Removal of *Cryptosporidium* and *Giardia* at a Central Florida Water Reclamation Facility

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In 1999, Florida added pathogen monitoring requirements to its reuse rules (Chapter 62-610, Florida Administrative Code) (1). As a result, certain domestic wastewater treatment plants are required to monitor for the protozoan pathogens, *Cryptosporidium* and *Giardia*, and must report the results to the Florida Department of Environmental Protection (DEP). Previously, York, et al. and Walker-Coleman, et al. summarized the pathogen monitoring results (2, 3). Table 1 presents a summary of data received by the DEP through October 8, 2003. These results indicated that pathogen concentrations were greater than initially reported in the Monterey County and St. Petersburg studies (4, 5). It should be noted that there are issues inherent to the data set in Table 1. The various laboratories performing the analyses were not certified for EPA Method 1623 for non-potable water matrices. This translates to different quality assurance/quality control issues associated with the collection and analysis of the samples.

Table 1. Summary of Florida Pathogen Monitoring Data

Statistic	Giardia	Crypto
Number of observations	156	156
% having detectable concentrations	57%	31%
25 percentile (#/100 L)	ND	ND
50 percentile (#/100 L)	4.0	ND
75 percentile (#/100 L)	86	1.2
90 percentile (#/100 L)	334.7	14
Maximum (#/100 L)	4035	352.3
% greater than 5/100 L	46%	15%

Notes: (a) ND indicates a value less than detection.
(b) All numeric data are total numbers of cysts or oocysts per 100 L.

In 2002, DEP conducted follow-up sampling at three domestic wastewater treatment plants that reported high *Giardia* concentrations. A sample was taken at 3 different points within the 3 plants: prior to filtration, after filtration, and after disinfection. As shown in Table 2, the follow-up sampling revealed that the 3 plants were able to reduce their *Giardia* concentrations to below the 5 cysts or oocysts/100 liters guideline recommended by York et al (6).

In an effort to learn more about the removal of *Cryptosporidium* and *Giardia*, Florida DEP elected to conduct a sampling study to look at the ability of filtration and disinfection to remove *Cryptosporidium* and *Giardia.* This study was designed to be compatible with the ongoing Water Environment Research Foundation (WERF) study, which is looking at the removal efficiency of

different treatment processes for various pathogens and indicator organisms. The WERF study is being completed by researchers at Michigan State University and the University of South Florida.

Table 2. Before and After DEP 2002 Follow-up Pathogen Sampling Study

	Plant A	Plant B	Plant C
Giardia Concentration Initially Reported (cysts/100 L)	58	2575	302
Follow-up Sampling *Giardia* Concentration (cysts/100 L)	4	3	<1

Note: Before and After *Cryptosporidium* concentrations were below detection at all 3 plants.

The DEP contracted with Orange County Utilities (OCU) to conduct sampling at the Altamonte Springs Water Reclamation Facility (WRF). Dr. Terri Slifko of OCU was the principal investigator for the study. The facility was sampled at three points within the treatment plant (before and after filtration and after disinfection) and at two points within the distribution system (at 501 San Sebastian and 234 Robin Road).

Facility Design

The Altamonte Springs WRF (also known as Project APRICOT) is an advanced activated sludge facility with a design capacity of 12.5 million gallons per day (MGD). The treatment train includes influent screening, grit removal, primary sedimentation, activated sludge/nitrification process, secondary clarification, flocculation, denitrification filtration, post aeration, and chlorination. Aluminum sulfate (Alum) can be added to the secondary clarifier and the flocculation basins. Methanol is fed to the filters as a carbon source for the denitrification process.

The facility's deep-bed, multi-media filters have a 36-inch top layer of anthracite (average media size: 11.32 mm). The middle layer consists of 36 inches of silica sand (average media size: 3.30 mm). The bottom layer is 18 inches of gravel (average media size: 22.22 mm). Uniformity coefficients for each filter layer are 1.40, 1.18, and 1.42, respectively.

The facility has two chlorine contact chambers designed to provide approximately 30 minutes of contact time at an average flow rate of 12.5 mgd (15 minutes at peak hourly flow of 25 mgd). The dimensions of each chlorine contact chamber are 240 ft x 10 ft x 7 ft. The volume of each basin is approximately 125,000 gallons (250,000 gallons total). The facility uses chlorine gas for disinfection.

Project APRICOT is a citywide 83-mile dual distribution system that provides reclaimed water for irrigation of residential lawns and greenspaces in Altamonte Springs. Reclaimed water is also used in a commercial car wash, street sweeping, dust control, and to fight fires in the city. The distribution system delivers reclaimed water throughout the city's 5,900-acre reuse service area.

Operational History

One year of operational data submitted to DEP by the Altamonte Springs facility is provided in Table 3.

Although this facility has the ability to add chemicals to enhance filtration, chemicals are not routinely added.

Operational data for Altamonte Springs during the time of sampling were within parameter limits. Operational data is provided in Table 4.

Table 3. 12-Month Operational Data for Altamonte Springs Facility

Month	Maximum Turbidity (NTU)	Minimum Cl_2 Residual (mg/L)	Maximum $CBOD_5$ (mg/L)
August	1.9	1.0	<2.0
September	1.5	1.0	7.0
October	1.7	1.0	2.0
November	1.5	1.0	3.0
December	1.9	1.0	3.0
January	1.1	1.0	3.0
February	1.9	1.1	2.0
March	1.9	1.4	2.0
April	1.9	1.0	2.0
May	1.4	1.0	<2.0
June	1.0	1.2	<2.0
July	1.7	1.0	ND

Notes: Data from Discharge Monitoring Reports (monthly averages from August 2002 through July 2003). TSS values were generally 1 mg/L or less than detection (less than 1 mg/L) during this reporting period. ND = no data.

Table 4. Operational Data during DEP Study Sampling

Sampling Event	Flow (mgd)	Cl_2 Residual (mg/L)	Theoretical Cl_2 Contact Time (min.)	CT (min-mg/L)	$CBOD_5$ (mg/L)	Fecal Coliforms (cfu/100 mL)	TSS (mg/L)
March 11	7.1	ND*	50.7	-	1.0	<1.0	1.0
April 8	6.8	1.8	52.9	95.2	<1.0	<1.0	<1.0
April 30	9.5	2.2	37.8	83.2	7.0	<1.0	<1.0
May 13	8.1	1.9	44.4	84.4	<1.0	<1.0	<1.0

Note: Theoretical chlorine contact times are based on 250,000 gallons chlorine contact chamber volume. * Missing data due to incorrect sampling location.

Pathogen Sampling Results

Pathogen monitoring results from the DEP Study are provided in Tables 5-8.

Pathogen concentrations after chlorination were less than detection except for one positive value of 1.9 oocysts/100 liters for *Cryptosporidium*. Pathogen concentrations within the distribution system were less than detection except for two positive values of 2 oocysts/100 liters for *Cryptosporidium*. The three positive values are below the 5 oocysts/100 liters guideline recommended by York et al (6).

Microscopic examination of cysts and oocysts were collected and analyzed using Method 1623. The percentage of cysts and oocysts presumed to be potentially viable (those with complete internal structure) was estimated using the DAPI staining technique outlined in EPA Method 1623.

***Giardia* Viability:** Eighty percent of the samples collected (post-clarifier) on 3/11/03 were DAPI positive. Sixty-five percent of the samples collected (post-clarifier) on 4/8/03 and 5/13/03 were DAPI positive (potentially viable) for *Giardia*.

***Cryptosporidium* Viability:** The 3/11/03 and 5/13/03 post-clarifier and distribution system samples were 100 percent potentially viable for oocysts based on DAPI staining. Viability for the 4/8/03 samples was not determined due to staining problems.

For the samples collected on 4/30/03, internal structure for *Cryptosporidium* and *Giardia* could not be determined due to debris interference.

The data shows that the plant's filters are capable of reducing *Giardia* concentrations by about 3-logs, and *Cryptosporidium* concentrations below 5 oocysts/100 liters.

Previous Pathogen Monitoring

Previous data submitted to the DEP suggests that facilities that include deep-bed filters may be more effective than facilities that include shallow-bed filters at pathogen removal. This data also suggests that facilities that provide nitrification may do a better job of controlling the protozoan pathogens than facilities that do not provide nitrification (2, 3).

The Altamonte Springs facility submitted a Pathogen Monitoring Report Form to DEP on May 5, 2002. The samples were collected and analyzed on April 9, 2002 and April 18, 2002, respectively. The sampling results, provided in Table 9, show that the Altamonte Springs WRF has consistently low pathogen concentrations.

Conclusion/Summary

The study results indicate that the Altamonte Springs WRF treatment process is effective at controlling *Cryptosporidium* and *Giardia* concentrations.

Pathogen concentrations after filtration and chlorination and within the distribution system were below the DEP recommended concentrations of 5 cysts or oocysts/100 L, and the treatment plant operated within permit limits during pathogen sampling.

The study suggests that water reclamation facilities that provide reclaimed water for public access reuse can effectively control *Cryptosporidium* and *Giardia*.

References

1. Florida Department of Environmental Protection. Reuse of Reclaimed Water and Land Application. Chapter 62-610, F.A.C. Tallahassee: Florida Department of Environmental Protection. August 1999.

2. York, D.W., L. Walker-Coleman, and P. Menendez. "Pathogens in Reclaimed Water: The Florida Experience." Proceedings of Water Sources 2002, Las Vegas, NV, AWWA and WEF. 2002.

3. Walker-Coleman, L., D.W. York, and P. Menendez. "Protozoan Pathogen Monitoring Results for Florida's Reuse Systems." Proceedings of Symposium XVII. WateReuse Association. Orlando, FL. September 8-11, 2002.

4. Sheikh, B., and R.C. Cooper. Recycled Water Food Safety Study. Report to Monterey County Water resources Agency and Monterey Regional Water Pollution Control Agency. 1998.

5. Rose, J.B., and R.P. Carnahan. Pathogen Removal by Full Scale Wastewater Treatment. A Report to the Florida Department of Environmental Protection. Tampa: University of South Florida. 1992.

6. York, D.W., and L. Walker-Coleman. "Is it Time for Pathogen Standards?" Proceedings of the 1999 Florida Water Resources Conference. AWWA, FPCA, and FW&PCOA. Tallahassee, FL. April 25-28, 1999.

Table 5. Pathogen Results for March 11, 2003 Sampling Event at Altamonte Springs WRF

Sampling Location	*Cryptosporidium* Concentration (oocysts/100 L)	*Giardia* Concentration (cysts/100 L)	Turbidity (NTU)	TSS (mg/L)	CL_2 Residual (mg/L)	Volume Tested (L)	Time Collected
Post Clarifier	27.0	2277.0	2.0	4.0	<0.1	11.2	12:52
Post Filter	2.0	<2.0	0.3	1.0	0.3	53.3	12:26
Post Disinfection	<2.0	<2.0	0.4	1.0	*0.06	53.3	11:25
Distribution Site 1 (San Sebastian)	<2.0	<2.0	0.2	<1.0	0.5	60.0	09:43
Distribution Site 2 (Robin Road)	<2.0	<2.0	0.2	1.0	0.4	60.0	10:25

* Sample taken after dechlorination

Table 6. Pathogen Results for April 8, 2003 Sampling Event at Altamonte Springs WRF

Sampling Location	*Cryptosporidium* Concentration (oocysts/100 L)	*Giardia* Concentration (cysts/100 L)	Turbidity (NTU)	TSS (mg/L)	CL_2 Residual (mg/L)	Volume Tested (L)	Time Collected
Post Clarifier	10.0	2000.0	1.6	2.0	<0.1	10.0	15:35
Post Filter	<2.0	<2.0	1.5	<1.0	<0.1	50.0	15:15
Post Disinfection	<1.8	<1.8	0.4	<1.0	1.8	54.0	13:30
Distribution Site 1 (San Sebastian)	<1.9	<1.9	0.2	<1.0	0.3	53.0	10:45
Distribution Site 2 (Robin Road)	<2.0	<2.0	0.2	<1.0	0.2	50.0	11:50

Table 7. Pathogen Results for April 30, 2003 Sampling Event at Altamonte Springs WRF

Sampling Location	*Cryptosporidium* Concentration (oocysts/100 L)	*Giardia* Concentration (cysts/100 L)	Turbidity (NTU)	TSS (mg/L)	CL_2 Residual (mg/L)	Volume Tested (L)	Time Collected
Post Clarifier	10.0	830.0	2.4	5.0	<0.1	10.0	15:08
Post Filter	<2.0	<2.0	0.6	<1.0	<0.1	50.0	14:50
Post Disinfection	1.9	<1.9	0.3	<1.0	2.2	51.5	13:50
Distribution Site 1 (San Sebastian)	<2.0	<2.0	0.5	1.0	0.3	50.0	11:55
Distribution Site 2 (Robin Road)	<2.0	<2.0	0.6	<1.0	0.3	50.0	12:25

Table 8. Pathogen Results for May 13, 2003 Sampling Event at Altamonte Springs WRF

Sampling Location	*Cryptosporidium* Concentration (oocysts/100 L)	*Giardia* Concentration (cysts/100 L)	Turbidity (NTU)	TSS (mg/L)	CL_2 Residual (mg/L)	Volume Tested (L)	Time Collected
Post Clarifier	7.0	1698.2	1.3	1.0	<0.1	14.2	10:52
Post Filter	<2.0	<2.0	0.3	1.0	<0.1	50.2	10:06
Post Disinfection	<2.0	<2.0	0.6	<1.0	1.89	50.5	09:45
Distribution Site 1 (San Sebastian)	2.0	<2.0	0.3	<1.0	0.2	50.0	14:49
Distribution Site 2 (Robin Road)	2.0	<2.0	0.4	<1.0	0.2	50.0	14:25

Table 9. Previous Pathogen and Operational Sampling Data for Altamonte Springs

Sampling Location	Parameter	Measurement
After Filter/Prior to Disinfection	Turbidity (NTU)	0.60
After Filter/Prior to Disinfection	Total Suspended Solids (mg/L)	1.00
After Disinfection	Cryptosporidium (oocysts/100 L)	< 0.96
After Disinfection	Giardia (cysts/100 L)	< 0.96
After Disinfection	Chlorine Residual (mg/L)	1.89