Back to basics: high-loaded activated sludge

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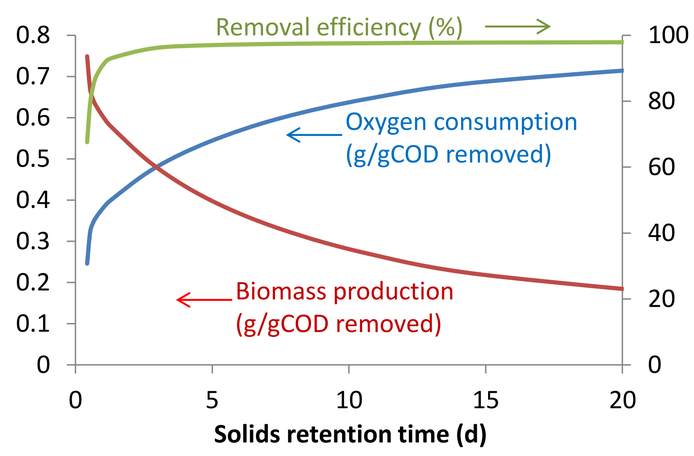
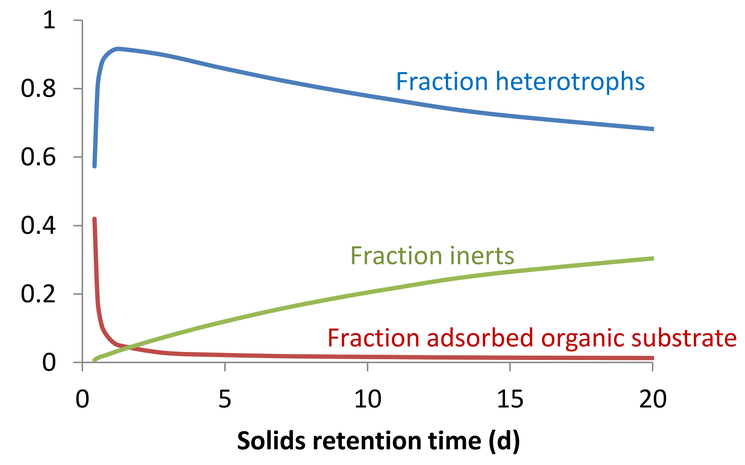
INTRODUCTION

In modern wastewater treatment plants, organics removal and nitrification is often combined in the activated sludge process, which then has to be operated with a long solids retention time and be low-loaded.

With the development of new nitrogen removal processes and an increased focus on resource recovery, high-loaded activated sludge processes should be designed to maximize recovery of organic material through adsorption and non-oxidative uptake, and to minimize oxygen consumption per unit of removed organics.





Left: Simulated oxygen consumption, biomass production, and COD removal rate at various solids retention times. Right: Simulated fraction heterotrophs, adsorbed organics, and inert material in the mixed liquor suspended solids. A simplified version of ASM1 (Model C in Gujer and Henze, 1991) was used for the simulation.

Our view of the evolution of the aerobic activated sludge process

Past
-High-loaded activated sludge
-Focus on organics removal

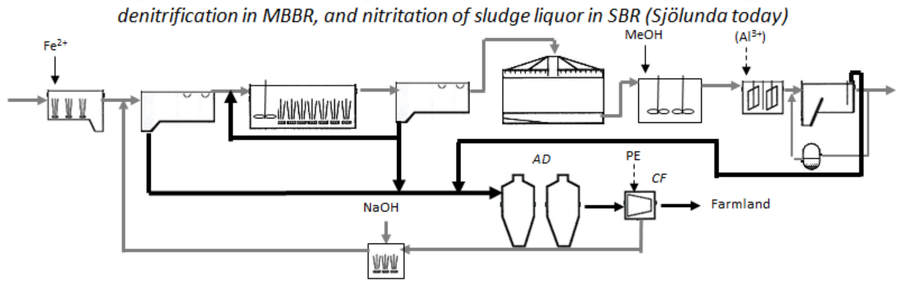
Present
-Low-loaded activated sludge
-Focus on combined removal of organics and nutrients, minimization of sludge production

Future
-High-loaded activated sludge
-Focus on maximized resource recovery and minimized resource use
-Organics mainly removed through non-oxidative uptake and valorized in anaerobic processes
-Nutrients removed/recovered in separate processes such as anammox, stripping and capture, and struvite precipitation

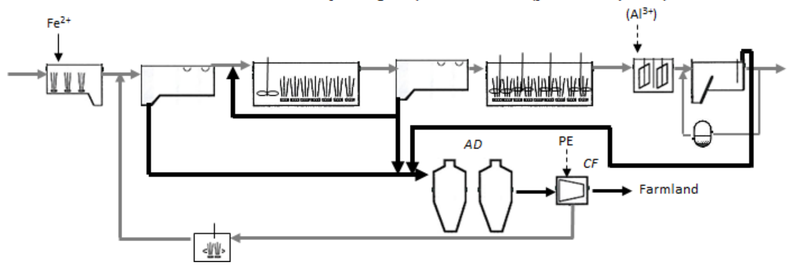
A VISION FOR SJÖLUNDA WWTP

Sjölunda WWTP in Malmö, Sweden, consists of primary settlers, a high-loaded activated sludge process, nitrifying trickling filters and post-denitrification with methanol in MBBRs. In a future vision for the plant, the MBBRs would be used for mainstream nitritation-anammox and the high-loaded activated sludge would be optimized for removal of organics through adsorption and non-oxidative uptake. Potential savings include 2000 ton methanol-COD/year. Lowering the activated sludge SRT from 32 to 20h could result in 23% lower aeration requirements, and 10% higher biogas production (Martinello, 2013).

Pre-settling with pre-precipitation, high-loaded activated sludge, nitrifying trickling filters, post-denitrification in MBBR, and nitritation of sludge liquor in SBR (Sjölunda today)

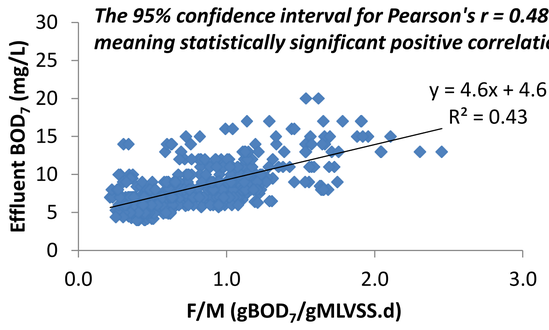


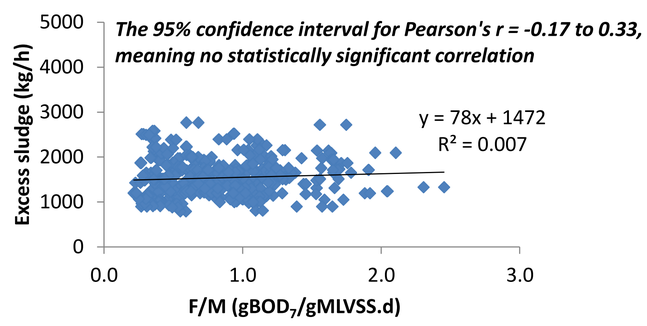
Pre-settling with pre-precipitation, high-loaded activated sludge, nitritation-anammox in MBBR, and nitritation-anammox of sludge liquor in MBBR (futuristic plant)



EXPERIENCES FROM GRYAAB

The Rya WWTP in Gothenburg, Sweden consists of primary settlers, denitrifying activated sludge, nitrifying trickling filters, and post-denitrification in MBBRs. Analysis of over 4 years of data from the full-scale plant showed a statistically significant positive correlation between organic loading (temperature-corrected F/M ratio*) and effluent BOD_7 concentration. No significant correlation between loading and amount of withdrawn excess secondary sludge could be observed.





*The temperature-corrected F/M ratio was calculated to account for variations in biological reaction rates with temperature (T): $(F/M)_{20°C} = (F/M)_T/\theta^{(T-20)}$, where θ was assumed to equal 1.135 (Metcalf & Eddy et al., 2003).

RESEARCH NEEDS

Reducing energy requirements and increasing resource recovery in an activated sludge process by increasing the organic loading may not be straight-forward. Here are a few things to consider:

- The effluent quality could deteriorate because of higher selective pressure on the microbial community at lower SRT, resulting in lower biodegradability of the incoming organics. What is the trade-off between lower treatment efficiency and higher resource efficiency?
- The flocculation and settling ability of sludge may change and affect solids separation. Problems with foaming could appear, which has been observed at the Sjölunda WWTP. How can this be prevented?
- What mechanisms govern adsorptive- and non-oxidative uptake of organics by the activated sludge, and how can we design processes to maximize this uptake?
- How do the high-loaded activated sludge integrate with other processes at the plant, e.g. is a portion of the organics needed for denitrification and what are the treatment requirements if the effluent is fed to a main-stream anammox process?
- How should we valorize the increased amount of organic material recovered in a high-loaded activated sludge plant?

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References
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