Wastewater

Solids retention time control in wastewater treatment

In wastewater treatment, the selection of Solids Retention Time (SRT) control has many consequences in process performance, sludge production, and oxygen requirements. Until now, automation of SRT control has not attracted much attention. However, several suitable instruments and control strategies now exist and the case studies presented here demonstrate some of the benefits of automatic SRT control.

Solids Retention Time (SRT) is a critical activated sludge design and operating parameter. The selection of an SRT has many consequences related to process performance, sludge production, and oxygen requirements. The traditional method for controlling SRT is to manually adjust the sludge wasting rate based on the food-to-microorganism (F/M) ratio or mixed liquor suspended solids (MLSS) concentration. The effectiveness of closed-loop control of SRT has been demonstrated in many locations. In addition to reducing variability in actual SRT other benefits cited include reduced foaming, improved sludge settling characteristics, improved performance of downstream sludge thickening, and fewer laboratory process control measurements. Automated SRT control is likely to be of great benefit for overloaded or nutrient removal facilities. However, a big reason that automated SRT control is not more widely practised is that many operators and engineers fear that a malfunction or misapplication of the control system will lead to a process upset. A better understanding of the proper application of SRT control is needed.

A review of published information and the authors experiences reveal how SRT control can be optimised for the most stable results. Control system design requires accounting for process dynamics, selection and location of instrumentation, and development of a control strategy. The basic components of an SRT control system include flow and level meters, online suspended solids sensors, and a PLC or microprocessor. The control handle

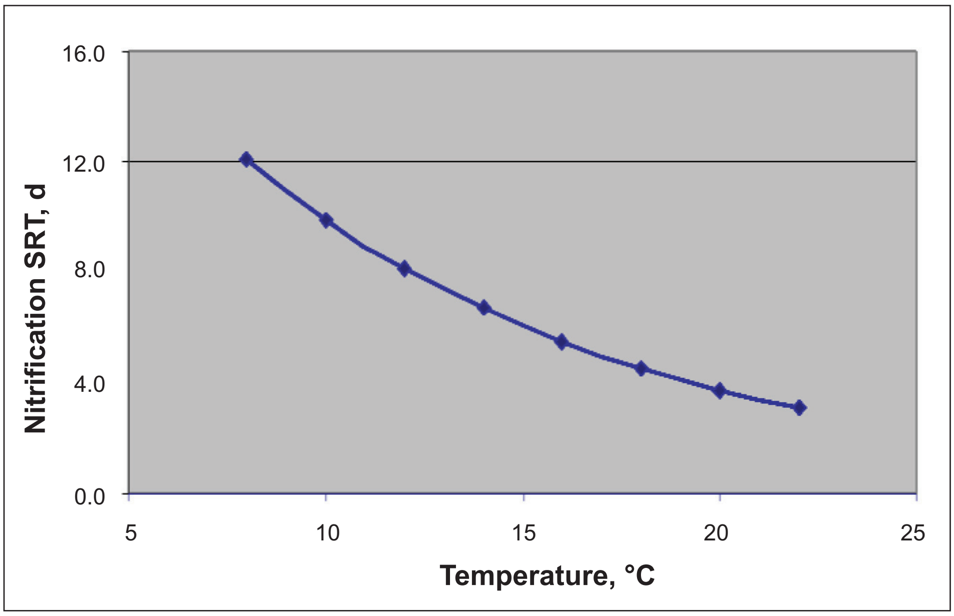

Figure 1: Nitrification SRT related to temperature.

Activated sludge function	Impact of SRT	Optimum SRT
COD removal	Too low: Elevated BOD in treated effluent. Too high: increased oxygen requirements; increased energy usage.	As low as possible to permit development of a flocculent sludge and nitrification, if required.
Nitrification	Too low: incomplete nitrification; elevated ammonia in treated effluent; denitrification not possible Too high: increased oxygen requirements; increased energy consumption; increased nitrate (degrades denitrification performance).	4 to 8 days
Denitrification	Too low: incomplete denitrification; elevated nitrogen in treated effluent; higher chemical usage in denitrification filters Too high: increased oxygen requirements; increased energy usage.	10 to 15 days
Phosphorus Removal	Too low: Enhanced biological phosphorus removal (EBPR) will not occur. Increased chemical usage. Too high: Phosphorus uptake rate is reduced. Supplemental chemical addition could be required.	5 to 12 days
Final Settling	Too high: Increased solids loading; filamentous bulking; increased total suspended solids in treated effluent. Too low: poor settling; increased total suspended solids in effluent.	Variable – depends on treatment goals.
Sludge Treatment	Too low: higher sludge production. Too high: reduced sludge dewaterability; lower sludge digestability; reduced biogas production.	Variable – depends on treatment goals

Table 1. Impact of solids retention time on wastewater treatment processes.

is the waste activated sludge flow rate. The control structure and calculations differ among the various methods. Maintenance of the online instrumentation, including evaluation of data quality, has shown to be one of the biggest challenges.

The Concept of SRT

The activated sludge process is a biological process that relies on the development of a mixed culture of microorganisms to metabolise pollutants in wastewater. It was originally developed to remove organic pollution from municipal wastewater but has been proven for nutrient removal. Design innovations have produced configurations that can remove nitrogen and phosphorus. Dissolved oxygen, sludge recirculation, and sludge wasting are the three controllable operating parameters once the aeration tanks and settling tanks are in the ground. Automation of dissolved oxygen (DO) control is presently the subject of intense interest because of the energy required for injecting it into the process. However, SRT, controlled through sludge wasting, is the single most important design and operating parameter affecting the performance of activated sludge systems (Metcalf & Eddy, 2004).

The SRT represents the time spent by microorganisms in the system, or the time available for micoorganisms to reproduce. It is also referred to as mean cell retention time (MCRT) or sludge age. Each microorganism has a characteristic regeneration time which depends on many factors. If SRT is longer than regeneration time of a particular organism, it will proliferate. Otherwise, it will be washed out of the system. For instance, the minimum SRT required for nitrifying microorganisms is shown in Figure 1.

At a temperature of 2°C, an SRT greater than or equal to four days, is required for nitrifiers to regenerate at a faster rate than they are wasted from the system. At an SRT less than four days, nitrifiers will be removed at a faster rate than they regenerate, and they will be washed out of the system resulting in no nitrification occurring. A WWTP having a discharge limit for ammonia will need to maintain a sufficient SRT for nitrification to occur. If nitrification is not required, it is desirable to maintain an SRT to wash nitrifiers out of the system and minimise energy consumption for aeration because nitrifiers exert a substantial oxygen demand.

The concept of SRT, to most wastewater operators, is based on the parameter food to microorganism ratio (F/M ratio) which is the ratio of the organic load to the mass of microorganisms in the system calculated as follows:

$$F/M = \frac{BOD\ Load,\ lbs./day}{MLVSS,\ lbs.}$$

BOD load represents the influent organic load. MLVSS is mixed liquor volatile suspended solids which is a measure of the amount of biomass in the system. SRT and F/M are related by the following equation:

$$Y \times \frac{F}{M} - k = \frac{1}{SRT}$$

Therefore, a constant F/M implies a constant SRT because the yield (Y) and k (decay) are generally constant for a particular system. Also, the values are inversely related such that a lower F/M requires a higher SRT and vice versa.

Automation of SRT control reduces operation and maintenance requirements and improves treatment performance. Measurement of MLSS is critical to either F/M or SRT operating control strategy. The information provided by online TSS sensors day eliminates the need for daily grab samples and manual measurement of TSS reducing laboratory testing requirements, often by over 75%. Furthermore, continuous measurement and automatic calculation of SRT reduces the operator attention required. The manual strategy for SRT control is to find one or maybe two seasonal strategies that work under all conditions because the effects of a change to sludge wasting are not immediately apparent and the consequences for an improper adjustment could be dire and long-term. The alternative is to live with the inefficiencies from carrying excessive solids inventory.

Maintaining an optimum SRT through automatic SRT control also improves treatment performance. Automatic SRT equalises sludge flow and eliminates intermittent peak loading of solids treatment processes that occurs with manual SRT control. The loadings cascade through the plant as recycle liquid is decanted and recycled back to liquid treatment. Automatic SRT control also impacts microbial community structure. In general, the higher the SRT, the more biodiversity, the more functions supported. The risk of too low an SRT is that a particular function is not supported. This is most critical for nitrification because it is the only practical approach for ammonia removal. Furthermore, without nitrification there cannot be denitrification. On the other hand, an SRT that is too high increases operating cost and reduces treatment capacity. For example, automatic SRT control has been demonstrated to eliminate nocardia foaming