Florida Water Resources Conference

Abstract

Subject Area: Wastewater Treatment Process

2nd Subject Area: Regulatory Issues / Public Communications

Paper Title: Managing the 'other' advanced sewage treatment systems: An assessment of Florida's aerobic treatment units and similar onsite sewage treatment systems

Abstract:

Onsite Sewage Treatment and Disposal Systems (OSTDS) serve the wastewater needs of approximately one-third of Florida's residents. While most are conventional OSTDS or septic systems, there are some other systems that provide additional or advanced pretreatment before disposal. These systems are generally permitted as aerobic treatment units (ATU) or performance-based treatment systems (PBTS). They are managed differently from conventional systems, with Florida's regulations requiring that a system be inspected by the county health department inspector once a year and by the system's maintenance entity twice a year. We will present results from a study assessing the performance and management of such systems in Florida.
The Florida Department of Health received a grant from the Environmental Protection Agency's Nonpoint Source Pollution program (Section 319) to assess the performance and management of advanced systems throughout Florida. The study included several components, including: inventorying systems; surveying various user groups; assessing the operational status of systems; and sampling systems, including analyses for carbonaceous biochemical oxygen demand (cBOD5), total suspended solids (TSS), total nitrogen (TN), and total phosphorus (TP). Following an inventory effort, random samples of systems were selected for user surveys and for further field assessment. Six different user groups; including owners/users, regulators, maintenance entities, installers, manufacturers, and engineers; were surveyed to determine their perceptions of how advanced onsite systems are managed and performing. Project staff performed field visits on over 500 systems, and obtained at least one effluent sample from 340 systems, during the time from February through September of 2011. Field work has been completed, data analysis and reporting is nearing completion as of the time of abstract submission. In the presentation we will summarize the results of the inventory effort, highlight some results of the survey of owners and users of advanced systems, and discuss results from the assessment and sampling of a random sample of advanced systems.

Date when work/project/program was or will be completed: September 30, 2011 (field work) data analysis ongoing, anticipated completion of reporting to funding agency March 2013

Will this or a similar paper be presented or published elsewhere within the next 12 months? Yes. Florida Water Resources Journal has indicated interest in publishing an article based on the results of this work. Related materials, such as project reports will eventually be posted on the agency's web-site. Some initial results have been presented at the 2012 annual conferences of the Florida Onsite Wastewater Association and the Florida Environmental Health Association.

Has this paper been submitted to FWRC for consideration previously? Yes, we submitted an abstract for FWRC 2012 that was accepted. However, we had to withdraw the presentation and did not submit a paper.

If approved, can your abstract be included on the Technical CD? Yes

Do you feel this paper is worthy of a Workshop at FWRC? No.

MANAGING THE 'OTHER' ADVANCED SEWAGE TREATMENT SYSTEMS: AN ASSESSMENT OF FLORIDA'S AEROBIC TREATMENT UNITS AND SIMILAR ONSITE SEWAGE TREATMENT SYSTEMS

By: Eberhard Roeder, Ph.D., P.E. and Elke Ursin, Florida Department of Health

Introduction

Onsite Sewage Treatment and Disposal Systems (OSTDS) serve approximately one-third of all households in Florida. While most of them are conventional OSTDS or septic systems, there are some other systems that provide additional or advanced pretreatment before disposal. These systems are generally permitted as aerobic treatment units (ATU) or performance-based treatment systems (PBTS). A property owner may need or want an advanced system because the property is located in area where more stringent state or local regulations exist, because state regulations allow advanced systems with smaller drainfields or reduced setbacks in some instances, or for protection of the environment with cleaner wastewater.

Generally, advanced systems differ from conventional systems by allowing for variability in design, needing more frequent checkups and maintenance, and producing a cleaner effluent. They are managed differently from conventional systems, with Florida's regulations (Section 381.0065 Florida Statutes and Chapter 64E-6 Florida Administrative Code) requiring that a system be inspected by the county health department inspector once a year and that a system owner contract with a maintenance entity, which in turn visits the system for maintenance twice a year. Since 2001, when a change in Florida Statutes decreased operating permit fees and resulted in the discontinuation of a sampling program implemented by the county health departments, there had been no systematic assessment of effluent quality of advanced systems in Florida. A review of aerobic treatment unit sampling results gathered previously in one county, showed high variability of effluent quality that was at least in part related to differences in sample locations (Roeder and Brookman, 2006).

The Florida Department of Health, Bureau of Onsite Sewage Programs received a grant from the Environmental Protection Agencies Nonpoint Source Pollution program (Section 319) to assess the performance and management of advanced systems throughout Florida. The study addressed several issues such as: a pilot project in Monroe County assessing variability of samples 2007-2009; development of an inventory of advanced systems in 2010 through 2011; a survey of various user groups in 2010; an assessment of the operational status and sampling of systems, mainly for cBOD5, TSS, total nitrogen, and total phosphorus during the time from February through September of 2011. In the following the results of the inventory effort are summarized, some results of the survey of owners and users of advanced systems are highlighted, and initial results of assessing and sampling a random sample of advanced systems are discussed.

Inventory of Advanced Systems

The objective of the inventory was to allow random and stratified random sampling for later surveys and site visits. The development of a project-specific inventory of advanced systems required the aggregation and consolidation of data from the Department of Health's statewide permitting data system, a third-party web-based maintenance reporting system that is offered to county health departments and maintenance entities through a contract with the Florida Department of Environmental Protection, and supplemental data obtained from county health departments and the Bureau of Onsite Sewage Programs. The resulting inventory, implemented in MS-Access, presented a snapshot of source databases in the second half of 2010. The consolidation steps utilized had the aim to match records from different sources to each other and generate a list of addresses for subsequent surveys and site visits. The project report contains additional details of the database development process (Ursin and Roeder, 2011).

The database identified nearly 16,600 addresses for advanced systems in Florida. Compared to the approximately 2.7 million onsite systems estimated to exist in Florida, this indicates that less than one percent fall into the "advanced" categories. Advanced systems in Florida are often concentrated in certain counties due to more stringent state regulatory or local ordinance requirements. Over 60% of the advanced systems in Florida can be found in the five counties with the most systems: Monroe, Charlotte, Brevard, Franklin, and Lee counties. Statutory requirements have triggered the high numbers in Monroe County, while local ordinances covering parts of Charlotte, Brevard and Franklin County are behind the high numbers there. In Lee County the flexibility of allowing larger houses, and/or smaller drainfields for advanced systems on a given lot appears to have been the reason behind the higher numbers there. Advanced systems are predominantly residential ATU systems. Just over half of the systems with installation dates were installed within 2 – 5 years of January 1, 2010, coinciding with the building boom in Florida.

Extended aeration is the predominant technology approach used in Florida, employed by over 90% of the inventoried systems that included treatment technology information. Fixed film and mixed approaches such as fixed activated sludge treatment share the remainder of the market. Figure 1 displays the distribution of systems by different manufacturers in Florida. Each of the manufacturers offers generally one to three different product lines of aerobic treatment units, usually based on the same technology. Consolidated, Aqua-Klear, Hoot, Norweco, and Clearstream are the top five manufacturers used in Florida. Those manufacturers that had less than 100 systems each identified were combined into the "Other" category.

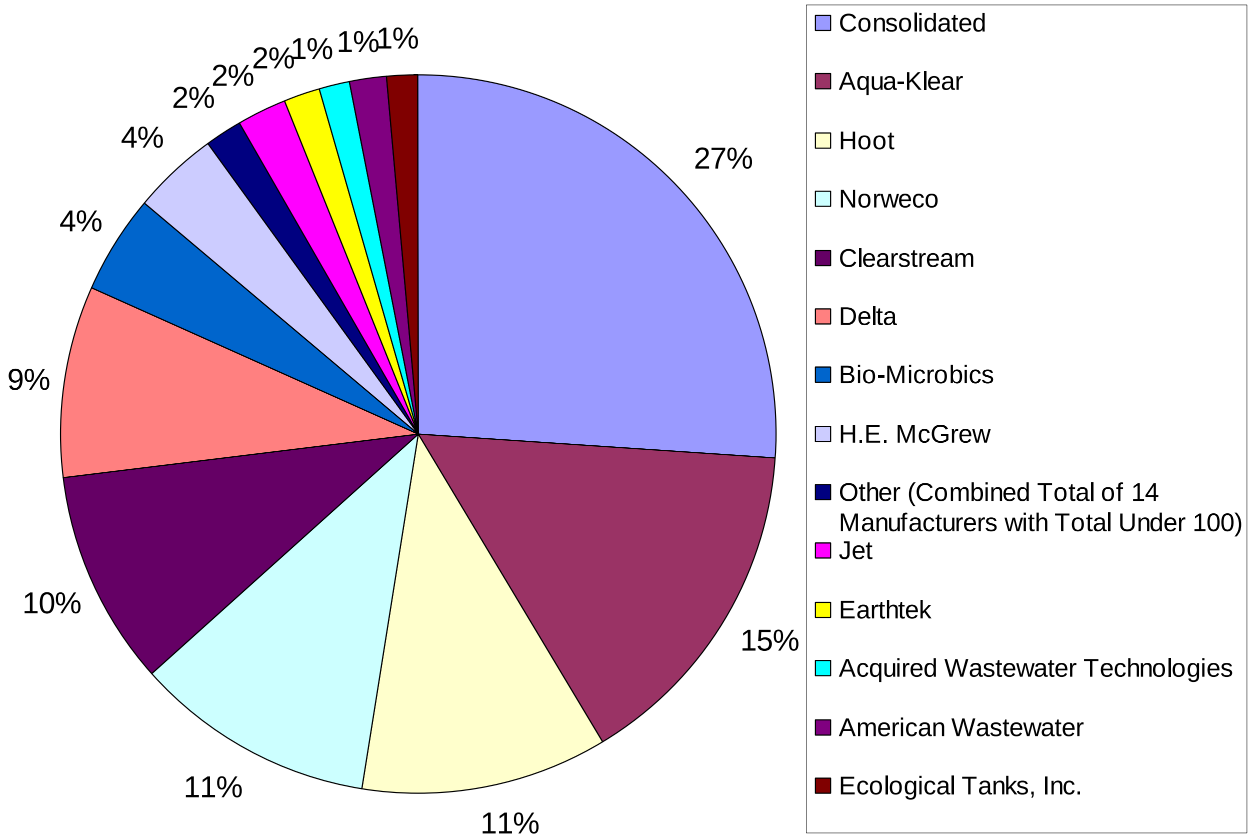

Figure 1. Distribution of manufacturers of advanced treatment systems for which this information was available (n=9,161)

Survey of User Groups

The objective of the user group surveys was to allow a representative sample of several user groups to voice their views and opinions as well as to measure the practices and perceptions of these user groups about the management of advanced onsite systems. Florida State University's Survey Research Lab (FSU-SRL) performed the survey and provided methodological expertise. Survey questions included both some that were targeted to specific user groups as well as some overlapping questions, where appropriate, to gauge differences between the groups on specific issues. The project considered six user groups: system owners/users, regulators, installers, manufacturers, maintenance entities, and engineers.

FSU-SRL sent a total of 3,793 surveys to a stratified random sample of system owners/users and 660 completed surveys (17.4%) were returned. The addresses stemmed from an intermediate development stage of the inventory database that allowed stratification according to if the systems was an ATU or a PBTS and if the facility served was residential or commercial. Most of the surveys that were returned were by full-time residents that owned the home with the advanced system and for systems serving less than 4 people. Fifty-five percent reported never experiencing problems, thirty-three percent reported experiencing problems once or twice within last year, and eleven percent experienced problems several times. The major sources of problems were system malfunctions such as pump failures, electrical malfunctions, faulty alarms, and bad motors. Figure 2 shows how satisfied system owner/users were with their systems, with 79% being either very satisfied or satisfied.

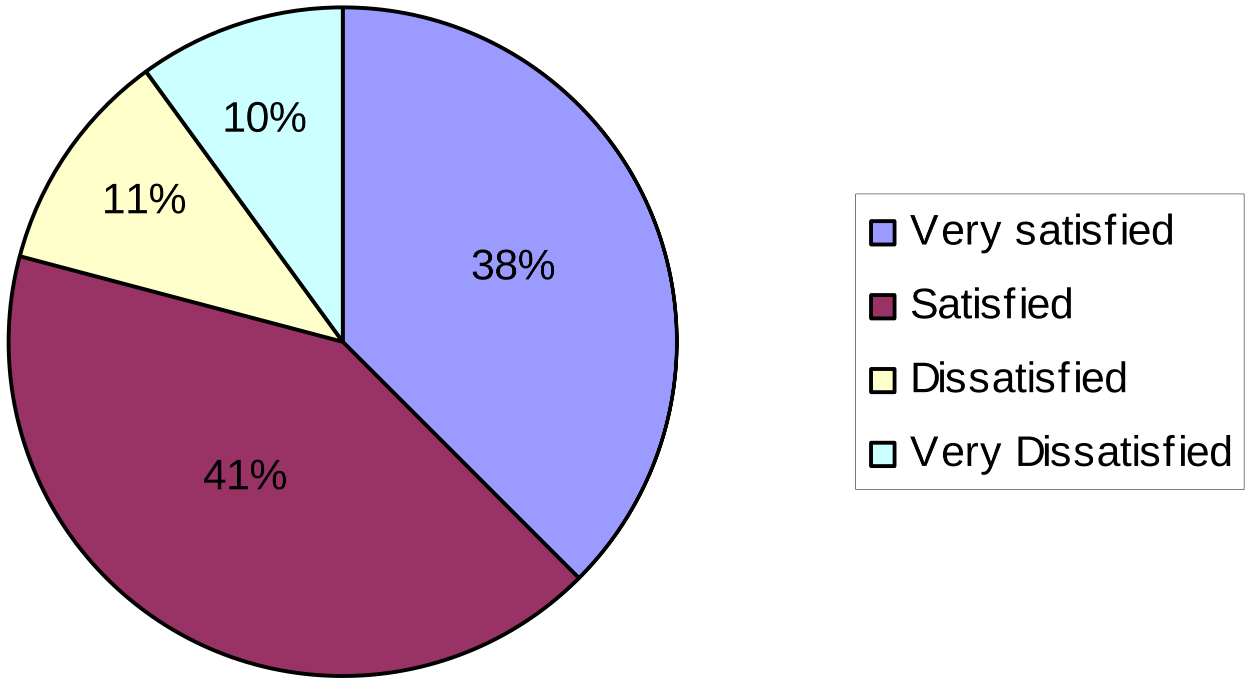

Figure 2. System owner/user satisfaction (Question: How would you describe your overall satisfaction with your advanced onsite sewage system (septic system))

FSU-SRL sent surveys to all county health departments, and all installers (septic tank contractors), maintenance entities, and engineers for which the department had contact information from licensing or permitting files. The response rates for installers (9%), maintenance entities (15%), and engineers (12%) were lower than for the owner/user group. More than half of the responding installers and about a third of the responding engineers indicated that they are not involved in the installation of advanced systems. This is likely a reflection of the small share that they constitute of the overall onsite sewage market as is the fact that eleven (of sixty-seven) county health departments reported not having a single advanced system installed in their county.

Figure 3 compares the responses from engineers, maintenance entities, installers, and regulators regarding their overall perception of treatment performance. All of these groups predominantly indicated that both ATU and PBTS performance is either good or excellent. When comparing this result with how satisfied homeowners are (Figure 2) this seems to indicate that advanced systems are fairly well accepted among the different user groups.

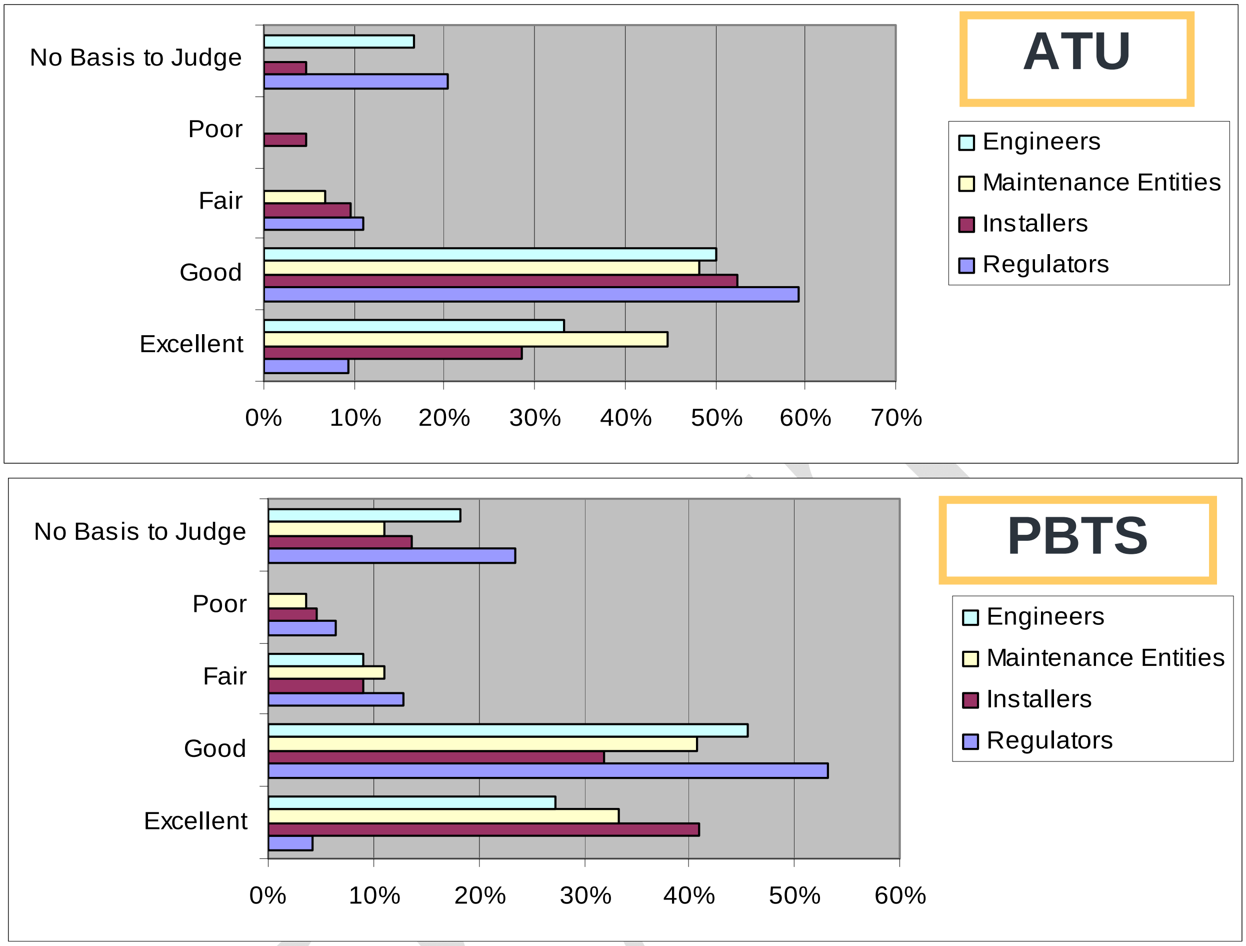

Figure 3. Comparison of the perceptions of overall treatment performance of advanced systems between groups (Question: How would you rate the OVERALL TREATMENT PERFORMANCE of the advanced systems you are involved with?)

Assessment and Sampling of Advanced Treatment Systems

The inventory allowed system selection for further permit review, site assessment, and sampling. Most sites were selected as a random sample from the inventory, while others were chosen to ensure that a variety of technologies were part of the sample population. For purposes of this paper, only those that were selected as a purely random sample are included in the subsequent discussions and calculations (901 systems of 1014). The distribution of these sites generally aligned with the distribution of advanced systems in the state, with counties that have the most advanced systems having the highest representation in the random sample.

Project staff performed field assessments, usually combined with sampling, of over 550 systems throughout Florida. Logistical challenges and time constraints prevented sampling in about ten southern Florida counties (with a total of 87 selected sites) and kept the completion rate in Monroe at about 25% of the 260 selected systems. Of the systems that had a field assessment, 480 were from the purely random selection and only these will be discussed further. The detailed field assessments encompassed an initial assessment, similar to inspections that county health departments perform and, where feasible, field measurements and sampling. Lab samples were packed in ice and sent overnight to a NELAP certified lab.

The field assessment included a check to see if the system was operational (power was on, no sanitary nuisance existed, aeration resulted in bubbles and mixing of sewage, and alarms were not on). Since the site visits were largely unannounced, these operational assessments can provide a general indication that could be applied to the larger population of advanced systems. Approximately five percent of the visited sites were vacant. Thirty percent of the sites visited were considered to be not operating properly (143 out of 480 systems). The main cause for a system to be non-operational was that the power indicator was off, followed by the aeration not working (Table 1). The most common combination of non-functional conditions was that the power was switched off, the power indicator was not on, and the aeration was not working. Since all three of these are a direct result of the power being off, this is not surprising, but it is interesting to note that the most common reason a system was not operational (20%) had to do with the power being off. If all power related operational status indicators are grouped together, we are left with three meta-groups: power related issues, sanitary nuisance related issues, and alarm issues. Power related issues consist of 70% of all operational problems followed by sanitary nuisance issues (9%), alarm issues (8%), power and alarm issues (8%), and finally power and sanitary nuisance issues (6%).

Table 1. Distribution of issues leading to a non-operational status for non-vacant systems

Reason For Non-Operational Status (non-vacant systems)		
	# Not OK	% Not OK
Power switched off	54	43%
Power indicator off	79	62%
Aeration not working	73	57%
Sanitary nuisance	20	16%
Alarm issue	19	15%

One means to provide an assessment of treatment performance was the comparison of effluent to “influent” data. Samplers obtained these samples by drawing from the clear zone of a pretreatment compartment or trash tank of systems. These samples represent then not raw sewage, but sewage that already has undergone some settling and anaerobic treatment. In this way these samples are more comparable to septic tank effluent, although septic tanks tend to be typically larger by a factor of about three.

In reviewing the influent data, several samples showed high nitrate/nitrite nitrogen values. Samples with values above 5 mg/L nitrate/nitrite were excluded as inconsistent with an anaerobic pretreatment step (six of forty-seven samples). Possible causes are a misidentification of compartments in the field, or interaction between aeration treatment and pretreatment compartments. Table 2 summarizes the results of the pretreatment effluent sampling. The data show considerable and somewhat skewed variability with an interquartile range that is larger than the median value. The median value for cBOD5 (76mg/L) is much lower than the median for septic tank effluent reported by Lowe et al. (2009) (216 mg/L) while the median values for TSS (68 mg/L) were similar to the 61 mg/L reported by Lowe et al. (2009). The median values for TN (46 mg/L) and TP (8.3 mg/L) in this study were both somewhat lower than the 60 mg/L and 9.8 mg/L, respectively reported by Lowe et al. The concentrations can also be compared to results from a pilot study for this project (Roeder, 2011). There, influent concentrations of advanced treatment systems that appeared to be most representative for pretreatment tank effluent showed median concentrations of 99 mg/L, 64 mg/L, 76mg/L and 10 mg/L for cBOD5, TSS, TN and TP, respectively. Again, the current study showed lower nutrient concentrations, which could be related to differences in water usage.

Table 2. Pretreatment effluent or influent data summary.

"Influent" Pretreatment Effluent (mg/L)		cBOD5	TSS	TKN	NOx	TN	TP
N	Valid	39	41	41	41	41	40
	Missing	2	0	0	0	0	1
Mean		115.2	92.0	51.9	0.3	52.3	9.0
Std. Deviation		100.0	111.4	37.6	0.7	37.3	5.6
Minimum		.0	7.0	.118	.019	2.970	.670
Maximum		393	630	181	3	181	34
Percentiles	10	14.0	20.0	11.8	0.0	12.0	3.3
	25	43.5	28.0	22.8	0.0	24.0	6.0
	50	76.4	68.0	45.8	0.1	45.9	8.3
	75	174.0	115.0	74.6	0.2	74.8	10.5
	90	259.0	147.2	103.5	1.3	103.5	14.3

The effluent concentrations are shown in Table 3. For the purposes of this analysis, the last sampling point of a treatment unit before dispersal in a drainfield, or borehole in Monroe County was used as representative of the overall treatment unit performance in cases when more than one sampling point had been sampled. The median concentrations for cBOD5 (5.4 mg/L) and TSS (19 mg/L) show substantial removal as compared to the influent concentrations. TN concentrations have been reduced. The TKN and nitrate-nitrite concentrations indicate that there is a wide variability occurring among systems in the extent of nitrification. TP concentrations are only about 1 mg/L lower than before the aeration step. Based on the median effluent concentrations relative to influent concentrations, the typical removal effectiveness of the advanced treatment units are 93% for cBOD5, 72% for TSS, 34% for TN, and 10% for TP. The removal effectiveness for cBOD5, TN, and TP is consistent with expectations for such treatment systems. The removal effectiveness of TSS is somewhat lower than expected, and suggests entrapment of inert solids during the sampling process.

Table 3. Effluent concentration summary for the random sample of systems.

Effluent (mg/L)		cBOD5	TSS	TKN	NOx	TN	TP
N	Valid	308	308	308	305	307	307
	Missing	1	1	1	4	2	2
Mean		25.5	36.7	21.5	16.2	37.6	8.0
Std. Deviation		53.5	56.5	32.2	21.1	32.6	4.4
Minimum		2.000	3.500	0.087	0.008	0.517	0.007
Maximum		450	484	252	108	290	29
Percentiles	10	2.0	3.5	0.1	0.0	7.4	2.9
	25	2.2	6.8	1.5	0.2	16.2	5.3
	50	5.4	19.0	7.7	6.0	30.3	7.5
	75	23.7	42.0	27.9	26.2	51.5	10.0
	90	63.9	92.0	69.1	47.3	77.0	13.0

Two comparisons of effluent concentrations were performed, using the Kruskall-Wallis test. First, effluent concentrations from systems with an unsatisfactory operational status (about 20%) were compared to effluent concentrations from systems with a satisfactory operational status. Secondly, effluent concentrations from sampled systems that had been found with power switched off, with power indicator off, or where aeration did not appear to occur (about 15%) were compared to all other effluent samples. In both cases, the systems that appeared operational performed significantly (level of significance <5%) better than the non-operational ones for cBOD5 and TN but not significantly different for TSS and TP. The operational systems under each definition did increase the removal effectiveness based on median concentrations for TN by about 4% to nearly 40% but did not do so for cBOD5. The apparent lack of aeration power for treatment systems resulted in samples with median concentrations that indicated lack of nitrification, no nitrogen removal, and reduced cBOD5 removal (from 93% to 57%). The substantial fraction of low cBOD5 effluent concentrations in samples from non-operational treatment systems and the measurement of high nitrite/nitrate concentrations in some of these samples indicate that the power operational status at the time of the visit is not completely predictive of effluent concentrations at the same time, for example, because of the hydraulic residence time in the treatment unit.

Conclusions

Advanced OSTDS are utilized throughout Florida for various reasons and require more maintenance and management than a conventional OSTDS. By far the most common treatment approach in these systems is extended aeration.

During visits to almost five-hundred randomly selected systems, approximately one-third were found in a status that would require follow-up by the maintenance entity. The main reason for this was an apparent lack of power to the system.

Influent, or better pretreatment tank effluent, concentrations measured on the samples discussed, indicated wide variability in strength. Median cBOD5, TN, and TP concentrations were lower than reported in recent studies, which may be related to differences in water usage.

Median effluent concentrations indicated over ninety percent removal for cBOD5, about three-quarters removal for TSS, one-third for TN, and nearly none for TP. These are generally consistent with the treatment steps employed, while the lower than expected TSS removal may be in part related to the sampling process.

Advanced treatment systems assessed as operational, either as overall assessment or based on power supply and aeration effectiveness, perform significantly better than non-operational ones with respect to cBOD5 and TN-removal.

Acknowledgements

This paper was funded in part by a Section 319 Nonpoint Source Management Program Implementation grant from the U.S. Environmental Protection Agency through an agreement/contract with the Nonpoint Source Management Section of the Florida Department of Environmental Protection. We would also like to thank the Wakulla, Monroe, Charlotte, Lee, and Volusia County Health Department's for their support and cooperation.

Notice

The information contained within this paper does not necessarily reflect the official opinion of the Florida Department of Health and no official endorsement should be inferred.

References

Lowe, K.R., M.B. Tucholke, J.M.B. Tomaras, K. Conn, C. Hoppe, J.E. Drewes, J.E. McCray, J. Munakata-Marr. 2009. Influent Constituent Characteristics of the Modern Waste Stream from Single Sources. WERF.

Roeder, E. and Brookman, W.G. 2006. Performance of aerobic treatment units: monitoring results from the Florida Keys. *Journal of Environmental Health* 69(4) 17-22.

Roeder, E. and Brookman, W.G. 2008. Comparison of multiple grab and 24-hour time-composite samples from aerated onsite sewage treatment systems. *Conference Proceedings, 81st Annual Water Environment Federation Technical Exhibition and Conference*, Chicago, IL Oct 18-22, 2008.

Roeder, E. 2011. Task 1: Monroe County detailed study of diurnal and seasonal variability of performance of advanced systems. Final task report for DEP Agreement G0239.

Ursin, E. and Roeder, E. 2011. Task 2: Database of advanced systems in Florida. Database development, database structure, and summary statistics. Final task report for DEP Agreement G0239.