AVOIDANCE OF EXCESS SLUDGE BY APPLICATION OF SURFACE-ACTIVE SUBSTANCES – RESULTS

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ABSTRACT

Activation of the micro-organisms in the activated sludge process by dosing additional nutrients into the influent of the sewage treatment plant, clear improvement of the biological oxygen availability as well as the lytic process of bacteria by surfactants allow to operate a municipal sewage treatment plant in theory without excess sludge production, in practice it will be reduced by upto 65 %. Operating results from several municipal sewage treatment plants where the process for excess sludge avoidance has been used successfully are already available. Besides minimisation of excess sludge production, significant ammonia and phosphorous reduction could be observed. Moreover, the settling behaviour of the activated sludge in the final clarification tank could be influenced in a positive way.

INTRODUCTION

In 1996 about 2.7 million tons of sewage sludge, measured as dry solid matter, have been disposed of in Germany [Esch and Krüger, 1999]. According to Kollatsch [1998], the proportionate operating costs for sewage sludge treatment and especially for sludge disposal amount to 30 - 50 % of the total operating costs of sewage treatment plants.

THEORY

There is a fundamental difference between the natural biological processes occurring in the body of water and those taking place in sewage treatment plants: The sludge loading ratio in sewage treatment plants is considerably higher, due to a higher carbon charge in the inflow and a too low concentration of bacteria in the activated sludge tank, respectively. As a result there is not enough oxygen available for the biological processes, and most of the metabolism processes run rather inefficiently. The organic load of waste water is not aerated but predominantly transformed into biomass. This so-called excess sludge is continuously withdrawn from the system so that organisms with short reproduction times (bacteria) dominate. As a result the number of bacteria-consuming organisms with long reproduction times become insufficient. Dorau [1998] proposes the thesis that the biological self-optimising processes running in municipal sewage treatment plants are constantly disturbed by interference from outside, especially by excess sludge withdrawal.

In most municipal sewage treatment plants, the oxygen needed for the metabolism of the micro-organisms is fed by fine-bubble aeration into the activated sludge tank. The air bubbles produced at

the bottom of the activated sludge tank are still very small. Rising towards the water surface, they unite to bigger ones, as a result of hydrostatic pressure, and thus reduce their specific surface. The low efficiency of most aeration systems (only about 5 to 15 %, related to the total oxygen quantity supplied [Imhoff and Imhoff, 1993]) is especially due to this effect, called coalescence. While the fringe areas of an activated sludge floc are well supplied with oxygen, a deficiency of oxygen is often found in its interior. Excess sludge production directly depends on the oxygen partial pressure. Increasing the oxygen availability in the activated sludge tank results in higher oxygen partial pressure so that the deeper layers of the activated sludge floc, too, are sufficiently supplied. The inside layers also take part in aerobic decomposition and increase the potential for aeration of endogenous substances. Summarizing, excess sludge production can be described as a function of sludge loading ratio, oxygen availability/partial pressure and waste water composition:

excess sludge production = f (F/M, oxygen partial pressure, waste water composition)

APPLICATION OF THE EXCESS SLUDGE AVOIDANCE PROCESS

According to Steinmetz [1996], under the notion “surface-active agents or surfactants” are subsumed organic compounds containing a lipophilic hydrocarbon residue and a hydrophilic functional group which due to their chemical properties are able to reduce the surface tension of aqueous systems. So-called bio-surfactants are especially suited to be applied in activated sludge tanks because they are biodegradable and highly effective already in low concentrations. Bio-surfactants are lipids or lipid derivatives which are synthesised by micro-organisms during their growth phase.

Using surfactants, it is possible to modify coalescence in a positive way and thus to considerably increase biological oxygen utilisation. The surface available becomes larger, and more oxygen goes into solution. By surfactants the flake matrix described above is attacked, parts of the matrix as well as cells are submitted to lytic processes, and more flake portions take an active part in the purification process. The finer and smaller the activated sludge flakes are, the better oxygen is able to diffuse into the interior of the flake, even at low oxygen concentrations. The application of the excess sludge avoidance process requires a step by step procedure:

1. The micro-organisms are stimulated by additional nutrients, so that the biological process is stimulated to adapt to the new milieu conditions. After an adaptation time of one or two weeks, excess sludge withdrawal is stopped.

2. When a defined starting point is reached, characterised by a change of the microscopic pattern and a determined MLSS concentration, the second process phase begins with addition of surfactants into the return-sludge flow. In this way the increase of MLSS in the activated sludge tank is slowed down. Optimal dosing results in a steady MLSS concentration in the activated sludge tank, and, with this, nearly infinite sludge age.

RESULTS

In the first half of 2001, the process for excess sludge avoidance described was applied at six municipal sewage treatment plants. Reliable findings about the savings made are already available from two of these plants. Table 1 presents their features.

Table 1 Characterisation of the sewage treatment plants

Plant	Load [PT]	Characterisation of the waste water
1	11,000	predominantly municipal
2	33,000	30 - 40 % industrial

Excess sludge reduction is presented in Figure 1, expressed in percent and related to historical data. It becomes apparent that the result of the reduction is higher at the plants which are not influenced by industrial waste water.

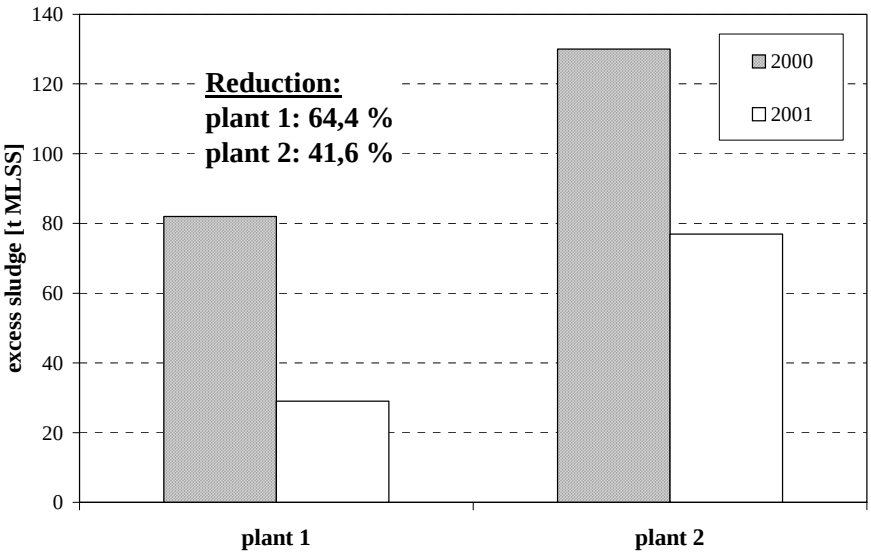

Figure 1 Excess sludge reduction at two sewage treatment plants

Besides excess sludge reduction of up to nearly 65 %, some other effects were observed which positively influence the operation of sewage treatment plants. Dosing of the nutrient supplement during pilot-scale tests with a completely separated activated sludge plant (volume each: 4 m³), operated in parallel, and had as a result positive effects on the sludge index. After nearly one week the filamentous bacteria observed under the microscope had completely disappeared. Applying the excess sludge avoidance process, it is possible to influence the development of filamentous organisms and thus to respond at short notice to problems with bulking sludge.

Comparing studies with or without applying the excess sludge avoidance process at the pilot plant described above resulted in the ammonium effluent concentrations clearly decreasing within a period of more than three weeks, at a sludge loading rate of about 0.2 kg $B.O.D._5$/kg MLSS · d. The waste water temperature was 12 °C, and aeration in the activated sludge tank was adjusted to an oxygen target value of 1 mg/l.

Figure 2 clearly shows that the efficiency of ammonium elimination was more than 50 % only for 5 % of the cases studied with the reference line where the excess sludge avoidance process had not been applied. On the contrary, the efficiency of the test line was only in 5 % of the cases below 50 %.

From the test results it becomes clear that even with a sludge loading rate of about 0.2 kg $B.O.D._5$/kg MLSS · d the improved biological oxygen availability has a positive effect on the nitrification

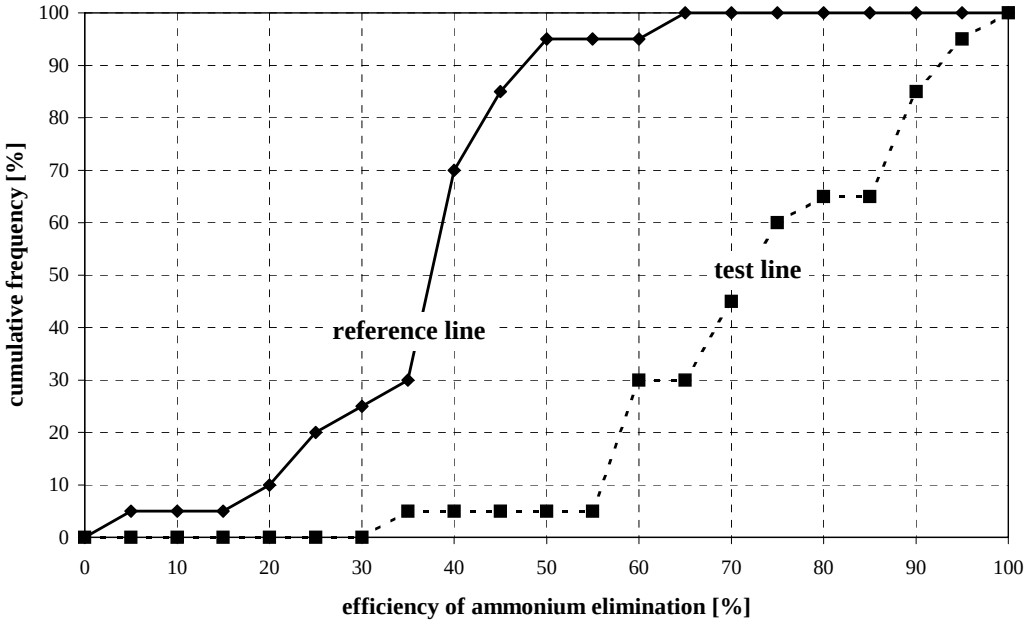

Figure 2 Comparison of the ammonium elimination efficiency

efficiency, due to the addition of surfactants. Air supply may probably be reduced at constant nitrification, lowering at the same time the energy costs, or overloaded sewage treatment plants might improve nitrogen elimination. Further studies will have to focus on the quantification of the increased nitrification potential.

Since about six months the excess sludge avoidance process is applied at a sewage treatment plant charged with 140,000 PT. The plant treats waste water with predominantly industrial character (80 %). After having applied the new process for three weeks, it was observed that the visibility depth improved by nearly 25 %, although the MLSS content was reduced by about 2 g/l. For more than three months already, the visibility depth is kept at this improved level.

By applying the excess sludge avoidance process it was also possible to intensify phosphorus elimination at the sewage treatment plants studied. The precipitant quantity was partly reduced by 65 %.

CONCLUSION

For the first time a sound process well tried in practice is available which is very well suited to avoid excess sludge production as required by the Recycling and Waste Act. Moreover, biological phosphorus and ammonium elimination is improved. The cost for excess sludge avoidance are by about 50 – 80 % compared with thermo treatment cost in Germany, depending upon the sewage treatment plant in question.

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