Journal of Hazardous Materials, 1 (1975/77) 303—318 303

THE ACUTE TOXICITY OF 47 INDUSTRIAL CHEMICALS TO FRESH AND SALTWATER FISHES

GAYNOR W. DAWSON
Water and Waste Management Section, Battelle-Northwest, Richland, Wash. (U.S.A.)
and
ALLEN L. JENNINGS
Marine Activities Branch, U.S. Environmental Protection Agency, Washington, D.C. (U.S.A.)
and
DANIEL DROZDOWSKI and EUGENE RIDER
Biological Services Division, U.S. Testing Company, Inc., Hoboken, N.J. (U.S.A.)
(Received August 16, 1976)

Summary

Of the 47 substances tested, 29 clearly qualify as hazardous under proposed criteria. Three of the remaining 18 substances have freshwater LC_{50} values in the 550—650 ppm range but displayed saltwater toxicities below 500 ppm and, therefore, also qualify as hazardous. The remaining 15 substances were clearly well above the proposed criteria.

Introduction

With the inclusion of Section 311 in the Water Pollution Control Act Amendments of 1972 (PL 92—500), the U.S. EPA has been charged with designating hazardous substances which pose a threat to human health or the environment when spilled. Pursuant to this mandate, proposed rules have been constructed which define as hazardous substances that display toxicity at or below one of the following prescribed thresholds [1]:

- oral LD_{50} of 50 mg/kg body weight;
- dermal LD_{50} of 200 mg/kg body weight;
- inhalation LC_{50} of 20 mg/m^3 for vapors and 2 mg/m^3 for dusts or mists;
- 96 hour LC_{50} for aquatic species of 500 mg/l; or
- 14 day IL_{50} for aquatic plants of 100 mg/l.

To date, the aquatic toxicity limit has proven to be the single most important factor in qualifying substances as hazardous. And yet, data are scarce on many industrial chemicals which, therefore, cannot be classified at this time. This has stimulated additional work with acute bioassays to fill in existing data gaps. The work reported herein is one such effort. The chemicals tested were selected from the Oil and Hazardous Materials—Technical Assistance Data System

(OHM—TADS) [2] on the basis of little or no existing fresh or saltwater toxicity data.

Experimental

All bioassays were conducted at the United States Testing Company Incorporated, Biological Services Division, Hoboken, New Jersey. Chemicals used in bioassays were obtained from commercial sources and were either research or chemically pure grades.

Freshwater species

Aquaria. Fish were held in all glass 30 gallon fish aquaria equipped with aeration and charcoal filters. Aquarium water was periodically freshened by partial changing with "new" water. Diatom filters were used at intervals to supplement the filtering of the charcoal filters.

Temperature. Facilities were housed in an air conditioned room with a constant temperature setting of 23° C.

Test containers. All glass 5-gallon aquaria were used as test "trial" containers. One gallon glass wide mouth jars (without lids) were used as screening containers. Water levels in the containers were brought to a depth of greater than 15 centimeters for testing purposes and the total volume adjusted to assure that a minimum of 1 liter of water was present for every 1 gram of fish. Test containers were placed on racks mounted with individual valve-operated aeration setups which provided oil-free compressed air if necessary. Containers for re-use were always washed with an acid water solution, followed by a rinse and then a re-washing with detergent and a final rinse.

Dilution water. Potable well water, obtained from an underground source in Passaic County, was used as the holding water and dilution water for the testing. The pH of the water was 7.6—7.9 with a "hardness" of 55 mg/l (as $CaCO_3$). The water was collected on a weekly basis and stored in clean polyethylene vessels at a uniform temperature.

Test animals. Bluegill sunfish (*Lepomis macrochirus*), obtained from commercial hatcheries in the vicinity of the New York metropolitan area were used. The fish were held for an acclimation period of fourteen days prior to testing. During that time, holding tank counts were taken and any group showing greater than 5 percent mortality was judged "unfit". Fish were maintained on a commercial fish food diet supplemented with minced frozen shrimp.

Disease prevention. Groups of fish that were in contact with unhealthy fish were treated for disease prevention immediately before acclimation. These fish were placed in a dilute bath of potassium permanganate for 15 minutes, rinsed, and then immersed in a Tetracycline HCl solution (250 mg/gal.) for 24 hours. If no evidence of disease was then observed, the fish were used for testing purposes.

General procedure. Fish, approximately 33 mm to 75 mm in length, were selected at random for the assays. Fish were not fed for 48 hours prior to testing. The "trial" fish were placed in the assay vessels before doses of the chemicals were added. Dilutions of the test substances, when necessary, were made in distilled water or in a solvent with relatively low toxicity. Most samples did not require dilution and it sufficed to pipet or pour the appropriate amount of toxicant into the test waters. Dissolved oxygen readings were taken daily and pH was noted at the end of the assay time period. If dissolved oxygen was being depleted rapidly, either by the test organism or chemical and biochemical demand, aeration was initiated. Aeration of a mild intermittent type was used, that is, a valve adjusted mild bubbling through air stones which was turned on and off manually depending on the oxygen demand during the work day. Aeration was never used during the first 24 hours, thus allowing chemicals to act in an uninterrupted state at the onset of the test period. Mortality counts were taken daily. Dead fish were immediately removed at the time of first observation. Median lethal concentrations (LC_{50}) were arrived at by plotting survival percentages on semi-logarithmic paper and drawing a straight line "fit" through or near significant points above and below 50 percent survival.

Saltwater species

Holding aquaria. Fish were held in all glass 30 gallon fish aquaria equipped with aeration and charcoal filters. Aquarium water was periodically freshened by partial changing with "new" water. Diatom filters were used at intervals to supplement the filtering of the charcoal filters.

Temperature. Facilities were housed in an air conditioned room with constant temperature setting of 20° C.

Test containers. All glass 5 gallon aquaria were used as test "trial" containers. One gallon glass wide mouth jars (without lids) were used as screening containers. Water levels in the containers were brought to a depth of greater than 15 centimeters for testing purposes and the total volume adjusted to assure that a minimum of 1 liter of water was present for every 1 gram of fish. Test containers were placed on racks mounted with individual valve-operated aeration setups which provided oil-free compressed air if necessary. Containers for re-use were always washed with an acid water solution, followed by a rinse and then a re-washing with detergent and a final rinse.

Dilution water. The same potable well water, pH 7.6—7.9 "hardness" 55 mg/l (as $CaCO_3$), was used as the base for a synthetic seawater mix. "Instant Ocean" synthetic sea salt mix was added to freshwater until a specific gravity of 1.018 was achieved. This salt concentration corresponded with the specific gravity of the natural seawater the specimens were collected from. The necessary volume of saltwater for testing was made one day in advance and stored in clean polyethylene vessels at a uniform temperature.

Test animals. Tidewater silversides (*Menidia beryllina*) were collected in nets primarily from "Horseshoe Bay" at Sandy Hook, New Jersey (Gateway National Park). The fish were held for an acclimation period of fourteen days prior to testing. As in the freshwater acclimation, any group showing greater than 5 percent mortality was judged "unfit". Fish were maintained exclusively on a minced frozen shrimp diet.

General procedure. Fish approximately 40 mm to 100 mm were selected at random for the assays. Silversides of this size were the most abundant during collection and provided the best survival rate during transportation to the laboratory. The "trial" fish were placed in the assay vessels before doses of the chemicals were added. Dilutions, dissolved oxygen and pH monitoring were conducted in the same manner as in the fresh-water methods. Aeration, during the test however, was of a continuous type. Continuous aeration was deemed necessary due to a combination of reasons: (1) larger more active fish; (2) lower oxygen solubility in saltwater; and (3) biochemical oxygen demand of the test substances. Mortality counts and LC_{50} calculations were the same as in the freshwater methods.

Control over fish viability was kept by observing the death rate in the stock tanks. Only fish from healthy tanks were used. As mentioned in the procedure, unfit tanks were those which had greater than 5 percent mortality during a two week period prior to testing. Much time was taken for the proper maintenance of the test animals. Salt and fresh water tanks were cleaned and refreshed often. The fish were fed regularly. The estimated death rate of control fish during the experiment was about 1.3 percent and 3.0 percent for fresh and salt water fish respectively.

Many of the chemicals in the tests had limited water solubilities. The values given for the LC_{50} reflect the total amount of substance introduced into the water and not simply the soluble fraction of the substance. In some cases, the chemical ratios added to the test waters were sufficiently small to allow complete solubility, in other cases (or at higher concentrations) the samples visibility remained undissolved.

Besides insolubility, some chemicals were volatile and chemical loss by vaporization occurred during these tests. Chemicals with specific gravities greater than water remained on the bottom and gradually diminished while others, like the ethers, floated on the surface and evaporated more readily.

With the above in mind and considering the nature of the static test, the results are an overall indication of expected toxicity of the chemicals should they be introduced into the water in a pure state under acute spill circumstances.

Results and discussion

Survival rates for each 24 hour observation period are given in Tables 1 and 2. LC_{50} values for the chemicals tested are summarized in Table 3. As can be noted there, values are quite consistent between fresh and saltwater species for most chemicals tested. Although the saltwater species generally appear slightly more sensitive for most toxicants, no anomalous results were evident between the two species for any specific material. The greatest variation between LC_{50} values appears for tetramethyllead in which the freshwater value

(continued on p. 314)

TABLE 1

Toxicity data for bluegill sunfish

Material	Material added (ppm)	% Survival after				Best fit 96 h LC_{50} (ppm)
		24 h	48 h	72 h	96 h	
Acetanilide 97%	320	40	40	40	0	
	180	100	100	100	40	
	100	100	100	100	50	100
	79	100	100	100	70	
Acetone cyanohydrin	5.6	0 (1 h)				
	3.2	0 (1 h)				
	1.0	0 (4 h)				
	0.75	10	10	10	10	0.57
	0.5	100	88	94	69	
Ammonium ferricyanide	560	100	50	0	0	
(purified)	420	90	20	0	0	
	320	100	80	50	50	300
	100	100	100	100	86	
	32	100	100	100	100	
Ammonium picrate	790	90	70	30	0	
	560	90	70	30	0	220
	320	90	80	50	30	
	180	90	80	70	60	
	100	100	100	100	92	
Amyl alcohol	760	0 (<24 h)	—	—	—	
(1-pentanol)	560	Narcosis	100	100	100	650
	320	Narcosis	100	100	100	
Benzyl alcohol	56	100	40	0	0	
	32	60	20	0	0	
	18	100	80	50	20	
	10	100	100	60	21	10
	5	100	100	100	100	
Brucine	63	0	—	—	—	
	40	40	30	20	20	36
	32	90	80	60	40	
	25	100	100	100	100	
n-Butyl acetate	250	0	—	—	—	
	180	0	—	—	—	
	125	100	90	50	0	100
	100	100	100	90	50	
	79	100	100	100	100	
Butylamine	79	80	20	10	10	
	50	80	70	50	20	
	32	80	50	60	50	32
	10	100	100	100	100	
Carbon tetrachloride	320	0	—	—	—	
	200	0	—	—	—	
(narcosis)	125	70	60	60	50	
(narcosis)	100	30	20	20	20	125
	75	100	100	100	100	

continued

TABLE 1 (continued)

Material	Material added (ppm)	% Survival after 24 h	48 h	72 h	96 h	Best fit 96 h LC_{50} (ppm)
Chloronitrobenzene (technical)	5	67	67	0	—	
	3.2	90	90	80	20	
	2	100	100	0	0	
	1.5	90	30	20	0	1.2
	1	100	95	90	70	
Crotonaldehyde 85% aqueous	7.5	0	—	—	—	
	5.6	0	—	—	—	
	4.2	0	—	—	—	
	3.2	90	90	90	70	3.5
	1.8	100	100	100	100	
Cyanogen bromide	0.42	0	—	—	—	
	0.32	70	70	70	70	
	0.18	100	100	80	70	0.24
	0.10	100	100	100	100	
Cyclohexanol	1,350	30	30	30	10	
	1,000	80	70	70	64	1,100
	790	100	100	100	100	
Diacetone alcohol	560	90	80	20	10	
	420	50	50	50	50	420
	320	100	100	100	100	
o-Dichlorobenzene	50	0	—	—	—	
	32	70	50	30	20	
	24	90	90	90	90	27
	18	90	90	90	90	
Dichloroethane	1,000	20 (2 h)	20	0	—	
	560	57	43	43	39	
	420	100	100	100	100	550
	320	100	100	100	90	
1,2-Dichloropropane	560	0	—	—	—	
	320	60	50	50	50	320
	180	100	100	100	100	
Diethylene glycol mono-butyl ether	3,200	33	0	—	—	
	2,400	50	50	50	10	
	1,800	100	100	80	20	
	1,000	100	100	90	70	1,300
	100	100	100	100	100	
Diethylene glycol mono-ethyl ether	10,000	90	90	90	90	
	3,200	100	100	100	100	>10,000
Diethylene glycol mono-methyl ether	10,000	40	0	—	—	7,500
	5,600	100	100	100	100	
Dimethyl sulfate (99%)	32	0	—	—	—	
	18	0	—	—	—	
	10	0	—	—	—	
	7.5	90	90	90	90	7.5
	50	70	70	70	70	

continued

TABLE 1 (continued)

Material	Material added (ppm)	% Survival after 24 h	48 h	72 h	96 h	Best fit 96 h LC_{50} (ppm)
p-Dioxane	10,000	100	100	100	100	
	7,900	90	90	90	90	>10,000
Epichlorohydrin	56	0	—	—	—	
	42	50	0	—	—	
	37	100	90	80	60	
	32	100	90	80	70	35
	10	100	100	75	75	
Ethyl ether	10,000	100	100	100	100	
	7,900	100	100	100	100	>10,000
Ethylene glycol diacetate	125	0	—	—	—	
	100	31	30	30	30	
	79	95	95	95	85	90
	50	100	100	100	100	
Ethylene glycol monethyl ether	10,000	100	100	100	100	
	1,000	100	100	100	100	>10,000
Ethylene glycol monobutyl ether	2,400	40	40	20	0	
	1,800	50	50	50	30	
	1,000	100	100	90	80	1,490
	790	100	100	100	100	
	320	100	100	100	100	
Ethylene glycol monomethyl ether acetate	100	0	—	—	—	
	75	40	40	30	20	
	50	60	40	40	40	
	25	100	100	90	90	45
	10	100	100	100	100	
Ethylene glycol monomethyl ether	10,000	100	100	100	100	>10,000
	3,200	100	100	100	100	
Hexylene glycol	10,000	100	100	100	100	>10,000
	3,200	100	100	100	100	
Isodecyl diphenylphosphate	10,000	100	100	90	10	
	5,000	90	80	80	80	6,700
	1,000	100	100	100	100	
Isopropyl ether	10,000	30	30	30	30	
	79,000	100	100	100	100	
	5,000	80	70	70	70	7,000
	1,000	100	100	100	100	
Methane sulfonyl chloride (98%)	18	0	—	—	—	
	13	0	—	—	—	
	10	100	100	100	100	11
	7.6	100	100	100	100	
Methyl bromide	14 (∿3.3 ml/l)	30	0	—	—	
	11 (∿2.5 ml/l)	60	50	50	50	11
	7 (∿1.7 ml/l)	100	90	90	90	
	1.4 (∿0.33 ml/l)	100	100	100	100	

continued

TABLE 1 (continued)

Material	Material added (ppm)	% Survival after 24 h	48 h	72 h	96 h	Best fit 96 h LC_{50} (ppm)
Methyl chloride	1800 (∿800 ml/l)	0	Died in 5—20 min		—	
	900 (∿400 ml/l)	10	10	10	10	
	450 (∿200 ml/l)	100	90	90	90	550
	300 (∿133 ml/l)	100	100	100	100	
Morpholine	560	40	0	—	—	
	420	90	80	40	10	
	370	100	80	50	40	350
	320	100	100	100	80	
	10	100	100	100	100	
Polypropylene glycol	2,400	90	30	10	0	
	1,800	100	100	90	70	
	1,000	100	80	80	77	1,700
Propionaldehyde	180	70	0	—	—	
	132	100	80	60	60	
	100	100	71	71	71	130
	79	100	100	100	90	
Sodium fluorosilicate	100	10	—	—	—	
	75	0	—	—	—	
	56	100	100	100	100	65
	32	100	100	100	100	(49 as SiF_6)
Strychnine (98%)	10	0	—	—	—	
	2	100	90	70	20	
	1	100	100	80	10	
	0.75	100	100	100	80	0.87
(slight effects)	0.50	100	100	100	100	
Tetramethyllead in toluene (168% ML)	125	0	—	—	—	
	90	100	90	10	0	
	79	100	100	95	70	84
	50	100	100	100	100	
Thallium acetate	320	100	100	10	0	
	250	100	80	70	10	
	100	85	85	71	71	170
	32	100	100	100	100	(132 as Tl)
Tricresyl phosphate	10,000	73	44	33	33	
	7,900	85	50	15	15	
	5,000	100	100	90	80	7,000
	3,200	100	100	100	100	
Triethylene glycol	10,000	100	100	100	100	>10,000
	7,900	100	100	100	100	
Triphenyl phosphate	560	100	70	20	0	
	420	100	90	90	80	
	320	80	70	60	40	290
	180	100	100	100	90	
	125	100	100	100	100	
Vinylidene chlorine	750	0	5 h	—	—	
	560	0	8 h	—	—	
	320	0	<24 h	—	—	220
	180	100	80	70	70	
	132	100	100	100	100	

TABLE 2

Toxicity data for tidewater silversides

Material	Material added (ppm)	% Survival after 24 h	48 h	72 h	96 h	Estimated 96 h LC_{50} (ppm)
Acetanilide	320	50	50	0	—	
	2∿10	100	100	80	0	
(severe effects)	180	100	100	100	100—20 at 120 h	115
	100	100	90	90	60	
	75	100	90	70	60	
Acetone cyanohydrin	0.75	0	2 h	—	—	
	0.50	50 (2 h)	50	50	50	0.50
	0.25	100	100	100	100	
Ammonium ferricyanide	320	70	30	10	0	
	240	80	40	30	20	195
	180	100	100	80	70	
Ammonium picrate	180	0	—	—	—	
	100	60	0	—	—	
	75	95	30	30	20	66
	56	100	100	100	100	
Amyl alcohol (1-pentanol)	560	50	0	—	—	
	320	90	30	10	0	
	180	100	80	70	50	180
	100	100	100	100	90	
Benzyl alcohol	32	100	30	20	20	
	18	90	30	30	20	15
	10	90	80	80	80	
Brucine	32	80	60	40	20	
	18	100	100	80	70	20
	10	100	100	100	90	
n-Butyl acetate	320	0	—	—	—	
	240	0	—	—	—	
	180	64	60	56	56	
	132	100	80	80	80	185
	100	100	100	100	100	
Butylamine	100	100	100	0	—	
	50	95	60	0	—	
	32	100	33	33	33	24
	18	100	100	75	65	
	10	100	100	100	100	
Carbon tetrachloride	320	0	—	—	—	
	180	100	80	60	50	
	100	100	60	60	60	150
	75	100	100	100	90	
m-Chloronitrobenzene (technical)	1.5	90	50	40	10	
	1.0	90	30	0	—	
	0.50	90	90	80	40	0.55
	0.25	100	100	100	100	

continued

TABLE 2 (continued)

Material	Material added (ppm)	% Survival after 24 h	48 h	72 h	96 h	Estimated 96 h LC_{50} (ppm)
Crotonaldehyde	3.2	0	—	—	—	
	1.8	90	90	20	10	1.3
	1.0	100	100	100	90	
Cyanogen bromide	0.56	0	—	—	—	
	0.42	85	85	85	85	
	0.32	100	100	100	100	0.47
	0.18	100	100	100	100	
Cyclohexanol	1,000	100	90	50	30	
	750	75	35	25	25	720
	500	100	100	100	100	
Diacetone alcohol	560	40	20	20	20	
	420	80	40	30	30	420
	320	100	100	100	100	
o-Dichlorobenzene	18	0	—	—	—	
	10	20	10	10	10	7.3
	5	100	100	100	100	
Dichloroethane	560	0	—	—	—	
	420	50	50	50	30	
	320	90	90	90	90	480
	180	100	100	100	100	
1,2-Dichloropropane	320	10	10	10	0	
	240	100	80	50	50	
	180	70	70	70	70	240
	100	100	100	100	100	
Diethylene glycol mono-butyl ether	2,400	100	100	50	0	
	1,800	100	100	100	80	2,000
	1,000	100	100	100	100	
Diethylene glycol mono-ethyl ether	10,000	100	80	80	80	>10,000
Dimethyl sulfate	18	6	0	—	—	
	15	100	90	90	50	15
	10	100	100	100	100	
p-Dioxane	10,000	70	20	10	10	
	7,900	80	30	10	0	6,700
	5,000	100	90	90	90	
Epichlorohydrin	32	100	30	0	—	
	18	100	90	70	50	18
	10	90	90	90	90	
Ethyl ether	10,000	90	90	90	90	>10,000
Ethylene glycol diacetate	100	100	40	30	10	
	75	100	90	60	60	78
	56	100	100	80	80	

continued

TABLE 2 (continued)

Material	Material added (ppm)	% Survival after 24 h	48 h	72 h	96 h	Estimated 96 h LC_{50} (ppm)
Ethylene glycol monobutyl ether	1,800	90	70	30	20	
	1,320	100	100	90	30	1,250
	1,000	100	100	100	70	
Ethylene glycol mono-ethyl ether	10,000	100	100	100	100	>10,000
Ethylene glycol mono-methyl ether	10,000	100	95	90	60	>10,000
	5,000	100	100	100	90	
Ethylene glycol mono-methyl ether acetate	100	0	—	—	—	
	75	20	10	0	—	
	50	60	30	30	30	40
	25	100	100	100	100	
Hexylene glycol	10,000	100	70	60	50	
	7,900	100	60	60	60	10,000
	5,000	100	100	100	100	
Isodecyl diphenylphosphate	5,000	30	20	20	10	
	3,200	60	20	10	10	
	2,000	100	40	30	20	1,400
	1,000	100	100	100	70	
Isopropyl ether	10,000	0	—	—	—	
	7,500	0	—	—	—	
	5,000	20	20	20	20	6,600
	3,200	100	100	100	100	
Methane sulfonyl chloride	24	20	20	10	0	
	18	50	50	40	30	15
	10	100	100	100	100	
Methyl bromide	14 (∿3.3 ml/l)	0	—	—	—	
	11 (∿2.5 ml/l)	70	60	60	60	12
	7 (∿1.7 ml/l)	100	100	80	80	
Methyl chloride	900 (∿400 ml/l)	0–1 h	—	—	—	
	450 (∿200 ml/l)	0–1 h	—	—	—	
	300 (∿133 ml/l)	40	40	40	40	270
	150 (∿ 67 ml/l)	100	100	100	100	
Morpholine	560	70	30	0	—	
	420	100	100	50	20	400
	320	100	100	100	100	
Polypropylene glycol	1,320	100	20	0	—	
	1,000	85	0	—	—	
	750	100	50	50	25	650
	560	100	100	100	100	
Propionaldehyde	132	67	30	30	23	
	100	95	85	70	55	100
	75	100	100	80	80	

continued

TABLE 2 (continued)

Material	Material added (ppm)	% Survival after				Estimated 96 h LC_{50} (ppm)
		24 h	48 h	72 h	96 h	
Sodium fluorosilicate	320	0	—	—	—	
	180	0	—	—	—	
	100	100	100	100	100	160
	75	100	100	100	100	(121 as SiF_6)
Strychnine	2.0	30	30	20	0	
	1.0	80	70	70	40	0.95
	0.5	100	100	100	100	
Tetramethyllead in toluene (68% TML)	79	10	0	—	—	
	50	0	—	—	—	
	25	100	100	70	30	13.5
	10	100	100	80	60	
Thallium acetate	180	0	—	—	—	
	100	80	0	—	—	
	75	90	40	0	—	
	56	100	40	10	10	31
	32	100	70	30	30	(24 as Tl)
	24	100	100	90	70	
	18	100	100	100	100	
Tricresyl phosphate	10,000	100	40	40	40	
	5,600	90	90	90	90	
	3,200	100	100	100	100	8,700
	1,800	100	100	100	100	
Triethylene glycol	10,000	100	100	100	100	>10,000
Triphenyl phosphate	560	30	0	—	—	
	320	10	1	0	—	
	180	100	40	20	10	95
	100	100	90	70	30	
	75	100	100	100	100	
Vinylidene chloride (1,1-dichloroethylene)	320	10	10	0	—	
	250	100	90	80	70	250
	180	100	90	90	80	

(*continued on p. 317*)

is 6.2 times that of the saltwater value.

Four of the chemicals displayed LC_{50} values above the published solubility level. This could result from higher solubility at the temperatures tested, but is more likely a result of dissolution kinetics and volatilization. For these substances; ethyl ether, isopropyl ether, methyl chloride, and tricresyl phosphate; further work should be performed with careful analysis of the water to determine the actual soluble levels of the contaminate at each level of response.

A subsequent update of the OHM-TADS files has revealed some new data which can be compared to that reported here. These are presented in Table 4. The ammonium ferricyanide level is of particular interest. It reflects the high toxicity potential for spills in sunlight as a result of cyanide release. This type

TABLE 3

Summary of median lethal concentration (LC_{50}) 96 h fish bioassay, static method

Chemical	Bluegill sunfish (mg/l)	Tidewater silverside (mg/l)
Acetanilide	100	115
Acetone cyanohydrin	0.57	0.50
Ammonium ferricyanide	300	195
Ammonium picrate	220	66
Amyl alcohol (1-pentanol)	650	180
Benzyl alcohol	10	15
Butyl acetate	100	185
Butylamine	32	24
Carbon tetrachloride	125	150
Crotonaldehyde	3.5	1.3
Cyanogen bromide	0.24	0.47
Cyclohexanol	1,100	720
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	420	420
o-Dichlorobenzene	27	7.3
Dichloroethane	550	480
Dichloropropane (1,2-dichloropropane)	320	240
Diethylene glycol monoethyl ether	10,000	10,000
Diethylene glycol monobutyl ether	1,300	2,000
Dimethyl sulfate	7.5	15
Dioxane	10,000	6,700
Epichlorohydrin	35	18
Ethyl ether	10,000	10,000
Ethylene glycol diacetate	90	78
Ethylene glycol monobutyl ether	1,460	1,250
Ethylene glycol monethyl ether	10,000	10,000
Ethylene glycol monoethyl ether acetate	45	40
Ethylene glycol monomethyl ether	10,000	10,000
Hexylene glycol (2-methyl-2,4-pentanediol)	10,000	10,000
Isodecyl diphenyl phosphate	6,700	1,400
m-Nitrochlorobenzene (chloronitrobenzene)	1.2	0.55
Methanesulfonyl chloride	11	15
Methyl bromide	11	12
Methyl chloride	550	270
Morpholine	350	400
Polypropylene glycol	1,700	650
Propionaldehyde	130	100
Sodium fluorosilicate	65	160
Strychnine	0.87	0.95
Tetramethyllead	84	13.5
Thallium acetate	170	31
Tricresylphosphate	7,000	8,700
Triethylene glycol	10,000	10,000
Triphenylphosphate	290	95
Vinylidene chloride (1,1-dichloroethylene)	220	250

TABLE 4

Comparison of values obtained with previous studies

Material	96 h LC_{50} (ppm)		Previous study results	Ref.
	Freshwater	Saltwater		
Ammonium ferricyanide	300	195	1.34 ppm releases toxic levels of CN^- in sunlight	3
N-Amyl alcohol	650	180	10 ppm 94 h TLm for goldfish	4
			350—500 ppm 24 h critical range for creek chub	5
			440 ppm 48 h threshold toxic effect for daphnia at 23° C	6
Benzyl alcohol	10	15	360 ppm 48 h threshold effect for daphnia at 23°C	6
			640 ppm 96 h threshold effect for scenedesmus at 24° C	6
Butyl acetate	100		44 ppm 48 h TLm for daphnia at 23° C	6
			320 ppm 96 h TLm for scenedesmus at 24° C	6
		185	150 ppm 24 h TLm for brine shrimp (static)	7
			32 ppm 48 h TLm for brine shrimp (static)	7
Butylamine	32	24	30—70 ppm 24 h TLm for brine shrimp (static)	5
Diacetone alcohol	420	420	5—10 ppm had no effect on phormidium ambiguum	8
o-Dichlorobenzene	27		10 ppm 72 h total kill with fatheat minnows	9
			4 ppm 72 h partial kill value with fathead minnows	9
			3 ppm 72 h no toxic effect on fathead minnows	9
		7.2	13 ppm stopped growth of marine plankton	10
			>100 ppm 48 h LC_{50} for hard clam eggs	8
			>100 ppm 288 h LC_{50} for hard clam larvae	8
1,2-Dichloroethane	550		500 ppm LC_{50} for fathead minnows	11
			5 ppm 24 h no effect level for rainbow trout and bluegill	11
		480	150 ppm TLm for pin perch in aerated saltwater	6
			320 ppm 24 h TLm for brine shrimp (static)	7

continued

TABLE 4 (continued)

Material	96 h LC_{50} (ppm)		Previous study resylts	Ref.
	Freshwater	Saltwater		
Dichloropropane	320	240	>100 ppm 48 h TLm for shrimp	12
Epichlorohydrin	35		36 ppm 48 h LC_{50} for harlequin fish (static and flow through)	8
		18	11.8 ppm 96 h TLm for sheepshead minnow	9
Ethylene glycol monobutyl ether	1,490	1,250	1000 ppm 24 h TLm for brine shrimp	7
Ethylene glycol monomethyl ether	>10,000	>10,000	15,520 ppm 96 h LC_{50} for rainbow trout fingerlings at 12° C	13
			12,610 ppm 96 h no mortality level for rainbow trout fingerlings at 12° C	13
Hexylene glycol	>10,000	>10,000	5900 ppm 24 h TLm for brine shrimp (static)	7
Sodium fluorosilicate	65	160	50 ppm lethal to tinca vulgaris	6
			0.08—0.13 ppm not toxic to gammorus pseudolimnaeus or fathead minnow	8
Strychnine	0.87	0.95	1.7 ppm narcosis in 0.16 h with lemon shark	8
Tetramethyllead	84	13.5	0.02 ppm 96 h LC_{50} for tetraethyllead with bluegill	14
Thallium acetate	132 as Tl		0.03 ppm Tl LD_{50} for atlantic salmon	15
			0.4 ppm Tl lethal to tadpoles	15
		24 as Tl	10 ppm Tl 96 h LC_{50} to brown shrimp	16

of effect may not be seen in laboratory evaluations such as that reported here. In general, the data are in good agreement with previous studies when consideration is given to the different levels of sensitivity between test species. However, it is emphasized that these values are approximate in nature. If anything, they are high and, therefore, are useful as a conservative determination of which materials are likely to qualify as hazardous substances under Section 311, but they do not compare to values which could be obtained from a more rigorous undertaking. Consider the case of thallium acetate in freshwater. The high values obtained here probably reflect the formation of insoluble salts such that the soluble levels of Tl are much closer to those reported in earlier studies. The reported value of 10 ppm, however, is still well below the 500 ppm value proposed as the threshold for regulation as hazardous substances.

References

1 Federal Register, Vol. 40, No. 250, December 30, 1976.
2 C.H. Thompson and G.W. Dawson, "Emergency Data for Hazardous Substances", 28th Annual Purdue Industrial Waste Conference, Lafayette, Indiana, May 1—3, 1973.
3 G.E. Burdick and M. Lipschustz, "Toxicity of Ferro and Ferricyanide Solutions to Fish and Determination of the Cause of Mortality", Trans American Fish Society, Vol. 78, 1948.
4 A.D. Little, Inc., Relationship Between Organic Chemical Pollution of Fresh Water and Health, FWQA, 71632, December 1970.
5 L.A. Gillette, D.L. Miller and H.E. Redman, "Appraisal of a Chemical Waste Problem by Fish Toxicity Test", Sewage and Industrial Wastes, 24 (1975) 1397.
6 J.E. McKee and H.W. Wolf, "Water Quality Criteria", USPHS, Control Board, Pub. 3-A, April 1971.
7 K.S. Price, G.T. Waggy and R.A. Conway, "Brine Shrimp Bioassay and Seawater BOD of Petrochemicals", Journal WPCF, 46 (1) 1974.
8 H.T. Kemps, R.L. Little, V.L. Holman and R.L. Darby, "Water Quality Criteria data Book, Vol. 5 Effects of Chemicals on Aquatic Life", U.S. EPA, PB 234 435, September 1973.
9 Data from files of Dow Chemical Company provided by Dr. R.J. Moolenaar, June 4, 1974.
10 R. Ukeles, "Growth of Pure Cultures of Marine Phytoplankton in the Presence of Toxicants", Applied Microbiology, 10 (6) (1962) 532.
11 Oceanography International, October 1970.
12 J.E. Portman, "The Toxicity of 120 Substances to Marine Organisms", Shellfish Information Leaflet, Fisheries Experimental Station, Conway, N. Wales, Ministry of Agriculture, Fisheries, and Food, September 1970.
13 P. Benville, "Acute Toxicity of Nine Solvents to Rainbow Trout Fingerlings", (unpublished) transmitted from Tiburon Laboratory, NOAA, July 10, 1974.
14 C.G. Wilber, The Biological Effects of Water Pollution, Charles C. Thomas, Springfield, IL, 1969.
15 V. Zitko, "Toxicity and Pollution Potential of Thallium", The Science of the Total Environment, 4 (1975) 185.
16 J.E. Portmann and K.W. Wilson, "The Toxicity of 140 Substances to the Brown Shrimp and Other Marine Animals", Shellfish Information Leaflet No. 22, Fisheries Experiment Station, Conway, N. Wales, December 1971.