

BIOASSAYS OF CITY OF DELAND MAIN WASTEWATER TREATMENT PLANT DELAND, VOLUSIA COUTNY, FLORIDA

NPDES #FL0020303

Biological Section
Bureau of Water Analysis
June 17, 1981

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INTRODUCTION

The Deland Main Wastewater Treatment Plant is located on South Amelia Avenue just south of Deland, Volusia County, Florida (Figure 1). This facility serves approximately 16,000 residents of the city (1974 NPDES Permit) and has recently doubled its design capacity from 2.0 to 4.0 MGD. Treatment of wastewater consists of primary and secondary clarifiers, trickling filters, third stage aeration basins, aerobic sludge digestion and chlorination (Figure 2). The dried sludge is disposed of by land spreading. Treated wastewater is piped west of the city and discharged to the St. Johns River.

For a number of years, this plant has been criticized for adversely affecting water quality in the St. Johns River. In January 1981, it received a Notice of Violation for failure to submit a schedule for a pretreatment program, an industrial survey and other technical information. In a June 1980 NPDES Compliance Inspection Report, the plant exceeded its limits for BOD and suspended solids, and was cited for inadequate maintenance of records and reports. In 1976, an Administrative Order was issued against this plant for exceeding its BOD and Suspended Solids limitations.

On 6 to 8 May, 1981, the Biological Section performed static, acute toxicity bioassays on effluent samples from the Deland Main Wastewater Treatment Plant, to determine the existence and extent of toxicity to the biota of the receiving waters. The results of these tests are presented in this report.

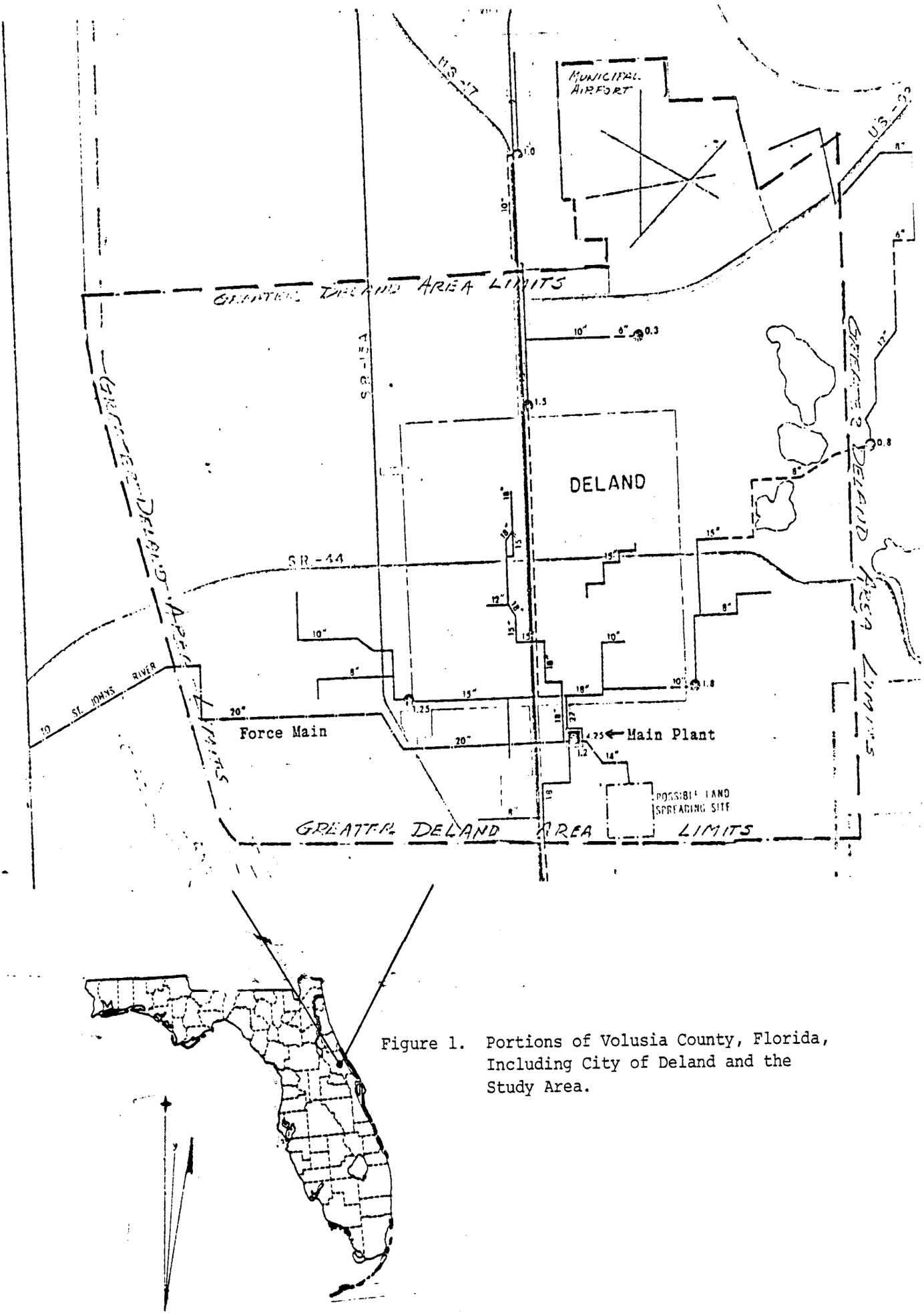


Figure 1. Portions of Volusia County, Florida, Including City of Deland and the Study Area.

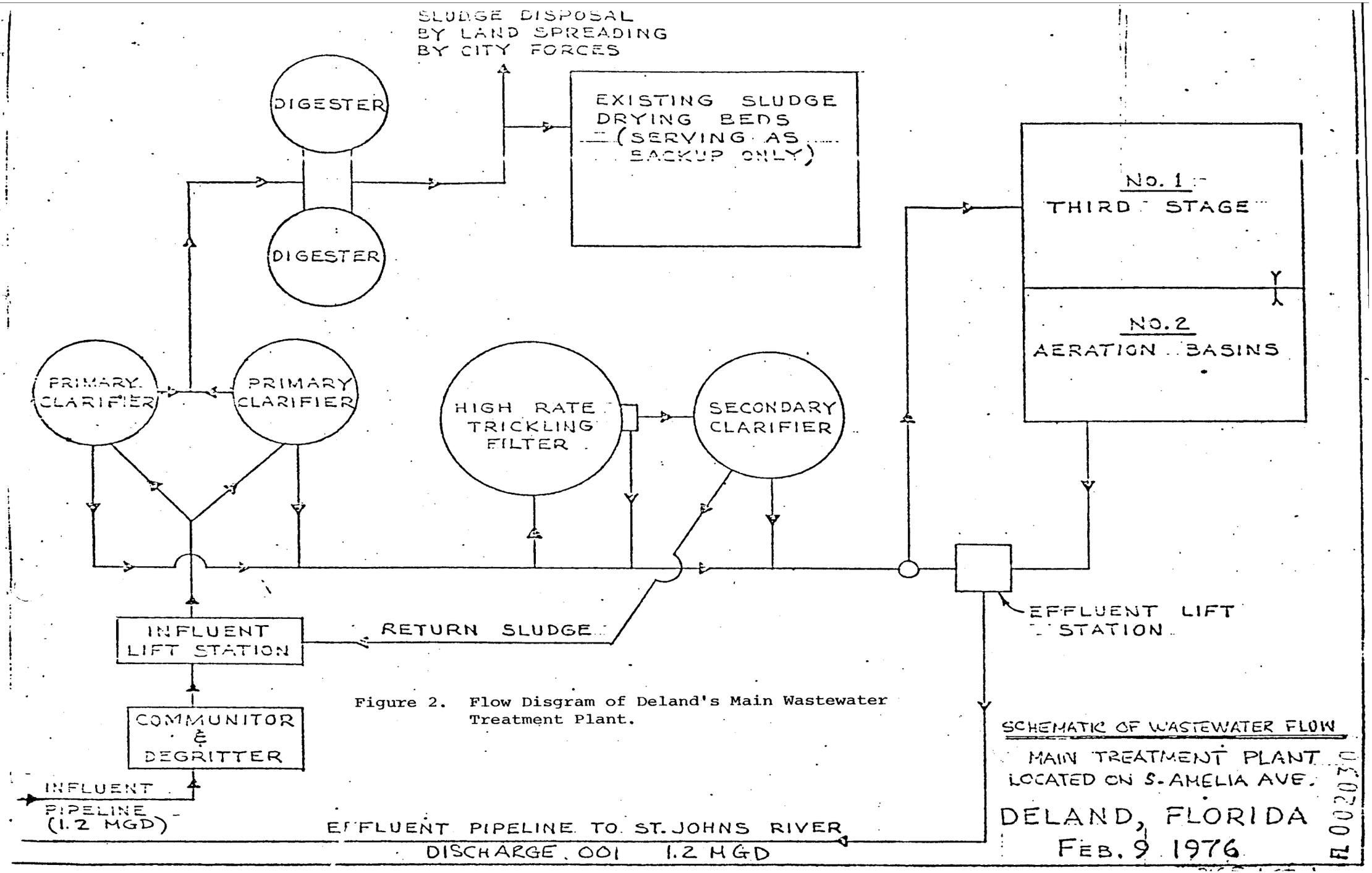


Figure 2. Flow Disgram of Deland's Main Wastewater Treatment Plant.

METHODS AND MATERIALS

Test methods used to conduct these static bioassays are extensively described by Peltier (1978). The organsm 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 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 2½ gallon all glass aquaria filled with unchlorinated DER well water, using a 16:8 hour light-dark cycle. Organisms are fed a liquified blend of Purina Trout Chow® and Cerophyl® twice daily, and are kept at a constant temperature of $22^{o} \pm 1^{o}C$. The aquaria are cleaned weekly by siphoning off half the water along with the detritus and excess daphnids. They are then refilled 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.

To ensure the uniform sensitivity of these test organisms to toxic substances, the Biological Section conducts monthly Standard Reference Toxicant Bioassays using sodium lauryl sulfate as the reference toxicant.

Test Methods

Three separate 48 hour static bioassays were conducted from 1055 hours on 6 May to 1130 hours on 8 May, 1981. Grab samples of chlorinated effluent (Outfall #001) and of effluent collected prior to chlorination were obtained by Mr. Guy Hadley of DER's St. Johns River District at 1732 hours on 5 May, 1981, using standard wastewater sampling procedures. The samples were iced and transported to the DER laboratory in Tallahassee 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 Biological 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, it 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[1]. This test was intended to evaluate the combined toxicity of the effluent and the chlorine reaction products.

Freshwater for dilution of the effluent sample was obtained from the same DER deep well that is used to culture the test organisms. The concentration series selected for this study (Table 1) is that recommended by APHA (1976).

Two replicates, each with six concentrations and a control, were used to test with 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. Neonates were then transferred individually by glass pipette, examined for injury, and were loaded 10 per chamber, resulting in 20 per test concentration.

Dissolved oxygen, pH, temperature and the number of live organisms were recorded for each test chamber at 0 hours, 24 hours, and 48 hours. Total alkalinity, total hardness, and conductivity were recorded at the beginning of the test for the controls and the 100% effluent concentration. Additionally, ammonia concentrations, including the total (expressed as mg/l as N) and the unionized fraction (expressed as mg/l as NH_3) were recorded for the control water and for each of the 100% effluent concentrations. These values were recorded on the bioassay data forms and are presented in Tables 2 through 4. Organisms were not fed during these tests.

[1] De-Chlorination was accomplished by adding a calculated amount of sodium thiosulfate.

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

Water flea (Daphnia pulex)

Concentration	Dilution Water	Effluent	Total Vol.
Control	200 ml	---	200 ml
5.6%	188.8 ml	11.2 ml	200 ml
10.0%	180 ml	20 ml	200 ml
18.0%	164 ml	36 ml	200 ml
32.0%	136 ml	64 ml	200 ml
56.0%	88 ml	112 ml	200 ml
100%	----	200 ml	200 ml

Table 2. Data recorded during 48 hour, Daphnia pulex, static acute toxicity bioassay of City of Deland Main Wastewater Treatment Plant, Deland, Volusia County, Florida, NPDES #FL0020303 on 6 to 8 May, 1981.

Test #1. Pre-Chlorinated Sample.

Conc. or %	Number of Live Organisms			Dissolved Oxygen (mg/ℓ)			pH			Total Alkalinity (mg/ℓ as $CaCO_3$)		Total Hardness (mg/ℓ as $CaCO_3$)		Temperature (°C)			NH_3/NH_3+NH_4 (mg/ℓ)		Conductivity (µmhos)
	0	24	48	0	24	48	0	24	48	0	48	0	48	0	24	48	0	48	0
Control	10	10	9	8.7	8.5	8.2	7.7	8.0	8.0	111		109		21.5	20.2	20.6	0/.02	.01/.21	
Control	10	10	8	8.7	8.5	8.4	7.7	8.0	8.1										200
5.6%	10	10	10	8.6	8.5	8.4	7.8	8.0	8.1					21.3	20.0	20.6			
5.6%	10	10	10	8.6	8.4	8.4	7.8	8.0	8.1										220
10%	10	10	8	8.5	8.4	8.4	7.8	8.1	8.1					21.3	20.0	20.6			
10%	10	10	10	8.5	8.4	8.4	7.8	8.1	8.1										240
18%	10	9	8	8.3	8.4	8.3	7.7	8.1	8.1					21.4	20.0	20.7			
18%	10	10	10	8.2	8.4	8.4	7.7	8.1	8.1										280
32%	10	9	5	7.9	8.3	8.2	7.7	8.1	8.1					21.3	20.1	21.1			
32%	10	10	10	7.7	8.3	8.2	7.7	8.1	8.1										330
56%	10	7[a]	1[a]	6.8	8.0	8.1	7.6	8.1	8.1					21.0	20.3	21.2			
56%	10	9[a]	5[a]	6.6	8.0	8.1	7.6	8.1	8.1										420
100%	10	6[a]	0[a]	4.9	7.6	7.9	7.6	8.1	8.1	305		149		20.8	20.6	21.2	.17/6.58	.67/11.2	
100%	10	5[a]	1[a]	4.8	7.4	7.9	7.5	8.1	8.1										650

Remarks: a. Remaining organisms severely stressed.

Table 3. Data recorded during 48 hour, Daphnia pulex, static acute toxicity bioassay of Deland Main Wastewater Treatment Plant, Deland, Volusia County, Florida, NPDES #FL0020303, Outfall #001 on 6 to 8 May, 1981.

Test #2. Chlorinated Sample.

Conc. or %	Number of Live Organisms			Dissolved Oxygen (mg/ℓ)			pH			Total Alkalinity (mg/ℓ as $CaCO_3$)		Total Hardness (mg/ℓ as $CaCO_3$)		Temperature (°C)			NH_3/NH_3+NH_4 (mg/ℓ)		Conductivity (μmhos)
	0	24	48	0	24	48	0	24	48	0	48	0	48	0	24	48	0	48	0
Control	10	10	10	8.7	8.6	8.3	7.8	8.2	8.2	111		109		21.5	20.5	20.5	0/.02	.01/.21	
Control	10	10	10	8.7	8.6	8.5	7.8	8.2	8.2										200
5.6%	10	0	-	8.7	8.5	-	7.8	8.2	-					21.5	20.5	-			
5.6%	10	0	-	8.7	8.5	-	7.8	8.2	-										230
10%	10	0	-	8.7	8.5	-	7.8	8.2	-					21.5	20.5	-			
10%	10	0	-	8.7	8.5	-	7.8	8.2	-										250
18%	10	0	-	8.7	8.5	-	7.8	8.2	-					21.7	20.5	-			
18%	10	0	-	8.7	8.5	-	7.8	8.2	-										280
32%	10	0	-	8.6	8.6	-	7.8	8.2	-					21.7	20.7	-			
32%	10	0	-	8.6	8.6	-	7.8	8.2	-										330
56%	10	0	-	8.3	8.6	-	7.7	8.2	-					21.7	20.7	-			
56%	10	0	-	8.3	8.6	-	7.7	8.2	-										425
100%	10	0	-	8.0	8.6	-	7.7	8.2	-	215		152		21.8	20.8	-	.17/6.3	.82/11.06	
100%	10	0	-	8.0	8.6	-	7.7	8.2	-										675

Remarks: Total chloride concentrations (HACH DPD).

Control = 0	18% = .22 mg/l
5.6% = .09 mg/l	32% = .35 mg/l
10.0% = .15 mg/l	56% = .60 mg/l
	100% = 1.10 mg/l

Table 4. Data recorded during 48 hour, Daphnia pulex, static acute toxicity bioassay of City of Deland Main Wastewater Treatment Plant, Deland, Volusia County, Florida, NPDES #FL0020303, Outfall #001 on 6 to 8 May, 1981,

Test #3. De-Chlorinated Sample.

Conc. or %	Number of Live Organisms			Dissolved Oxygen (mg/ℓ)			pH			Total Alkalinity (mg/ℓ as $CaCO_3$)		Total Hardness (mg/ℓ as $CaCO_3$)		Temperature (°C)			NH_3/NH_3+NH_4 (mg/ℓ)		Conductivity (µmhos)
	0	24	48	0	24	48	0	24	48	0	48	0	48	0	24	48	0	48	0
Control	10	10	9	8.7	8.5	8.6	7.9	8.2	8.2	111		109		21.4	20.6	20.5	0/.02	.01/.21	
Control	10	9	8	8.7	8.5	8.6	7.9	8.2	8.2										200
5.6%	10	10	10	8.7	8.5	8.6	7.8	8.2	8.2					21.4	20.6	20.4			
5.6%	10	10	10	8.7	8.5	8.6	7.8	8.2	8.2										230
10%	10	10	10	8.7	8.5	8.5	7.8	8.2	8.2					21.5	20.6	20.4			
10%	10	10	10	8.7	8.5	8.5	7.8	8.2	8.2										250
18%	10	10	9	8.7	8.5	8.3	7.8	8.2	8.2					21.6	20.6	20.5			
18%	10	10	8	8.7	8.5	8.4	7.8	8.2	8.2										280
32%	10	8	7	8.7	8.5	8.3	7.8	8.2	8.1					21.6	20.7	20.5			
32%	10	9	6	8.7	8.5	8.3	7.8	8.2	8.1										330
56%	10	8[a]	8	8.5	8.5	8.2	7.8	8.2	8.2					21.5	21.1	20.5			
56%	10	6[a]	6	8.5	8.4	8.2	7.8	8.2	8.2										425
100%	10	5[a]	5	8.3	8.4	8.1	7.8	8.2	8.2	215		152		21.5	21.2	20.7	.22/6.58	.83/11.06	
100%	10	5[a]	5	8.3	8.4	8.2	7.8	8.2	8.2										650

Remarks: a. Accurate counts could not be made on these because the organisms were completely paralyzed and it was difficult to differentiate between stressed and dead organisms.

Total chlorine residual 1.1 mg/l (HACH DPD) was neutralized with a calculated amount of .025 N sodium thiosulfate.

RESULTS AND DISCUSSIONS

The pre-chlorinated effluent from the City of Deland Main Wastewater Treatment Plant was acutely toxic to Daphnia pulex (24 and 48 hour LC_{50}s of >100% and 39.7% to 43.8%, respectively) (Table 5). The 96 hour LC_{50} would, therefore, be ≤43.8%. The chlorinated effluent also proved to be acutely toxic to Daphnia pulex (24 and 48 hour LC_{50}s of <5.6%) (Table 5). In fact, every organism died within 24 hours in every test concentration except the controls (Table 3). After 96 hours of exposure the LC_{50} would still be <5.6%. The de-chlorinated effluent also exhibited acute toxicity to Daphnia pulex (48 hour LC_{50} = 87% to 100%) (Table 5). A 24 hour LC_{50} could not be calculated since a number of organisms were too paralyzed to accurately determine the number of dead. A 96 hour LC_{50} would be ≤ 100%.

Although chemical analyses were not performed on this effluent, the toxicity it exhibited may be related to the concentrations of unionized ammonia found in the 100% effluent samples (Tables 2 - 4) (U.S. EPA 1976, 1977). Additionally, the toxicity exhibited by the chlorinated sample (Table 3) may be related to the synergistic effects of chlorine and ammonia (U.S. EPA 1976, 1977).

Chapter 17-3.051, Florida Administrative Code, indicates that "all waters of the State shall at all places and at all times be free from...components of discharges which...are acutely toxic." "Acute toxicity" is defined in Chapter 17-3.021(1) to mean "the presence of one or more substances...in amounts which are greater than one-third (1/3) of the amount lethal to 50% of the test organisms in 96 hours (96 hour LC_{50})...". In the absence of a mixing zone, this 1/3 of the 96 hour LC_{50} applies at the point of discharge. Chapter 17-4.244(4) states that "in no event shall the maximum concentration of wastes in the mixing zone exceed the amount lethal to 50% of the test organisms in 96 hours (96 hour LC_{50}) for a species significant to the indigenous aquatic community..." This criterion applies at the point of discharge if there is a mixing zone. The distinction between presence or absence of a mixing zone is not relevant here, however, since the testing procedure used does not involve effluent concentration. The 1/3 of the 96 hour LC_{50} criterion is three times as stringent at the 96 hour LC_{50} criterion, and therefore, in the absence of a mixing zone, the procedure used is very lenient. The procedure followed is also lenient in that testing is only done for 48 hours. The 96 hour LC_{50} derived from this testing is, therefore, reported as "less than or equal to" the 48 hour measurement. The value found after 48 hours can never be more restrictive than the value found after 96 hours. It must be noted that all organisms 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.

Table 5. LC_{50} Data for Bioassay of City of Deland Main Wastewater Treatment Plant, NPDES #FL0020303 on 6 to 8 May, 1981.

Organism	Method of Data Analysis	24 hour LC_{50} and 95% confidence intervals	48 hour LC_{50} and 95% confidence intervals
Daphnia pulex Test #1. Pre-Chlorinated Sample.	Binomial	A	43.8% (32 and 100)
	Moving Average	A	41.8% (33 and 57)
	Probit	>100% (81 and 302), B	39.7% (32 and 51)
Daphnia pulex Test #2. Chlorinated Sample.	Binomial	<5.6%, D	<5.6%, D
	Moving Average	<5.6%, D	<5.6%, D
	Probit	<5.6%, D	<5.6%, D
Daphnia pulex Test #3. De-Chlorinated Sample.	Binomial	C	100% (18 and ∞), B
	Moving Average	C	100% (0 and ∞), B
	Probit	C	87% (58 and 191), B

A. 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.

B. Due to the distribution of mortality, the LC_{50} value calculated by this method of statistical analysis does not meet the criteria established by the Committee on Methods for Toxicity Tests with Aquatic Organisms.

C. Due to inaccurate counts (organisms paralyzed), LC_{50}'s could not be calculated.

D. All organisms died within 24 hours in every test concentration.

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