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BIOASSAYS OF USN JACKSONVILLE NAVAL AIR STATION SEWAGE TREATMENT PLANT AND LANDFILL LEACHATE JACKSONVILLE, DUVAL COUNTY, FLORIDA

NPDES #FL0000957

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Biological Section
Bureau of Water Analysis
June 12, 1981

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INTRODUCTION

The USN Jacksonville Naval Air Station is á 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. Drums of oil, solvents and other substances are disposed of in the landfill. The plant has a design capacity of 3.0 MGD and is currently operating near this level, at 2.6 MGD. Discharge is to the St. Johns River (NPDES Outfall #001), however, a ditch near the landfill (not permitted) also empties into the St. Johns River. Leachate from the landfill may, at times of heavy rainfall, enter this ditch.

The NPDES permit for this facility contains discharge 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.

On 27 to 29 May, 1981, the Biological Section performed static, acute toxicity bioassays on samples of effluent from the sewage treatment plant and on water taken from the ditch near the landfill, to determine their effects on the biota of the receiving water. The results of these tests are presented in this report.

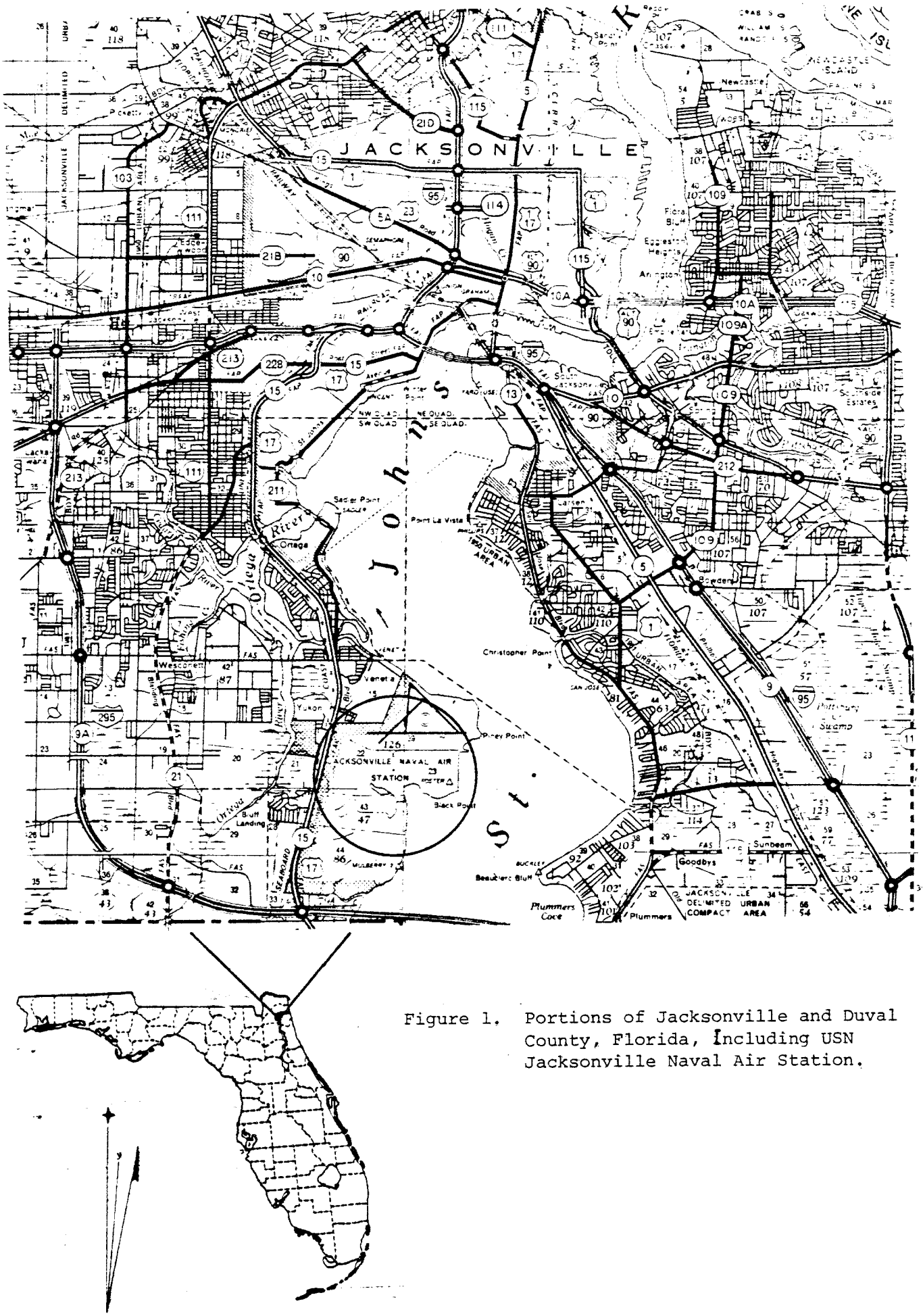


Figure 1. Portions of Jacksonville and Duval County, Florida, Including USN Jacksonville Naval Air Station.

METHODS AND MATERIALS

Test methods used to conduct these static bioassays are extensively described by Peltier (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 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 laboroatory 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 Purnia Trout Chow ® and Cerophyl ® twice daily, and are kept at a constant temperature of 22° ± 1°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

Four separate 48 hour static bioassays were conducted from 0945 hours on 27 May, 1981 to 0945 hours on 29 May, 1981. Grab samples of chlorinated effluent (Outfall #001), of effluent collected prior to chlorination and from the ditch near the landfill were obtained by Mr. Dennis Murrin of DER's St. Johns River Subdistrict at 0945 to 1100 hours on 26 May, 1981, using standard wastewater sampling procedures. Separate samples were obtained for chemical and biological testing. Samples for metals analysis were preserved with nitric acid. The samples for organic chemical analysis and for the bioassays were unpreserved. 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 from the sewage treatment plant, 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.

Water from the ditch near the landfill was also collected for toxicity analysis (Table 5). However, it was noted that there was no flow from the landfill to the ditch at the time of sampling.

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 (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 through a stainless steel screen to isolate the proper size and age organisms (neonates). These neonates were then transferred individually by glass pipette 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 and total hardness were recorded at the beginning of the test for the controls and the 100% effluent concentration. Specific conductance was also recorded for each test concentration at the beginning of the test. Additionally, ammonia concentrations, including total (expressed as mg/l as N) and unionized (expressed as mg/l as NH_3) fractions, were recorded for each of the controls and 100% effluent concentrations. These values were recorded on the bioassay data forms and are presented in Tables 2 through 5. 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 USN Jacksonville Naval Air Station Sewage Treatment Plant, Jacksonville, Duval County, Florida, NPDES #FL0000957 on 27 to 29 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	10	8.9	8.9	8.6	7.9	8.1	8.0	102		114		21.2	20.6	20.7	0/.02	-	
Control	10	10	9	8.9	8.9	8.6	7.9	8.1	8.0										198
5.6%	10	10	10	8.8	9.0	8.6	7.8	8.1	8.1					21.2	20.5	20.5			
5.6%	10	10	10	8.8	8.9	8.6	7.8	8.1	8.1										221
10.0%	10	10	10	8.7	8.8	8.7	7.8	8.0	8.1					21.3	20.4	20.3			
10.0%	10	10	10	8.7	8.8	8.7	7.8	8.0	8.1										237
18.0%	10	10	10	8.3	8.8	8.7	7.7	8.0	8.1					21.4	20.5	20.3			
18.0%	0[a]	0	0	8.3	8.8	8.8	7.7	8.0	8.1										268
32.0%	10	10	10	7.8	8.8	8.8	7.6	8.0	8.1					21.4	20.4	20.3			
32.0%	10	10	10	7.6	8.8	8.8	7.6	8.0	8.1										312
56.0%	10	10	10	6.5	8.8	8.8	7.4	8.0	8.1					21.3	20.4	20.3			
56.0%	10	10	10	6.5	8.7	8.8	7.4	8.0	8.1										395
100%	10	10	10	4.7	8.7	8.9	7.2	7.9	8.0	91		206		21.2	20.6	20.4	.04/4.2	.19/4.1	
100%	10	10	10	4.4	8.7	8.9	7.2	7.9	8.0										540

Remarks: a. This chamber not loaded by mistake.

Table 3. Data recorded during 48 hour, Daphnia pulex, static acute toxicity bioassay of USN Jacksonville Naval Air Station Sewage Treatment Plant, Jacksonville, Duval County, Florida, NPDES #FL0000957, Outfall #001 on 27 to 29 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	9	8.5	8.7	8.6	7.9	8.1	8.2	102		114		21.5	20.5	20.7	0/.02	-	
Control	10	10	10	8.5	8.8	8.6	7.9	8.1	8.2										198
5.6%	10	0	0	8.4	8.8	8.7	7.8	8.1	8.2					21.4	20.5	20.5			
5.6%	10	0	0	8.3	8.8	8.8	7.8	8.1	8.2										228
10.0%	10	0	-	8.2	8.9	-	7.8	8.1	-					21.3	20.5	-			
10.0%	10	0	-	8.2	9.0	-	7.8	8.1	-										240
18.0%	10	0	-	7.9	8.9	-	7.6	8.1	-					21.1	20.5	-			
18.0%	10	0	-	7.9	8.9	-	7.6	8.1	-										272
32.0%	10	0	-	7.3	8.9	-	7.5	8.0	-					20.9	20.5	-			
32.0%	10	0	-	7.3	8.9	-	7.5	8.0	-										315
56.0%	10	0	-	6.5	8.9	-	7.3	7.9	-					20.2	20.6	-			
56.0%	10	0	-	6.3	8.9	-	7.3	7.9	-										395
100%	10	0	-	5.1[a]	8.9	-	7.1	7.9	-	91		204		19.8	20.8	-	.02/4.2		
100%	10	0	-	4.9[a]	8.9	-	7.1	7.9	-										580

Remarks: a. These chambers were aerated to above 6.0 mg/l dissolved oxygen prior to loading of the test organisms.

Total Chlorine (HACH DPD)

5.6%=.15 mg/l 32%=.40 mg/l

10.0%=.20 mg/l 56%=.65 mg/l

18.0%=.28 mg/l 100%=1.1 mg/l

Table 4. Data recorded during 48 hour, Daphnia pulex, static acute toxicity bioassay of USN Jacksonville Naval Air Station Sewage Treatment Plant, Jacksonville, Duval County, Florida, NPDES #FL0000957, Outfall #001 on 27 to 29 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	10	8.5	8.8	8.6	7.9	8.1	8.2	102		114		21.4	20.1	20.5	0/.02	-	
Control	10	10	10	8.5	8.8	8.6	7.9	8.1	8.2										209
5.6%	10	10	10	8.4	8.8	8.6	7.8	8.1	8.2					21.4	20.5	20.6			
5.6%	10	10	10	8.4	8.9	8.6	7.8	8.1	8.2										228
10.0%	10	10	10	8.3	8.9	8.6	7.8	8.1	8.2					21.3	20.6	20.6			
10.0%	10	10	10	8.3	8.9	8.6	7.8	8.1	8.2										245
18.0%	10	10	10	8.2	8.9	8.6	7.7	8.1	8.1					21.3	20.7	20.7			
18.0%	10	10	10	8.2	8.9	8.6	7.7	8.1	8.1										273
32.0%	10	10	10	7.9	8.8	8.5	7.6	8.0	8.1					21.1	20.8	20.7			
32.0%	10	10	10	7.9	8.8	8.5	7.6	8.0	8.1										322
56.0%	10	10	10	7.2	8.8	8.5	7.4	8.0	8.1					20.8	20.8	20.7			
56.0%	10	10	10	7.2	8.8	8.5	7.4	8.0	8.1										402
100%	10	10	10	6.1	8.8	8.5	7.2	7.9	7.9	91		204		20.3	21.1	20.9	.02/4.2	.16/3.9	
100%	10	10	10	5.9	8.7	8.4	7.2	7.9	7.9										600

Remarks: Original Total Chlorine = 1.1 mg/l (HACH DPD).
Neutralized with sodium thiosulfate (0.025 N).
Final Total Chlorine < 0.01 mg/l (HACH DPD).

Table 5. Data recorded during 48 hour, Daphnia pulex, static acute toxicity bioassay of USN Jacksonville Naval Air Station ditch adjacent to the landfill, Jacksonville, Duval County, Florida, on 27 to 29 May, 1981.

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	8.5	8.8	8.6	7.9	8.1	8.2	102		114		21.5	20.5	20.4	0/.02	-	
Control	10	10	10	8.5	8.8	8.6	7.9	8.1	8.2										202
5.6%	10	10	10	8.3	8.8	8.6	7.8	8.1	8.2					21.5	20.5	20.4			
5.6%	10	10	10	8.3	8.7	8.7	7.8	8.1	8.2										228
10.0%	10	10	10	8.2	8.7	8.7	7.8	8.1	8.2					21.5	20.4	20.3			
10.0%	10	10	9	8.2	8.7	8.7	7.8	8.1	8.2										242
18.0%	10	10	10	7.8	8.7	8.7	7.8	8.1	8.2					21.7	20.3	20.2			
18.0%	10	10	10	7.8	8.7	8.7	7.8	8.1	8.2										270
32.0%	10	10	10	7.6	8.7	8.7	7.7	8.1	8.2					21.8	20.2	20.1			
32.0%	10	10	10	7.5	8.7	8.8	7.7	8.1	8.2										310
56.0%	10	10	10	6.8	8.6	8.7	7.6	8.0	8.2					21.8	20.2	20.0			
56.0%	10	10	10	6.8	8.5	8.8	7.6	8.0	8.2										380
100%	10	10	10	5.9	8.5	8.8	7.5	8.0	8.2	126		232		22.0	20.1	20.0	0/.28	.01/.08	
100%	10	10	10	5.9	8.5	8.8	7.5	8.0	8.2					"					530

Remarks:

RESULTS AND DISCUSSION

The pre-chlorinated and de-chlorinated samples of effluent from the USN Jacksonville Naval Air Station Sewage Treatment Plant were not acutely toxic to Daphnia pulex. However, the chlorinated sample exhibited extreme toxicity to Daphnia pulex, with 24 and 48 hour LC_{50}'s of <5.6% (Table 6). In fact, every organism died in every test chamber (except the controls) within 24 hours. Therefore, the 96 hour LC_{50} would also be <5.6%.

The water sample taken from the ditch near the landfill was not acutely toxic to Daphnia pulex. However, there had been no rain for sometime prior to sampling, and therefore, no leachate was expected.

The Chemistry Section has chemically characterized a sample of effluent from this facility with results presented in Table 7. No organic compounds were found, and of the metals analyzed for, only zinc (41 ug/l) was found in a significant concentration. According to the U.S. EPA (1976), a zinc concentration of 41 ug/l is approximately one-half the value reported to be acutely toxic to Daphnia, although under slightly different conditions.

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 as 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 6. LC_{50} Data for Bioassay of USN Jacksonville Naval Air Station Sewage Treatment Plant and Landfill, NPDES #FL0000957.

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		
	Moving Average	No Mortality	No Mortality
	Probit		
Daphnia pulex Test #2. Chlorinated Sample.	Binomial	<5.6% A	<5.6% A
	Moving Average	<5.6% A	<5.6% A
	Probit	<5.6% A	<5.6% A
Daphnia pulex Test #3. De-Chlorinated Sample.	Binomial		
	Moving Average	No Mortality	No Mortality
	Probit		
Daphnia pulex Landfill ditch sample.	Binomial		B
	Moving Average	No Mortality	B
	Probit		B

A. Accurate LC_{50} values cannot be calculated since every organism died in every test chamber (except controls) within 24 hours. Therefore, the LC_{50}'s are expressed as <5.6%.

B. Due to an insufficient number of dead organisms (only one organism died) an LC_{50} value cannot be calculated using this method of statistical analysis.

Table 7. Results of Chemical Analyses of Effluent from the USN Jacksonville Naval Air Station Sewage Treatment Plant, NPDES #FL0000957. Collected 26 May, 1981.

Organics

Acid Extractables	None Detected
Pesticides	None Detected
Base Neutral Extractables	None Detected

Metals

Antimony	< 200 ug/l
Arsenic	< 50 ug/l
Beryllium	< 10 ug/l
Cadmium	< 10 ug/l
Chromium	< 50 ug/l
Copper	< 25 ug/l
Lead	< 50 ug/l
Mercury	< 0.2 ug/l
Nickel	< 50 ug/l
Selenium	< 10 ug/l
Silver	< 15 ug/l
Thallium	< 100 ug/l
Zinc	41 ug/l[a]

a. Average of two values

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