BIOASSAYS OF THE [redacted] WASTEWATER TREATMENT PLANT

MERRITT ISLAND, BREVARD COUNTY, FLORIDA

NPDES #FL0026816

SAMPLED 10/18/83

Biology Section
Bureau of Water Analysis
December 7, 1983

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EXECUTIVE SUMMARY

Fortenberry WWTP, NPDES #FL0026816, Merritt Island, on 19 to 21 October, 1983.

Each of the pre-chlorinated, chlorinated and de-chlorinated effluents from this small domestic waste treatment facility were equally toxic to the test organism, Mysidopsis bahia, producing 48 hour LC_{50} values of 24.3%, 22.2%, and 19.0%, respectively. These results are very consistent with the results of two previous bioassays of this facility, in 1982 and early 1983. This suggests little or no alleviation by the facility of this problem.

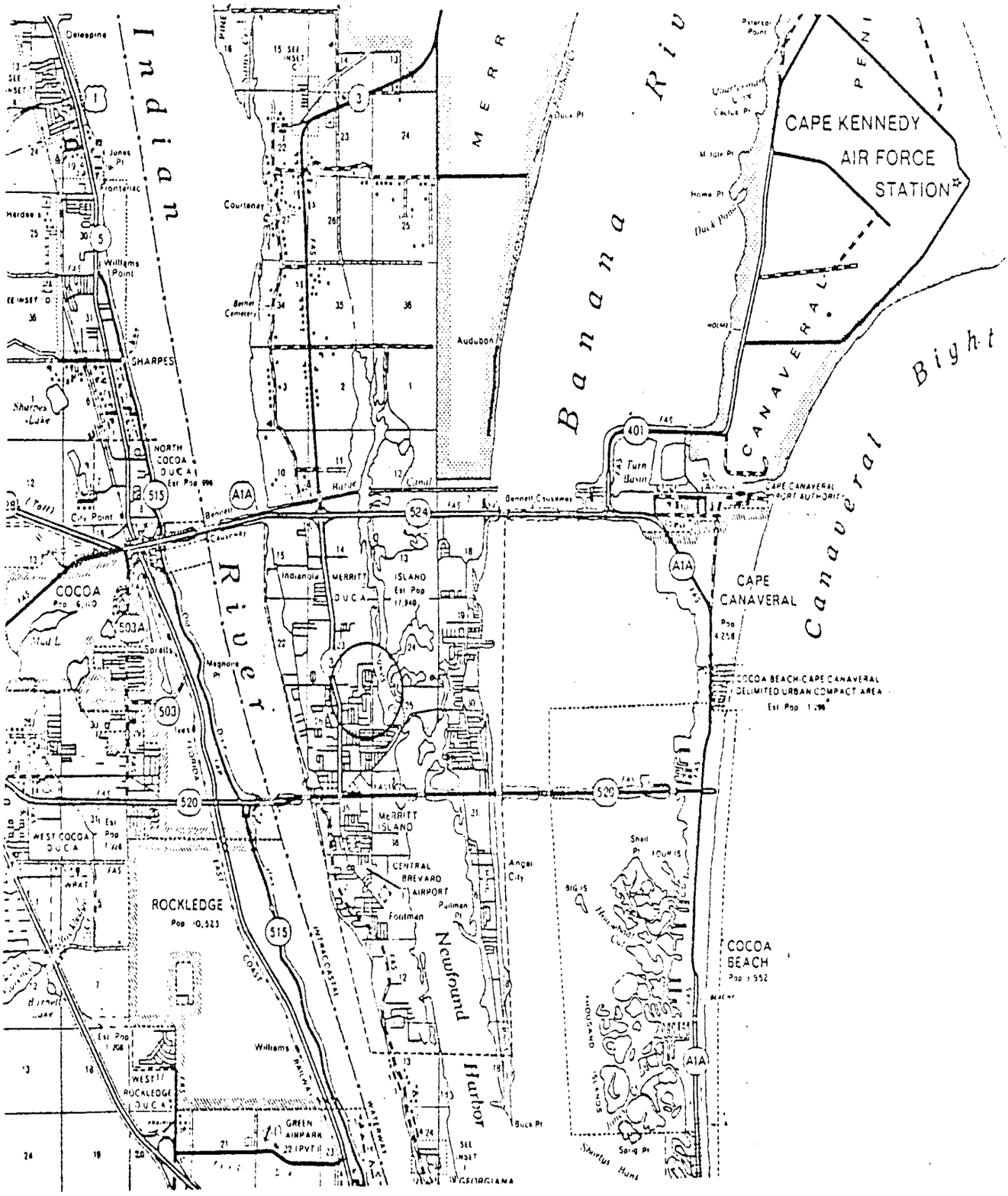
The toxicity noted in these latest bioassays could not have been caused solely by either ammonia or total residual chlorine, since ammonia was not present in significant concentrations, and the toxicity noted in the chlorinated effluent was essentially the same as that of the pre-chlorinated and de-chlorinated samples. Chemical analyses of these effluent samples indicated the presence of the pesticide Lindane (0.2 µg/l) in both pre- and post-chlorinated effluents, and a significant concentration of mercury (5.6 µg/l) in the final effluent. Lindane has been present in every Fortenberry STP effluent analyzed by the DER Chemistry Section, and may account for some of the toxicities noted in these and past bioassays. Additionally, the mercury detected in the effluent during these recent bioassays may have been sufficient to have contributed to the current toxicities noted.

INTRODUCTION

The Fortenberry Wastewater Treatment Plant is located at the corner of South Plumosa and Fortenberry Roads, in Merritt Island, Brevard County, Florida (Fig. 1). This relatively small facility (design capacity of 0.8 MGD) treats an average of 0.69 MGD of domestic waste from a population of approximately 10,000. According to the NPDES permit, no industrial wastes are treated at this facility. However, the plant has been in violation for exceeding BOD, TSS and fecal coliform limitations. Effluent is discharged to Fortenberry Ditch which flows to Sykes Creek, a tributary of Newfound Harbor. Newfound Harbor is a portion of the Banana River (Fig. 1).

The Biology Section had previously performed toxicity bioassays on samples of pre-chlorinated, chlorinated and de-chlorinated effluents from this facility in April, 1982, and again in January, 1983. The results of those tests indicated that all three effluents were consistently toxic to *Mysidopsis bahia*, producing 48 hour LC_{50} values of approximately 12%, 12% and 13%, and, 21.5%, 23.9%, and 24.5%, respectively (FDER 1982 and 1983). The toxicity of those effluents was attributed to the presence of the pesticides Lindane and Malathion, and to ammonia.

To further evaluate the existance and extent of toxicity of these samples of effluent to the biota of the receiving waters, the Biology Section performed additional static acute toxicity bioassays on grab samples on 19 to 21 October, 1983. The results of these latest tests are presented in this report. Those involved in performing these tests and in preparation of this report were: R. B. Frydenborg and M. L. Roll.



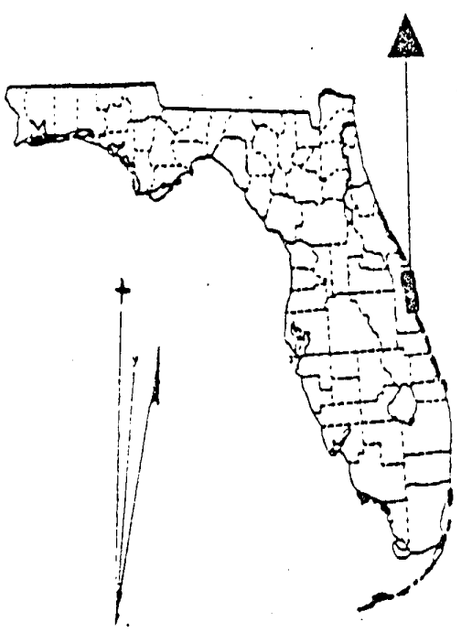


Figure 1. Portions of Brevard County, Florida, including City of Merritt Island and study area.

METHODS AND MATERIALS

Test methods used to conduct these static bioassays are extensively described by Peltier (1978). The organism selected for this study is among those recommended by Peltier (1978) and the U.S. EPA (1978). The life history and maintenance procedures used to culture the organism are detailed below.

History and Maintenance of Bicassay Organisms

Mysidopsis bahia (mysid shrimp) - In September, 1978, approximately 300 adult mysid shrimp were obtained from the EPA laboratory in Gulf Breeze, Florida. The mysids are cultured under a 16:8 hour light-dark cycle in 10 and 15 gallon all-glass aquaria equipped with undergravel filtration and aeration. The mysid shrimp are cultured over a wide range of salinities (10-30 ppt) to minimize acclimation periods to low or high salinity effluents. Seawater is obtained from the FSU Marine Laboratory located at Turkey Point, Florida (salinity range 17-31 ppt) and partial water changes are performed weekly. Freshwater, for dilution of the seawater as necessary, is obtained from a deep well near the DER laboratory. The mysids are fed twice daily with freshly hatched Artemia (brine shrimp) and are kept at a constant temperature of 22° plus or minus 1°C. Large juveniles to adult mysids were used in these tests.

To ensure the uniform sensitivity of these test organisms to toxic substances, the Biology Section conducts monthly standard reference toxicant bioassays using sodium lauryl sulfate as the reference toxicant.

Test Methods

Three separate 48 hour static acute toxicity bioassays were performed on samples of pre-chlorinated, chlorinated and de-chlorinated effluents from the Fortenberry WWTP. The tests were preformed from 1100 hours on 19 October to 1100 hours on 21 October, 1983. The samples were collected by Mr. Louis Ley of DER's Orlando office at 1540 hours on 18 October, 1983, using standard wastewater sampling procedures. Separate samples were obtained for chemical and biological testing. Samples for metal analyses were preserved with HNO_3. Samples for organic chemical analyses and for the bioassays were unpreserved. The samples were iced and transported to the DER laboratory in Tallahassee for analyses within 24 hours of collection.

To differentiate between the toxicity resulting from chlorine and the toxicity associated with some other component of the effluent, the Biology Section adopted the following test procedure:

Test #1. Pre-chlorinated Effluent (Table 2). This test was performed on an effluent sample collected at the end of the treatment process but prior to chlorination, and was intended to evaluate the toxicity of the effluent without the added toxic effects of chlorine.

Test #2. Chlorinated Effluent (Table 3). This test was performed on an effluent sample collected at the point of discharge.

Test #3. De-chlorinated Effluent (Table 4). This test was performed on a subsample of the chlorinated effluent sample in which the chlorine had been neutralized. De-chlorination was accomplished by adding a calculated amount of 0.025 N sodium thiosulfate. This test was intended to evaluate the combined toxicity of the effluent and the chlorine reaction products.

Saltwater for dilution of the effluent samples was obtained from the FSU Marine Laboratory at Turkey Point (salinity = 25.0 ppt). For test concentrations of 56% and below, this diluent was mixed directly with the effluent, achieving a range of final salinities (12.0 ppt to 23.9 ppt). For the 100% effluent test concentrations, freshly autoclaved artificial sea salts (Ocean 50®) were added until salinities of approximately 7 ppt were achieved (the lower limit of mysid shrimp salinity tolerance). Two control groups (Table 2) were then used to ensure that any mortality in the test organisms was not the result of toxic properties associated with the diluent, the artificial sea salts, or the salinity range. The control groups included:

1) Diluent Control - Turkey Point water (25.0 ppt). This represents the highest concentration of Turkey Point water used in the bioassays, and tests for toxicity in the diluent. This is also the highest salinity used in the bioassays, and therefore tests the tolerance of the organisms to this salinity.

2) Sea Salts Control - Well water, adjusted with artificial sea salts (Ocean 50®) to approximately 7 ppt salinity. This tests for toxicity of the highest concentration of artificial sea salts used in the bioassays, as well as for tolerance of the organisms to the lowest salinity used in the bioassays.

The concentration series selected for this study (Table 1) is that recommended by APHA (1980). Two replicates of each test concentration and of the controls were used to test with Mysidopsis bahia. Immediately prior to the bioassays, a suitable number of mysids were transferred by net from the 10 ppt, 15 ppt, 20 ppt, and 25 ppt salinity aquaria to culture dishes for observation and selection of individuals for the tests. Individual mysid shrimp were siphoned using a glass tube, carefully examined for injury, and transferred to wide mouth quart jars, each containing 500 ml of the appropriate concentration. For each concentration, the mysid shrimp were pre-acclimated to within 4 ppt salinity. Five organisms were loaded per test chamber, giving ten per concentration.

Dissolved oxygen (YSI Model 57 oxygen meter), pH (Corning Model 7 pH meter with Orion Ross® combination electrode), temperature (NBS calibrated glass thermometer), and the number of live organisms were recorded for each test concentration at 0 hours, 24 hours, and 48 hours. The salinity (YSI Model 33 S-C-T meter) of each test concentration was recorded at the beginning and end of the test. All instruments were calibrated daily according to manufacturer's recommendations. Ammonia concentrations, including the total and unionized fraction (expressed in mg/l as N and as NH_3, respectively), were recorded in the seawater control and the 100% effluent test concentrations at the beginning of the test. Total ammonia concentrations were determined using an Orion® specific ion probe and an Orion Ionalyzer®. The unionized fraction was then calculated based on the total ammonia concentration, and the pH, temperature, and salinity of the sample. These values were recorded on the bioassay data forms and are presented in Tables 2, 3 and 4.

Table 1. Concentration Series and Volumes Used for These Static Bioassays

Mydidopsis bahia (mysid shrimp)

Concentration	Dilution Water	Effluent	Total Volume
Control	500 ml	------	500 ml
5.6%	472 ml	28 ml	500 ml
10.0%	450 ml	50 ml	500 ml
32.0%	340 ml	160 ml	500 ml
56.0%	220 ml	280 ml	500 ml
100.0%[a]	------	500 ml	500 ml

[a] A 100% test concentration was not used in the bioassay of the chlorinated effluent.

Table 2. Data recorded during 48 hour, Mysidopsis bahia, static acute toxicity bioassay of the Fortenberry WWTP, Merritt Island, Brevard County, Florida, NPDES #FL0026816, on 19 to 21 October, 1983.

Test #1 Controls and Pre-chlorinated Effluent[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			NH_3/N (mg/l)		Salinity (ppt)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48	0	48
Seawater Control	5	5	4(5)[b]	6.6	6.2	6.9	8.0	7.9	7.8	21.4	21.5	20.4	0/0	---		
Seawater Control	5	5	5	6.6	6.2	6.9	8.0	7.9	7.8						25.0	24.8
Sea Salts Control	5(4)[b]	4	4	7.9	7.6	7.5	8.6	8.4	8.2	21.9	21.5	20.4				
Sea Salts Control	5(4)[b]	4	4	7.9	7.6	7.4	8.6	8.4	8.2						7.5	7.2
5.6%	5	5	4(5)[b]	6.5	6.2	6.8	8.0	7.9	7.9	21.4	21.3	20.1				
5.6%	5	5	5	6.5	6.3	6.9	8.0	7.9	7.9						23.5	23.2
10.0%	5	5	5	6.4	6.3	6.9	7.9	7.9	7.9	21.4	21.1	20.0				
10.0%	5	5	5	6.5	6.3	6.9	7.9	7.9	7.9						23.0	22.7
32.0%	5(4)[b]	4	1	6.1	6.5	7.0	7.6	7.8	7.9	21.4	21.0	20.0				
32.0%	5	3	1	6.1	6.5	7.1	7.6	7.8	7.9						18.0	17.8
56.0%	5	2	0	5.8	6.6	7.2	7.3	7.8	8.0	21.4	21.0	20.0				
56.0%	5	3	1	5.9	6.7	7.2	7.3	7.8	8.0						12.3	12.0
100.0%	5	0	0	5.6	6.6	7.0	7.7	8.0	8.1	21.6	21.1	20.1	.05/1.95	---		
100.0%	5	0	0	5.5	6.4	7.0	7.7	8.0	8.0						7.8	7.8

Remarks: [a] Total Residual Chlorine: None Detected (Hach DPD Method).

[b] Numbers in parentheses used to determine mortality since organisms were cannibalized.

Table 3. Data recorded during 48 hour, Mysidopsis bahia, static acute toxicity bioassay of the Fortenberry WWTP, Merritt Island, Brevard County, Florida, NPDES #FL0026816, on 19 to 21 October, 1983.

Test #2 Chlorinated Effluent[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			NH_3/N (mg/l)		Salinity (ppt)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48	0	48
5.6%	5(4)[b]	4	4	6.5	6.2	6.6	8.0	7.9	7.9	21.3	21.5	20.5				
5.6%	5	5	5	6.5	6.2	6.6	8.0	7.9	7.9						23.5	23.3
10.0%	5	5	4(5)[b]	6.6	6.5	6.7	7.9	7.9	7.9	21.2	21.5	20.4				
10.0%	5	5	5	6.6	6.7	6.9	7.9	7.9	7.9						22.9	22.7
32.0%	5	5	2	6.5	7.2	6.8	7.6	7.9	7.9	21.3	21.4	20.4				
32.0%	5	4	0	6.5	7.3	6.8	7.6	7.9	7.9						17.5	17.9
56.0%	5	1	0	6.7	7.5	6.0	7.4	7.9	7.9	20.7	21.6	20.5				
56.0%	5	0	0	6.7	7.6	6.0	7.4	7.9	7.9						12.0	12.1
100.0%[c]													.04/1.6	----		

Remarks: [a] Total Residual Chlorine: 1.3 mg/l (HACH DPD Method), 1.06 mg/l (Iodometric Method I).

[b] Numbers in parentheses used to determine mortality since organisms were either cannibalized or had jumped out.

[c] Due to a shortage of organisms and to the known toxicity of 1.3 mg/l chlorine, a 100% test concentration was not used.

Table 4. Data recorded during 48 hour, *Mysidopsis bahia*, static acute toxicity bioassay of the Fortenberry WWTP, Merritt Island, Brevard County, Florida, NPDES #FL0026816, on 19 to 21 October, 1983.

Test #3 De-chlorinated Effluent[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			NH_3/N (mg/l)		Salinity (ppt)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48	0	48
5.6%	5(4)[b]	4	3	6.5	6.3	6.7	8.0	7.9	7.9	21.4	21.1	20.1				
5.6%	5	5	5	6.4	6.3	6.7	8.0	7.9	7.9						23.9	23.2
10.0%	5(4)[b]	4	4	6.6	6.2	6.9	7.9	7.9	7.9	21.4	21.0	20.0				
10.0%	5	5	5	6.6	6.2	6.9	7.9	7.9	7.9						23.0	22.3
32.0%	5	3	0	6.8	6.4	7.0	7.7	7.9	7.9	21.6	21.0	20.0				
32.0%	5	5	0	6.8	6.5	7.0	7.7	7.8	7.9						18.0	17.9
56.0%	5	3	2	7.0	6.2	6.9	7.5	7.8	7.9	21.7	21.2	20.3				
56.0%	5	1	0	7.2	6.5	6.9	7.5	7.8	7.9						12.3	12.1
100.0%	5	1	0	7.6	6.9	6.7	8.0	8.1	8.0	22.3	21.5	20.4	0.03/0.6	----		
100.0%	5	1	0	7.6	7.2	6.7	8.0	8.1	8.0						7.5	7.3

Remarks: [a] Total Residual Chlorine: < 0.04 mg/l (HACH DPD Method).

[b] Numbers in parentheses used to determine mortality since organisms were cannibalized.

Table 5. LC_{50} Data for Bioassays of the Fortenberry STP, Merritt Island, on 19-21 October, 1983.

Organism	Method of Data Analysis	24 Hour LC_{50} and 95% Confidence Intervals	48 Hour LC_{50} and 95% Confidence Intervals
Test #1: *M. bahia*	Binomial	56.0% (10 and 100)	22.7% (10 and 56)
Pre-chlorinated	Moving Average	41.4% (31 and 58), c	24.3% (18 and 36),c
Sample	Probit	48.9% (35 and 64)	26.1% (16 and 35)
Test #2: *M. bahia*	Binomial	42.3% (32 and 56)	22.2% (10 and 56)
Chlorinated	Moving Average	42.3% (31 and 69)	a
Sample	Probit	42.3% (35 and 52)	a
Test #3: *M. bahia*	Binomial	49.0% (10 and ∞)	17.9% (10 and 100)
De-chlorinated	Moving Average	52.3% (34 and 94)	19.0% (13 and 28), c
Sample	Probit	53.1% (36 and 79), c	19.4% (0 and ∞), b

[a] Due to the distribution of mortality, an LC_{50} value cannot be calculated using this method of statistical analysis.

[b] Due to the distribution of mortality, results calculated using the probit method are not statistically sound.

[c] This LC_{50} value is reported in the text since it is the most statistically conservative value of the data set.

Table 6. Results of Chemical Analyses Performed on Effluents from the Fortenberry WWTP, NPDES #FL0026816, collected on October 18, 1983.

	Organics	
	Pre-chlorinated Effluent	Chlorinated Effluent
Base Neutral Extractables	N.D.	N.D.
Pesticide Extractables	Lindane (0.2 µg/l) several unidentified components	Lindane (0.2 µg/l) several unidentified components

Metals	
Cadmium	N.D.
Copper	N.D.
Lead	N.D.
Mercury	5.6 µg/l
Nickel	N.D.
Silver	N.D.
Zinc	26 µg/l

N.D. = None Detected

RESULTS AND DISCUSSION

The samples of pre-chlorinated, chlorinated, and de-chlorinated effluents collected from the Fortenberry WWTP proved to be equally toxic to the test organism, Mysidopsis bahia. The pre-chlorinated effluent produced a 24 hour LC_{50} of 41.4%, and a 48 hour value of 24.3% (Table 5). The chlorinated effluent produced a 24 hour LC_{50} of 42.3%, and a 48 hour value of 22.2% (Table 5). The de-chlorinated effluent produced a 24 hour LC_{50} of 53.1%, and a 48 hour value of 19.0% (Table 5). The 96 hour LC_{50}'s for these effluents would be less than equal to their 48 hour values.

The toxicity noted in these bioassays could not have been caused solely by either ammonia or total residual chlorine. The concentrations of total and unionized ammonia detected in these effluents (0.6 mg/l to 1.95 mg/l and 0.03 mg/l to 0.05 mg/l, respectively) are significantly below incipient toxicity levels for sensitive freshwater fish reported by Thurston, et al. (1981). Likewise, total residual chlorine was not present in the pre-chlorinated and de-chlorinated effluents, and the toxicity noted in the chlorinated effluent was greater than what would have been caused soley by chlorine. It is apparent that the toxicity noted in these bioassays was the result of some other chemical components and characteristics, and was not mitigated by either chlorination or by normal wastewater treatment at this facility.

The DER Chemistry Section has analyzed effluents from the Fortenberry WWTP for certain organics and metals (Table 6). These analyses indicated the presence of the pesticide Lindane (0.2 µg/l) in both pre- and post-chlorinated effluents, and a significant concentration of mercury (5.6 µg/l) in the final effluent. Lindane has been presnet in every Fortenberry STP effluent analyzed by the DER Chemistry Section, and may account for some of the toxicities noted in these and past bioassays. Additionally, the mercury detected in the effluent during these recent bioassays may have been sufficient to have contributed to the current toxicities noted. Eisler (1974 in U.S. EPA, 1976) found that concentrations of 1.0 µg/l mercury represent a distinct threat to selected species of marine organisms.

Discussion of the Toxicity Criteria

The toxicity standards of Chapters 17-3 and 17-4, F.A.C., are complex. Because of this complexity, they will be briefly reviewed here so that these test results may be more readily compared with the standards. For legal purposes, however, the language of the Florida Administrative Code should be consulted directly.

The two basic concepts utilized in the standards are acute and chronic toxicity (defined in 17-3.021(1) and (4), respectively). Simplifying the actual F.A.C. language somewhat, acute toxicity is defined as the presence of a substance in a concentration one-third as great as that concentration which kills one-half of the test organisms in 96 hours, i.e., one-third of the 96 hour LC_{50}. Chronic toxicity is similarly defined as one-twentieth of the 96 hour LC_{50}. Therefore, if a test solution kills one-half or more of a group of test organisms in 96 hours, it must contain at least three times the defined "acutely toxic" concentration and at least twenty times the "chronically toxic" concentration of some substance or substances. If a test solution causes that same mortality in less than 96 hours, (for example, in 24 or 48 hours), it is at least as toxic as the example given above, and actually is probably considerably more toxic.

The particular restrictions applied to a given discharger depend upon the existance of a mixing zone, whether as a specific part of the permit or based on the existance of a currently valid permit predating the language in Chapter 17-4 requiring mixing zone designation. In the absence of a mixing zone, the general criteria for surface waters (17-3.061) are applicable at all points, beginning at the point of discharge. This section prohibits the discharge of substances in concentrations which are chronically toxic (17-3.061(2)(p)); that is, the concentrations cannot exceed one-twentieth of the 96 hour LC_{50} as discussed above. If a mixing zone does exist, then this chronic toxicity standard is only applicable from the edge of the mixing zone and beyond. Within the mixing zone, the less stringent acute toxicity standard of the minimum criteria for all waters (17-3.051(1)(d)) applies: one-third of the 96 hour LC_{50}. The acute toxicity standard does not apply, however, to each point within a mixing zone not designated for dredge and fill permitting, but rather to the average of a number of points within such a mixing zone, based on the provisions of the surface water mixing zones section of Chapter 17-4 (17-4.244(4)). At the same time, though, this same rule prohibits waste concentrations within such a mixing zone (i.e., at any point within the mixing zone), from exceeding the 96 hour LC_{50}. Therefore, at any point within such a mixing zone, including the point of discharge, one-half of the test organisms cannot be killed in 96 hours. Within a mixing zone designated for dredge and fill permitting, the acute toxicity standard (one-third of the 96 hour LC_{50}) applies at all points, including the point of discharge.

From the above discussion, it should be clear that if the least stringent toxicity standard, the 96 hour LC_{50}, is exceeded at any point, from the point of discharge outwards, by any discharger, then a violation of the standards has occurred. This is an important consideration since the test

procedure here reported involves the measurement of the 50% lethal concentration, and not some fraction of that concentration. Any discharger required to meet the one-twentieth of the 96 hour LC_{50} standard is therefore being tested very leniently. Any reduction in the test period from 96 hours provides an added degree of leniency to a discharger.

A number of different dilutions were examined in order to determine by how much, if any, the discharge exceeds the 96 hour LC_{50}. For example, if the sample, after two-fold dilution with diluent (a 33% concentration), kills one-half of the test organisms after 96 hours, then the sample is three times as toxic as is allowed by that standard. Similarly, if a 5% solution of the sample kills 50% of the organisms, the sample is twenty times as toxic as is allowed. Toxicities are reported here in that manner, i.e., in terms of the percentage dilution of the test sample. The smaller the percentage which is reported means a correspondingly greater toxicity.

Note that even if a discharger receives a very large mixing zone not designated for dredge and fill permitting, the regulations require that the maximum toxicity at any point within the mixing zone be restricted to the 96 hour LC_{50}. The results here reported are based on actual effluent samples, representative of the effluent concentration which enters waters of the state at the point of discharge. If it is demonstrated that, under the conditions existing at the point of discharge, effluent concentrations will be less than at the actual sampling point (if the two points are different), the reported bioassay results will reflect the reduced discharge concentration.

With respect to the species of organisms used in these tests, the language of the F.A.C. indicates that they should be "significant to the indigenous aquatic community". All species used in these tests are significant to the indigenous aquatic community since they are sensitive to toxic substances which may be expected to impact the indigenous community.

The toxicity reported here is in excess of allowable limits.

LITERATURE CITED

American Public Health Association. 1980. Standard Methods for the Examination of Water and Wastewater. 15th ed. 1134 p.

Florida Department of Environmental Regulation, Biology Section. 1982. Bioassays of the Fortenberry Wastewater Treatment Plant, Merritt Island, Brevard County, Florida. NPDES #FL0026816. FDER. 17 p.

Florida Department of Environmental Regulation, Biology Section. 1983. Quality Assurance Manual for Performing Acute Toxicity Tests. FDER. 22 p.

Florida Department of Environmental Regulation, Biology Section. 1983. Bioassays of the Fortenberry Wastewater Treatment Plant, Merritt Island, Brevard County, Florida. NPDES #FL0026816. FDER. 15 p.

Peltier, W. 1978. Methods for measuring the acute toxicity of effluents to aquatic organisms. Environmental Research Laboratory. Athens, Georgia. EPA-600/4-78-012 (Revised July 1978). 51 p.

Thurston, R.V., Russo, R.C. and G.A. Vinogradov. 1981. Ammonia toxicity to fishes: Effect of pH on the toxicity of the unionized species. Env. Sci. Tech. 15(7): 837-840.

U.S. Environmental Protection Agency. 1976. Quality Criteria for Water. U.S. EPA, Washington, D.C. 256 p.

U.S. Environmental Protection Agency. 1978. Bioassay procedures for the Ocean Disposal Permit Program. Environmental Research Laboratory. Gulf Breeze, Florida. EPA-600/9-78-010. 121 p.