

YSI Technology Used to Improve Water Resource Recovery Facility Efficiency & Effluent Quality



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YSI Multiparameter Monitoring
Application Note A504-03

For those not familiar with the science of wastewater treatment, the experience of standing on a catwalk spanning an aeration basin's rolling boil of viscous fluid might do little to invoke an awareness of ecological health. However, when one looks beyond first appearance, and into the heart of the processes taking place, the similarities between a wastewater treatment system and that of a natural aquatic system are striking. Wastewater treatment systems in actuality are excerpts from natural aquatic communities that have been intensified and optimized to assimilate the copious amounts of wastes that would otherwise be poured into ambient waters.



An example of a water resource recovery facility.

Ron Schuyler, Wastewater Process Specialist, approaches waste treatment from a holistic perspective, and regards water resource recovery facilities (WRRFs) as complex living systems. 'The Bug Doctor', as Schuyler's colleagues affectionately call him, understands the hydraulic, physicochemical and biological vital signs of these systems and can determine their condition. Should a malady be diagnosed, Schuyler prescribes the remedies necessary to return the system to optimum health. One of Schuyler's "stethoscopes" is a YSI sonde equipped with DO, temperature, conductivity, pH, nitrate, ammonia and ORP, which is connected to a YSI handheld display. The sonde and handheld display is Schuyler's window into the nature of the processes taking place within these systems and provides the data essential to his diagnoses.

Tantamount among the objectives of wastewater treatment is the removal of nitrogen, which, in combination with phosphorus, causes eutrophication of ambient waters. Nitrogen usually enters a wastewater treatment system in the form of ammonia (NH_3) primarily and ammonium (NH_4^+). Influent ammonia, as well as ammonia in the early stages of treatment, is primarily the result of hydrolysis of urea, while microbial decomposition of nitrogenous compounds (i.e., proteins) increases the ammonia later in the process. Other sources of influent ammonia include, but are not limited to, manufactured compounds such as chemical degreasers and other cleaning products.

In the treatment process, as in natural systems, ammonia not used for biosynthesis first undergoes nitrification, an aerobic process wherein ammonia is oxidized to nitrite, thence to nitrate. Nitrification is carried out by bacteria such as *Nitrosomonas* and *Nitrobacter*. Much of the energy released through this process is used to reduce CO_2 for the formation of organic matter: a constant rejuvenation of the nitrifying community. At this stage, the treatment process may be reversed by harnessing another natural process, denitrification.

Denitrification is an anaerobic process wherein nitrate is reduced to nitrite, thence to elemental nitrogen, which is liberated to the atmosphere. It is important to note that, although some denitrification can occur aerobically, it occurs intensely under anaerobic conditions. Therefore, by maintaining anaerobic conditions (often termed "anoxic" if nitrate is available) at this phase of treatment, the WRRF can remove the maximum amount of nitrogen from the waste stream. Key participants in this process include

Simplified Diagram of Nitrification (a) Denitrification (b)



continued



many facultative anaerobic bacteria such as those in the genera *Pseudomonas*, *Achromobacter* and *Escherichia*. By harnessing and intensifying these natural processes, the WRRF can significantly decrease nitrogen concentrations from the waste stream before treated effluent is discharged to ambient waters.

Close monitoring and control of biological, physicochemical and hydraulic conditions are required to optimize the environment within the WRRF so that the nitrification and denitrification processes can be harnessed and intensified consistently. Schuyler reports that, in addition to certain microbial community compositions and densities, there are a few vital signs (parameters) common to both processes that, if measured accurately and over time, can provide him with valuable insight regarding the overall performance of a WRRF. These parameters also allow him to diagnose the cause(s) of reduced efficiency or diminishing effluent quality.

With their YSI sonde and handheld display systems, Schuyler and his colleagues continuously monitor DO, temperature, pH, ORP, ammonia and nitrate at various points within WRRFs for 12-24 hours. Schuyler reports, "Temperature can vary somewhat; however, as long as these do not change sharply or range widely from average or normal levels for these processes, few problems are observed. In contrast, pH, DO, ORP, ammonia and nitrate have, depending on the process, certain levels (or ranges) within which conditions are optimum; and outside of which treatment performance and efficiency, therefore effluent quality, will be diminished."

Of these parameters, Schuyler depends most on ORP, ammonia and nitrate. "With these parameters, measured over time, I can determine if the process is sufficiently oxidizing or reducing, and where process (nitrification or denitrification) performance is relative to where it should be."

With data from their sonde - along with careful analysis of hydraulics and microbial community composition and density - Schuyler and company can diagnose causes of diminishing

effluent quality, prescribe management strategies and corrective measures that will maintain and restore effluent quality, as well as improve efficiency and often reduce electrical costs. Schuyler estimates that "...75% of the WRRFs not monitoring ORP, ammonia and nitrate, continuously or at least frequently, as part of their management program, could save significant operating costs and improve effluent quality if they did so."

References

- Biological and Chemical Systems for Nutrient Removal. 1998. Water Environment Federation, 480 pp.
- Standard Methods for the Examination of Water and Wastes. 20th Edition, APHA, AWWA, WEF. 1999. 1,000 pp.