Control of the growth of *Microthrix parvicella* by using an aerobic selector – results of pilot and full scale plant operation

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Abstract A two-stage wastewater treatment plant experiences bulking sludge problems in winter, correlating with *Microthix parvicella* abundance. Pilot and full-scale studies of the use of an aerobic selector to control *M. parvicella* had little success, probably resulting from long chain fatty acid retention in foam at the tank surface. Initial pilot studies with reduced foam retention showed better results.

Keywords Aerobic selector; bulking; foaming; long chain fatty acids; *Microthix parvicella*; nitrification–denitrification

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Introduction

The WWTP Cologne – Langel is set up as a two stage (A–B process, according to Böhnke and Pinnekamp, 1989, Nitrification–Denitrification) treatment plant for at least 110,000 population equivalents (Figure 1). Bulking sludge problems occur in the second stage (0.08 kgBOD/kgMLSS·d) mostly in the winter months with a strong temperature dependence. Microscopic investigations of activated sludge population show a good correlation between SVI and the abundance of *Microthrix parvicella*.

In summer 2000 a two line pilot plant was built in Cologne – Langel at a proportion rate of 1:11,000 to investigate the use of an aerobic selector (Figure 2) for the control of the massive growth of *M. parvicella*. At the same time the WWTP (full scale) is equipped with an aerobic selector as well. The selector in full scale and in pilot plant is divided into three equal cascades. Due to hydraulic problems the full scale selector receives only 50% of the influent wastewater.

While the selector is in operation the return sludge from the intermediate settling tank to stage A is stopped and only excess sludge is wasted. This corresponds with a modification of the WWTP from two stage to one stage plant. 30% of the return sludge from the secondary clarifier is fed to the aerobic selector. This results in an average COD sludge loading of 6.5 [kg/kg·d] in the selector.

The second stage nitrification tank of WWTP Cologne – Langel is designed as a completely covered cascade of three aerated and one unaerated (endogenous denitrification) tanks. The cascades are connected below the water surface level. This leads to almost complete retention of foam if sludge bulking appears.

The layout of the pilot plant is equivalent to the full scale design, in case of modifications of the pilot plant layout they were only made in one of the two lines to ensure a proper comparison of pilot and full scale plant. After three months of operation (January 2001) one line of the pilot plant is modified to a selector system receiving the complete influent.

At the beginning of December 2000 this line of the pilot plant was temperated to ensure temperatures between 10 and 12°C.

Results

Characterisation of waste water influent

Table 2 gives the characteristics of the influent to the WWTP of Cologne Langel as an average of the last three years. Concentrations of long chain fatty acids (C_{16}–C_{18}, LCFA) result from representative 8 hour composite samples during one week in April 2000.

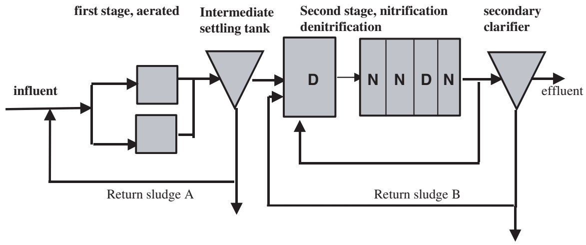

Figure 1 Flow sheet of WWTP Cologne – Langel

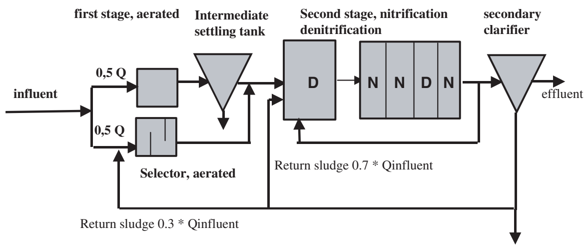

Figure 2 Integration of the aerobic selector

Table 1 Volumes of full scale plant

	[m³]
First stage	2·316
Intermediate settling tank	1,500
Selector	3·105
Total anoxic volume	7,800
Total aerobic volume	8,700
Secondary clarifier	2·3,100

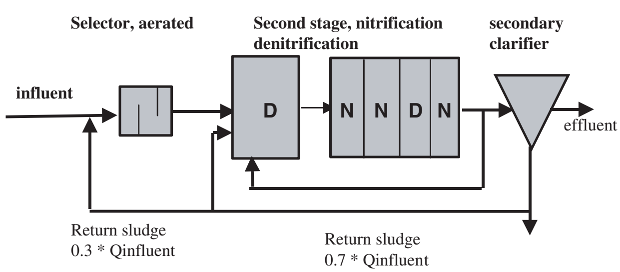

Figure 3 Aerobic selector receiving complete waste water influent (pilot plant)

Materials and methods

Microscopic investigations. To determine the total abundance of filamentous organism and *M. parvicella* the methods and categories described by (Knoop and Kunst, 1998) and (Knoop and Kunst, 1996) were used. Investigations were done every second week.

LCFA analysis. Measurement of LCFA was done by GC/MS Analysis.

Batch experiments. These were carried out with wastewater and sodium oleate to determine the rate of COD elimination and respiration as well. The evaluation of respiration and total elimination was done in accordance with Prendl (1997) and Ekama *et al*. (1986).

Table 2 Characteristics of waste water influent WWTP Cologne – Langel

	∅	min.–max.
Influent [m^3/d]	18,900	7,500–58,000
COD [mg/l]	544	90–1,000
BOD_5 [mg/l]	356	70–630
NH_4-N [mg/l]	32	2–51
TKN [mg/l]	51	3–138
P_{Tot} [mg/l]	8	2–27
BOD_5:N:P	100:14:2	–
LCFA [mg/l]	23	3–48
COD of LCFA [mg/l]	70	8–136

Selector operation in full scale and pilot plant

The aerobic selector in the full scale and the pilot plant was put into operation in November 2000. At this time the SVI varies between 150 and 170 [ml/g] in both plants.

As can be seen in Figure 4 the SVI in the full scale plant can only be controlled during start up of the selector operation in November 2000. With decreasing temperature in January 2001 there is a strong deterioration in sludge settleability in the full scale plant. The pilot plant was cooled down one month earlier which leads to comparable increase of SVI. After changing pilot plant layout due to Figure 3 (selector receiving complete influent) there is no further increase of SVI, but the SVI remains stable at 150–200 [ml/g]. Microscopic examinations of the activated sludge are summarised in Table 3.

The total filament category and the abundance of *M. parvicella* show only little variation after six months selector operation in both plants. It is however remarkable that there is less

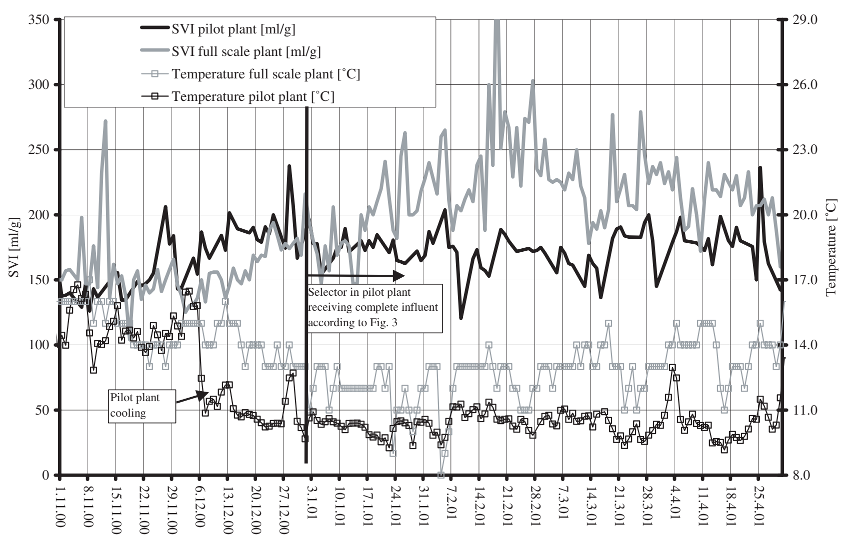

Figure 4 SVI in full scale and pilot plant

Table 3 Total filament category and abundance of *M. parvicella* in full scale and pilot plant

	Total filament category		Abundance of *M. parvicella*	
	full scale	pilot plant	full scale	pilot plant
Nov/Dec	4	4	5–6	5
Jan/Feb	5	5	6	5–6
March/Apr	5–6	5–6	6	5

M. parvicella in the system with full-stream-selector even if the temperature is significantly lower than in the full scale plant. These findings are more likely due to the missing primary clarifier (higher COD – load, less sludge age) than to a biological "selector effect".

Investigations of LCFA in the influent, activated sludge and foam make it evident that there is a huge accumulation of LCFA in the foam at the surface of the Nitrification/Denitrification tanks up to 200 [mg LCFA/l]. This accumulation is assumed to result from adsorption of the particulate fraction of LCFA (Quéméneur and Marty, 1994). Measurements of LCFA in the foam and suspended sludge in the batch experiment indicate that LCFAs are consumed in the suspended sludge but a part of them (up to 30%) accumulate and remain in the surface foam. Therefore the primary and maybe sole carbon source of *M. parvicella* (Slijkhuis, 1983; Andreasen and Nielsen, 1998) is always available in the system independent of plant operation with or without selector.

Batch experiments with sodium oleate serving as LCFA source show clearly that there is a rapid adsorption to the sludge floc. Investigations of Dueholm *et al*. (2001) indicate that LCFAs are consumed and taken up easily under aerobic and anoxic conditions. Experiments with the activated sludge from WWTP Cologne Langel showed a comparable aerobic respiration up to 10 [mgO_2/gMLVSS·h] of LCFA.

Further experiments in pilot plant during summer 2001 showed a significant lowering of the abundance of *M. parvicella* if surface foam retention is removed.

Conclusions

First experiences with the aerobic selector operation at the WWTP Cologne – Langel showed only little success in controlling the growth of *M. parvicella*. According to the substrate preferred by *M. parvicella*, investigations of influent quality showed no unusually high values of LCFA. Examination of LCFA in the foam indicate that there might be a pool of substrate at the surface of aeration tanks due to the almost complete retention of foam at WWTP Cologne – Langel. First investigations of uptake and consumption of LCFA indicate that there is a fast adsorption and significant respiration of these substrates.

Further investigations about the uptake and consumption of LCFA will be done. Corresponding to the strong temperature dependence of *M. parvicella*, investigations about the availability of LCFA in wastewater according to temperature are essential.

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