminated with Polycyclic Aromatic Hydrocarbons to the Estuarine Fish, Leiostomus xanthurus (submitted to Estuaries).

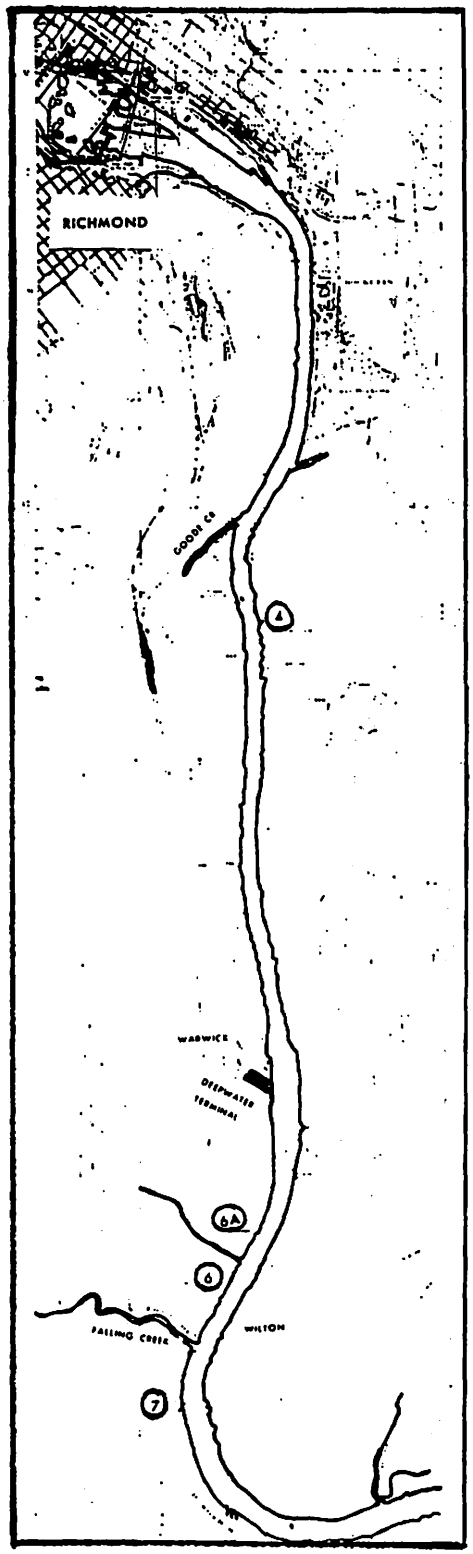

Figure 1. Location of sampling stations (Stations 6 and 7 were not sampled for the present study).

Table 1. Present and past concentrations of total resolved PAH (in ppb) in sediments from four stations located within the study area compared to concentrations in experimental suspensions.

Date	STATION 4	6A	6	7
August 1983	31,050	ns	ns	18,579
April 1984	4,497	ns	ns	2,049
June 1984	6,996	ns	ns	4,343
April 1985	4,583 ** 2,224 ** 4,160 ** 9,589 ** 308 ** 9,242 **	ns	7,253	5,693
February 1985 Test Sediments	2,747	4,425	ns	ns
Experimental Suspensions	2,565	4,139	ns	ns

ns = no samples collected.
** = replicate samples collected at the same time at the same station. (Data to be submitted in Huggett's Final Report).

Table 2. Sediment grain size distribution in sediment samples from control and test sites.

Grain Size	STATION control	4	6A
gravel*	2.3%	0.2%	0.0%
sand	15.3%	53.6%	18.0%
silt	27.2%	26.1%	42.1%
clay	55.2%	20.1%	39.9%

* All "gravel" consisted of pieces of tree bark or other large organic assemblages.

Table 3. Mortalities for the fathead and bluegill tests. Numbers represent the number dead after 10 days. The initial number in each tank at time 0 was 10 fish.

Treatment	Fathead Minnows		Bluegill Sunfish	
	A	B	A	B
Control water	0	0	0	0
Control sed. 100% Suspended	0	0	1	0
Sta. 4 100% Suspended	0	0	0	2
Sta. 4 56% Suspended	0	0	0	0
Sta. 4 32% Suspended	0	0	0	0
Sta. 6A 100% Suspended	0	0	0	0
Sta. 6A 56% Suspended	0	0	1	0
Sta. 6A 32% Suspended	0	0	0	0
Control sed. 100% Dissolved	0	0	1	1
Sta. 4 100% Dissolved	0	0	0	1
Sta. 4 56% Dissolved	0	0	0	0
Sta. 4 32% Dissolved	0	0	0	0
Sta. 6A 100% Dissolved	0	0	0	0
Sta. 6A 56% Dissolved	0	0	0	0
Sta. 6A 32% Dissolved	0	0	0	1