

BIOASSAYS OF THE JACKSONVILLE U.S. NAVAL AIR STATION SEWAGE TREATMENT PLANT DISCHARGE AND PORTIONS OF INDUSTRIAL WASTEWATER

JACKSONVILLE, DUVAL COUNTY, FLORIDA

NPDES #FL0000957

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APRIL 18, 1986

Biology Section
Division of Environmental Programs

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Biology Section
Bureau of Laboratories and
Special Programs
April 18, 1986

EXECUTIVE SUMMARY

Jacksonville NAS Sewage Treatment Plant Discharge and Portions of Industrial Wastewater, NPDES #FL0000957, on 22 to 24 January, 1986.

The final chlorinated effluent from this U.S. government facility proved to be acutely toxic to the test organisms, Daphnia pulex and Notropis leedsi, producing 48 hour LC_{50}'s of < 10% and 16.6%, respectively. This toxicity can be mostly attributed to the total residual chlorine (1.1 mg/l HACH DPD Method) measured in this sample. This same effluent after de-chlorination, was not toxic to the same test organisms.

The sample of industrial wastewater from this facility was not acutley toxic to either D. pulex or to N. leedsi, even though the sample was characterized by a high pH (9.9 s.u.). Several N. leedsi deaths were noted during the test, but the mortality was insufficient to calculate an LC_{50}.

The ammonia detected in these samples (maximum = 0.04 mg/l unionized) was insufficient to have contributed to the toxicity. Since the above toxicity was attributed mostly to chlorine, chemical analyses were not performed.

INTRODUCTION

The Jacksonville U.S. Naval Air Station is a U.S. Government facility located in Jacksonville, Duval County, Florida (Figure 1). The associated sewage treatment plant treats waste from the air station, including domestic waste, water from industrial cooling systems, boiler wash, vehicle and equipment cleaning operations, and other miscellaneous sources. The plant has a design capacity of 3.0 MGD and is currently operating near this level, 2.6 MGD. Discharge is to the St. Johns River (NPDES Outfall #001).

The NPDES permit for this facility contains limits for many potentially toxic substances, including chromium, zinc, copper, cyanide and phenol. Additionally, this facility has received notices for exceeding its permit limitations and for the inadequate disposal of sludges and solids.

The Biology Section had previously performed bioassays on samples of pre-chlorinated, chlorinated, and de-chlorinated effluents from this facility, in May, 1981. The results of those tests indicated that the pre-chlorinated and de-chlorinated effluents were not toxic to Daphnia pulex, while the chlorinated effluent was extremely toxic to Daphnia, with 24 and 48 hour LC_{50} values of < 5.6% (FDER 1981). The toxicity was attributed to the presence of total residual chlorine.

To again evaluate the existence and extent of toxicity of this effluents, the Biology Section performed additional static acute toxicity bioassays on grab samples, on 3 to 5 August, 1982. The results of those tests indicated that the effluent was not toxic. Only a small residual chlorine (< 0.05 mg/l) was detected at that time (FDER 1982).

Additional bioassays were performed in August, 1983, on samples of pre-, post-, and de-chlorinated effluents from this facility. Once again, the chlorinated effluent was extremely toxic to D. pulex (LC_{50} = < 5.6%). Mortality was also noted in the samples of pre- and de-chlorinated effluents (FDER 1983).

In January, 1986, DER's Northeast District requested additional bioassays to further evaluate the toxicity of this effluent. Grab samples of final effluent from the sewage treatment system and from upstream of the industrial wastewater system were collected. The results of this latest series of bioassays are presented in this report. Those involved in performing the tests and in preparation of this report were: M. L. Roll and P. G. Weiland.

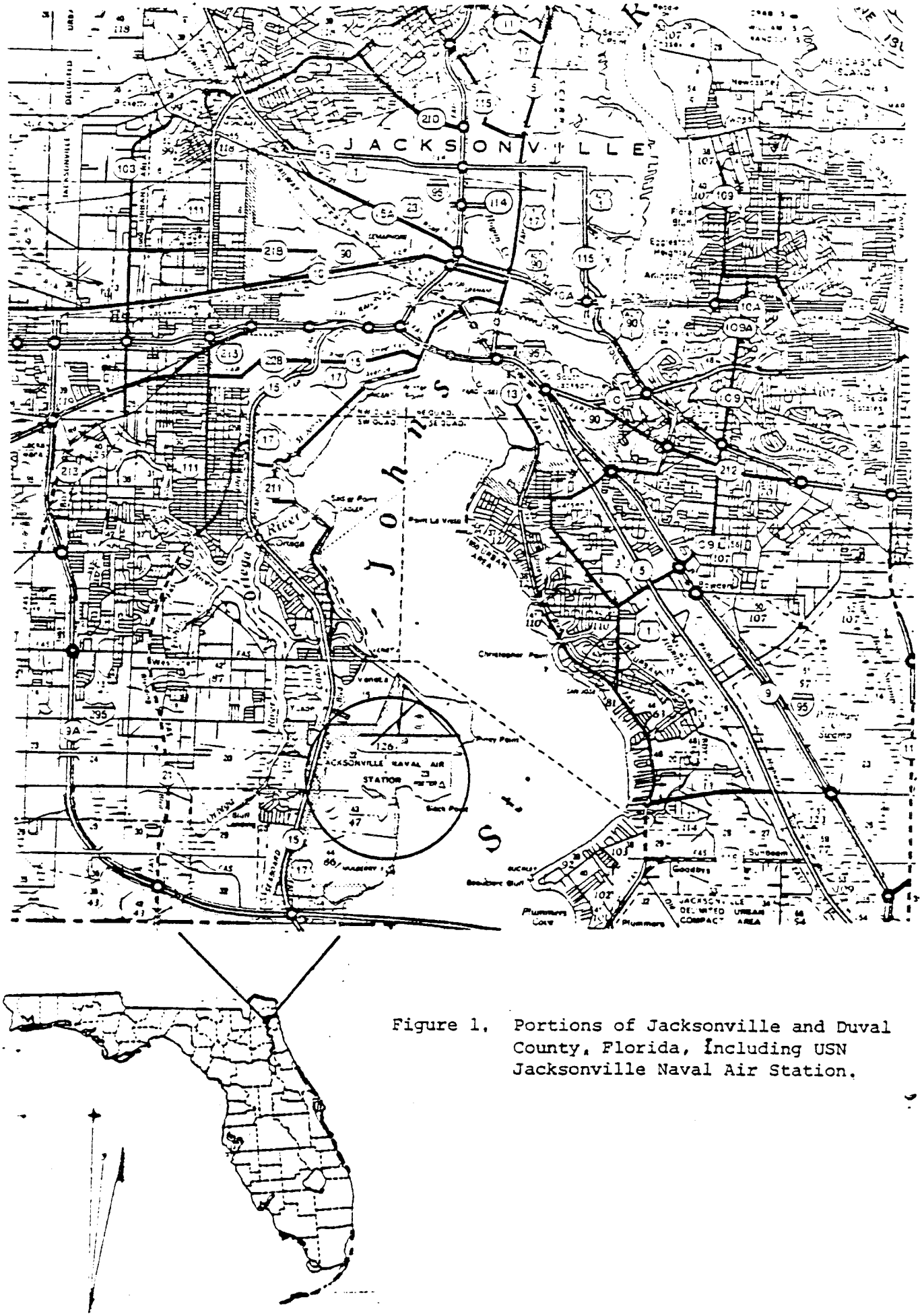


Figure 1. Portions of Jacksonville and Duval County, Florida, including USN Jacksonville Naval Air Station.

METHODS AND MATERIALS

Test methods used to conduct these static bioassays are extensively described by Peltier and Weber (1985) and the FDER Biology Section (1985). The organisms selected for this study include a species recommended by Peltier and Weber (1985), the U.S. EPA (1978), and the FDER Biology Section (1985). Additionally, the Biology Section maintains cultures of several species of organisms indigenous to the State of Florida. One of these indigenous species was also selected for testing. Life histories of these test organisms and maintenance procedures used to culture them are detailed below.

History and Maintenance of Bioassay Organisms

Daphnia pulex (water flea) - A breeding culture of Daphnia pulex was obtained from the EPA laboratory in Athens, Georgia, in March, 1979. This culture has been maintained since its arrival in 2 1/2 gallon all-glass aquaria, filled with unchlorinated DER well water, under a 16:8 hour light-dark cycle. Organisms are fed a liquified blend of Purina Trout Chow® and Cerophyl® twice daily, once daily on weekends, and are kept at a constant temperature of 22° ± 2°C. The aquaria are cleaned weekly by siphoning off half the water along with the detritus and excess organisms, and then refilling with fresh aerated well water. Additional measures are taken and/or new cultures started in the event of abnormal circumstances such as: declining populations, ephippia formation, or excessive fungal or bacterial growth.

Notropis leedsi (bannerfin shiner) - Approximately 40 adult bannerfin shiners were obtained from an indigenous population in the upper Suwannee River during October, 1981. The breeding stock is maintained in 30 and 125 gallon all-glass aquaria equipped with a flow-through water exchange system. Water for this system is unchlorinated and is pumped from the DER hour light cycle and are fed Tetra-Min® and frozen Artemia (brine shrimp) twice daily, and once daily on weekends. Breeding and egg hatching are encouraged at 25°C. The eggs are laid between stacked red ceramic tiles separated by a 3mm bead of silicone. Most of the eggs adhere to the tiles and are easily removed to heated, aerated hatching tanks. The narrow space between the tiles eliminates egg predation by adult fish. New hatching tanks are started regularly to segregate fry into even age groups. Newly hatched fry are fed a liquefied blend of Purina Trout Chow® and Cerophyl® twice daily. After one week, feeding is augmented with newly hatched Artemia nauplii and finely crushed Tetra Min®. The fish used in this test were approximately 23 days old at the time of the test.

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

Methods used to perform acute toxicity bioassays are described by Peltier and Weber (1985) and the FDER Biology Section (1985). Some of the methods described below are more specific than those of Peltier and Weber. These will be noted in more detail.

Sampling Methods and Test Dates

A total of six separate 48 hour static acute toxicity bioassays were performed on samples of final chlorinated and de-chlorinated effluents from the sewage treatment facility, and, on a sample collected upstream from the industrial wastewater area. The tests were perfromed from 1045 hours on 22 January to 1150 hours on 24 January, 1986.

The samples were collected by Mr. Jay Carver of DER's Northeast District at 1135 hours on 21 January, 1986, 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.

Test Temperature

Upon arrival of the iced (4°C) bioassay samples in the Tallahassee laboratory, the containers were placed in warm water and the temperature of the samples allowed to rise to 20° $\pm$ 2°C. Although this temperature may be different than the temperature of the sample during collection, it is the temperature range to which the test oranisms are acclimatized and is the range recommended in the above referenced bioassay protocols. This avoids stressful effects caused by exposure to unusually cold or warm samples.

pH Adjustment

Since the sample collected from the industrial wastewater area was characterized by a high pH (9.9 s.u.), additional 100% concentrations with their pH's adjusted with an acid (0.1 N HCl) to 7.2 s.u. were added to the bioassays. Toxicity noted in these pH adjusted concentrations would suggest that the toxicity was due to components other than the high pH.

Total Residual Chlorine

Since many wastewaters are chlorinated, especially those originating from sewage treatment facilities, it is often desirable to differentiate between the toxicity resulting from chlorine and the toxicity associated with other components of the wastewater. To accomplish this, the Biology Section performed concurrent bioassays on a sample of chlorinated

wastewater in which the chlorine had been neutralized. De-chlorination was accomplished by adding a calculated amount of 0.025N sodium thiosulfate. The total residual chlorine concentrations of the tested effluents are given on the bioassay data forms. A comparison of the results of these tests will distinguish between the toxicity due solely to residual chlorine and the toxicity inherently contained in the wastewater.

Freshwater Tests

Freshwater for dilution of the effluent samples was obtained from the same DER deep well that is used to culture the test organisms. The concentration series selected for this study is presented in Table 1.

Two replicates, of each concentration and a control, were used to test with the water flea, Daphnia pulex. Flint glass jars of 250 ml capacity were used as test chambers, and 200 ml of the appropriate test concentration was placed in each chamber. Daphnia were siphoned into a large culture dish to isolate the proper size and age organisms (neonates). To accomplish this, the water fleas were siphoned through a stainless steel screen. The trapped adults were then discarded. These neonates were then transferred by glass pipette, examined for injury, and were loaded 10 per chamber, resulting in 20 per test concentration. Water fleas were not fed during these tests.

Two replicates, of each concentration and a control, were used for the Notropis leedsi (bannerfin shiner) bioassays. The fish were transferred individually or by twos, into wide mouth quart jars containing 500 ml each of the appropirate test concentration, and were loaded 5 per chamber, resulting in 10 per concentration. Fish were not fed during these tests.

Test Parameters

Dissovled 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. Total alkalinity and total hardness (measured as $CaCO_3$ using HACH Chemical Company reagents) were recorded at the beginning of the test for the controls and the 100% effluent concentration. The specific conductance (YSI Model 33 S-C-T meter) of each test concentation was recorded at the beginning and end of the test. All instruments were calibrated daily accoridng to manufacturer's recommendations. Ammonia concentrations, including the total and unionized fraction (expressed in mg/ as N and as NH_3, respectively), were recorded in the controls 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 through 7.

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

Daphnia pulex (water flea)

Concentration	Dilution Water	Effluent	Total Volume
Control	200.0 ml	--------	200 ml
10.0%	180.0 ml	20.0 ml	200 ml
50.0%	100.0 ml	100.0 ml	200 ml
100.0%	--------	200.0 ml	200 ml

Notropis leedsi (bannerfin shiner)

Concentration	Dilution Water	Effluent	Total Volume
Control	500 ml	--------	500 ml
10.0%	450 ml	50 ml	500 ml
50.0%	250 ml	250 ml	500 ml
100.0%	------	500 ml	500 ml

Table 2. Data recorded during 48 hour, Daphnia pulex, static acute toxicity bioassay of Jacksonville NAS Sewage Treatment Plant, NPDES #FL0000957, on 22 to 24 January, 1986.

Sewage Treatment Plant, Chlorinated Effluent[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			Conductivity (umhos)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48
Control	10	10	10	9.4	8.8	8.5	7.5	8.1	7.9	21.0	19.7	20.1		
Control	10	10	10	9.4	8.8	8.5	7.5	8.1	7.9				210	202
10.0%	10	0	0	9.5	8.8	-b	7.5	8.1	-b	21.0	19.6	-b		
10.0%	10	0	0	9.5	8.8	-	7.5	8.1	-				232	-b
50.0%	10	0	0	9.6	8.9	-	7.4	8.1	-	21.2	19.5	-		
50.0%	10	0	0	9.6	8.9	-	7.4	8.1	-				345	-
100.0%	10	0	0	10.2	8.9	-	7.2	8.1	-	21.8	19.5	-		
100.0%	10	0	0	10.2	8.9	-	7.2	8.1	-				490	-

Control Water

NH_3(as NH_3)(mg/l): 0

Total Alkalinity (mg/l $CaCO_3$): 105

Total ammonia (as N)(mg/l): 0

Total Hardness (mg/l $CaCO_3$): 122

100% Effluent

NH_3(as NH_3)(mg/l): .03

Total Alkalinity (mg/l $CaCO_3$): 117

Total ammonia (as N)(mg/l): 3.5

Total Hardness (mg/l $CaCO_3$): 186

[a] Total Chlorine Residual: 1.1 mg/l (HACH DPD Method), 1.15 mg/l (Iodometric Method I).

[b] Remaining parameters were not recorded since all organisms were dead by 24 hours.

Table 3. Data recorded during 48 hour, Notropis leedsi, static acute toxicity bioassay of Jacksonville NAS Sewage Treatment Plant, NPDES #FL0000957, on 22 to 24 January, 1986.

Sewage Treatment Plant, Chlorinated Effluent[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			Conductivity (umhos)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48
Control	5	5	5	9.5	7.9	7.6	7.5	7.9	7.9	21.2	19.7	19.9		
Control	5	5	5	9.5	7.9	7.6	7.5	7.9	7.9				212	205
10.0%	5	5	5	9.7	8.1	7.7	7.5	7.9	7.8	21.2	19.5	19.6		
10.0%	5	3	3	9.7	8.1	7.7	7.5	7.9	7.9				243	230
50.0%	5	0	0	10.0	8.5	-b	7.4	7.9	-b	21.3	19.4	-b		
50.0%	5	0	0	10.0	8.5	-	7.4	7.9	-				362	-b
100.0%	5	0	0	10.4	8.6	-	7.2	7.9	-	22.0	19.4	-		
100.0%	5	0	0	10.4	8.6	-	7.2	7.9	-				570	-

Control Water	
NH_3(as NH_3)(mg/l) 0	Total Alkalinity (mg/l $CaCO_3$) 105
Total ammonia (as N)(mg/l) 0	Total Hardness (mg/l $CaCO_3$) 122

100% Effluent	
NH_3(as NH_3)(mg/l) .03	Total Alkalinity (mg/l $CaCO_3$) 117
Total ammonia (as N)(mg/l) 3.5	Total Hardness (mg/l $CaCO_3$) 186

[a] Total Chlorine Residual: 1.1 mg/l (HACH DPD Method), 1.15 mg/l (Iodometric Method I).

[b] Remaining parameters were not recorded since all organisms were dead by 24 hours.

Table 4. Data recorded druing 48 hour, Daphnia pulex, static acute toxicity bioassays of Jacksonville NAS Sewage Treatment Plant, NPDES #FL0000957, on 22 to 24 January, 1986.

Sewage Treatment Plant - De-chlorinated Effluent[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			Conductivity (umhos)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48
Control	10	10	10	9.4	8.5	8.2	7.6	8.1	8.1	21.0	19.7	19.8		
Control	10	10	10	9.4	8.5	8.2	7.6	8.1	8.1				208	202
10.0%	10	10	10	9.5	8.7	8.3	7.6	8.2	8.0	21.0	19.6	19.7		
10.0%	10	10	10	9.5	8.7	8.3	7.6	8.2	8.0				242	230
50.0%	10	10	10	9.5	8.7	7.9	7.5	8.2	7.9	21.1	19.5	19.7		
50.0%	10	10	10	9.5	8.7	7.9	7.5	8.2	7.9				355	340
100.0%	10	10	10	9.2	8.7	8.0	7.3	8.1	7.9	21.3	19.5	19.7		
100.0%	10	10	10	9.2	8.7	8.0	7.3	8.1	7.9				520	475

Control Water

NH_3(as NH_3)(mg/l): 0

Total ammonia (as N)(mg/l): 0

Total Alkalinity (mg/l $CaCO_3$): 105

Total Hardness (mg/l $CaCO_3$): 122

100% Effluent

NH_3(as NH_3)(mg/l): .04

Total ammonia (as N)(mg/l): 3.7

Total Alkalinity (mg/l $CaCO_3$): 127

Total Hardness (mg/l $CaCO_3$): 183

[a] Total Residual Chlorine: <0.02 mg/l (HACH DPD Method).

Table 5. Data recorded during 48 hour, Notropis leedsi, static acute toxicity bioassay of Jacksonville NAS Sewage Treatment Plant, NPDES #FL0000957, on 22 to 24 January, 1986.

Sewage Treatment Plant - De-chlorinated Effluent[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			Conductivity (umhos)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48
Control	5	5	5	9.5	7.9	7.6	7.6	7.9	7.8	21.2	19.7	19.7		
Control	5	5	5	9.5	7.9	7.6	7.6	7.9	7.8				212	205
10.0%	5	5	5	9.2	7.9	7.5	7.5	7.9	7.8	21.0	19.4	19.4		
10.0%	5	5	5	9.2	7.9	7.5	7.5	7.9	7.8				243	238
50.0%	5	5	5	9.4	7.8	7.0	7.4	7.9	7.7	21.0	19.4	19.3		
50.0%	5	5	5	9.4	7.8	7.0	7.4	7.9	7.7				370	350
100.0%	5	5	5	9.4	7.8	7.0	7.3	7.9	7.7	21.4	19.3	19.3		
100.0%	5	5	5	9.4	7.8	7.0	7.3	7.9	7.7				580	490

Control Water

NH_3(as NH_3)(mg/l): 0

Total ammonia (as N)(mg/l): 0

Total Alkalinity (mg/l $CaCO_3$): 105

Total Hardness (mg/l $CaCO_3$): 122

100% Effluent

NH_3(as NH_3)(mg/l): .04

Total ammonia (as N)(mg/l): 3.7

Total Alkalinity (mg/l $CaCO_3$): 127

Total Hardness (mg/l $CaCO_3$): 183

[a] Total Residual Chlorine: < 0.02 mg/l (HACH DPD Method).

Table 6. Data recorded during 48 hour, Daphnia pulex, static acute toxicity bioassay of Jacksonville NAS Sewage Treatment Plant, NPDES #FL0000957, on 22 to 24 January, 1986.

Industrial Wastewater[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			Conductivity (umhos)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48
Control	10	10	10	9.2	8.7	8.1	7.6	8.2	8.3	21.0	19.7	19.8		
Control	10	10	9	9.2	8.7	8.1	7.6	8.2	8.3				210	212
10.0%	10	10	10	9.3	8.6	8.3	8.2	8.4	8.2	21.0	19.6	19.7		
10.0%	10	10	10	9.3	8.6	8.3	8.2	8.4	8.2				238	237
50.0%	10	10	10	9.7	8.6	8.3	9.3	8.8	8.4	20.8	19.5	19.7		
50.0%	10	10	9	9.7	8.6	8.3	9.3	8.8	8.4				325	320
100.0%	10	10	10	10.2	8.3	8.2	9.9	9.3	8.7	20.7	19.5	19.7		
100.0%	10	10	10	10.2	8.3	8.2	9.9	9.3	8.7				450	435
pH adj. 100.0%	10	10	10	10.0	8.3	8.2	7.2	7.9	8.0	20.7	19.6	19.7		
pH adj. 100.0%	10	10	9	10.0	8.3	8.2	7.2	7.9	8.0				520	520

Control Water

NH_3(as NH_3)(mg/l): 0

Total ammonia (as N)(mg/l): 0

Total Alkalinity 105 (mg/l $CaCO_3$)

Total Hardness 122 (mg/l $CaCO_3$)

100% Effluent

NH_3(as NH_3)(mg/l): 0

Total ammonia (as N)(mg/l): 0.05

Total Alkalinity 95 (mg/l $CaCO_3$)

Total Hardness 118 (mg/l $CaCO_3$)

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

Table 7. Data recorded during 48 hour, Notropis leedsi, static acute toxicity bioassay of Jacksonville NAS Sewage Treatment Plant, NPDES #FL0000957, on 22 to 24 January, 1986.

Industrial Wastewater[a]

Concentration or %	Number of Live Organisms			Dissolved Oxygen (mg/l)			pH			Temperature (°C)			Conductivity (umhos)	
	0	24	48	0	24	48	0	24	48	0	24	48	0	48
Control	5	5	5	9.2	7.9	7.5	7.7	8.0	8.0	21.0	19.4	19.5		
Control	5	5	5	9.2	7.9	7.5	7.7	8.0	8.0				215	215
10.0%	5	5	5	9.4	8.0	7.5	8.3	8.2	8.0	20.9	19.3	19.4		
10.0%	5	5	5	9.4	8.0	7.5	8.3	8.2	8.0				242	237
50.0%	5	5	5	9.7	7.9	7.6	9.3	8.8	8.3	20.8	19.3	19.3		
50.0%	5	5	5	9.7	7.9	7.6	9.3	8.8	8.3				333	322
100.0%	5	5	5	10.0	6.8	6.7	9.9	9.3	8.5	20.6	19.3	19.4		
100.0%	5	5	5	10.0	7.4	7.5	9.9	9.3	8.7				468	422
pH adj. 100.0%	5	5	5	10.2	7.4	7.5	7.2	7.7	7.8	20.6	19.5	19.5		
pH adj. 100.0%	5	5	5	10.2	7.4	7.5	7.2	7.7	7.8				570	500

Control Water

NH_3(as NH_3)(mg/l) 0

Total ammonia (as N)(mg/l) 0

Total Alkalinity 105 (mg/l $CaCO_3$)

Total Hardness 122 (mg/l $CaCO_3$)

100% Effluent

NH_3(as NH_3)(mg/l) 0

Total ammonia (as N)(mg/l) 0.05

Total Alkalinity 95 (mg/l $CaCO_3$)

Total Hardness 118 (mg/l $CaCO_3$)

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

Table 8. LC_{50} Data for Bioassays of Jacksonville NAS Sewage Treatment Plant, NPDES #FL0000957, on 22 to 24 January, 1986.

Organism	Method of Data Analysis	24 Hour LC_{50} and 95% Confidence Intervals	48 Hour LC_{50} and 95% Confidence Intervals
Chlorianted Effluent			
Daphnia pulex	Binomial	< 10.0%, a	< 10.0%, a
	Moving Average		
	Probit		
Notropis leedsi	Binomial	16.6% (0 and 50)	16.6% (0 and 50)
	Moving Average	b	b
	Probit	b	b
De-chlorinated Effluent			
Daphnia pulex	Binomial	No Mortality	No Mortality
	Moving Average		
	Probit		
Notropis leedsi	Binomial	No Mortality	No Mortality
	Moving Average		
	Probit		
Industrial Wastewater			
Daphnia pulex	Binomial	b	b
	Moving Average	b	b
	Probit	b	b
Notropis leedsi	Binomial	b	b
	Moving Average	b	b
	Probit	b	b

[a] The LC_{50} is < 10.0% since all organisms were dead in this concentration.

[b] Due to an insufficient number of dead organisms, or to the irregular distribution of mortality, an LC_{50} value cannot be calculated using this method of statistical analysis.

RESULTS AND DISCUSSION

The final chlorinated effluent from the Jacksonville NAS Sewage Treatment facility proved to be acutely toxic to the test organisms, Daphnia pulex and Notropis leedsi, producing 48 hour LC_{50}'s of < 10% and 16.6%, respectively (Table 8). This toxicity can be mostly attributed to the total residual chlorine (1.1 mg/l HACH DPD Method) measured in this sample. This same effluent, after de-chlorination, was not toxic to the same test organisms (Tables 4 and 5).

The sample of industrial wastewater from this facility was not acutely toxic to either D. pulex or to N. leedsi, even though the sample was characterized by a high pH (9.9 s.u.). Several N. leedsi deaths were noted during the test, but the mortality was insufficient to calculate an LC_{50}. Since all N. leedsi survived in the pH adjusted sample, the mortality noted above was probably due to the high pH of the sample (Table 7).

The ammonia detected in these samples (maximum = 0.04 mg/l unionized) was insufficient to have contributed to the toxicity. Since the above toxicity was attributed mostly to chlorine, chemical analyses were not performed.

Biology Section's Recommendation

The final chlorinated effluent from the Jacksonville NAS Sewage Treatment Plant has been shown to be extremely toxic to aquatic organisms in various bioassay tests performed since 1981. Because this toxicity is likely due to the residual chlorine in the effluent, we recommend that this facility demonstrate compliance with the F.A.C. standard of a maximum total chlorine residual of 0.02 mg/l in the receiving waters.

LITERATURE CITED

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