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Ozone to Control Bulking and Foaming in Municipal Waste Water Treatment Plants

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ABSTRACT

Ozone is known to be effective for achieving positive treatment effects on sludge characteristics. One of these effects is the reduction in excess sludge generation in wastewater treatment operations. This application is known for many years and full scale plants are installed and in operation. The economical success of this application strongly depends on the required ozone dose to reduce a certain amount of excess sludge expressed as kg O_3/kg $TS_{removed}$. Economic dosage rates below $\leq$ 0.1 kg O_3/kg $TS_{removed}$ are proven in full scale plants.
In addition a significant reduction of bulking at the wastewater treatment operation as a result of the ozonation process is observed. Microbiological analyses indicate that this is as a result of the greater vulnerability of filamentous bacterial species to sludge ozonation. Investigations show a significant reduction in the population of all filamentous microbial species, with the most significant reductions being observed in Microthrix parvicella and Nocardia species. The dosage range of ozone required enabling foam reduction and bulking control is significantly lower than the dosage range for the excess sludge reduction. Ozone is an attractive alternative to chemicals to prevent the sludge bulking and improves in parallel the settlement behaviour of the sludge (reduced Sludge Volume Index SVI). Depending on operational conditions the SVI can be readily reduced from 300 to lower than 100 ml/g.

1. OZONATION OF RAS (RETURN ACTIVATED SLUDGE)

The most applied sludge ozonation processes are integrated in the return activated sludge line to reduce the growth of biomass and therefore to reduce the amount of waste activated sludge mass. Integration in RAS line means that a portion of activated sludge is treated by ozone in a bypass system and RAS is pumped back to the biological treatment step. Most common is the mixing of ozone and RAS with a venturi pipe. Some processes use a pressurized reactions system or a loop reactor to have a certain retention time. The following scheme shows the implementation on RAS treatment:

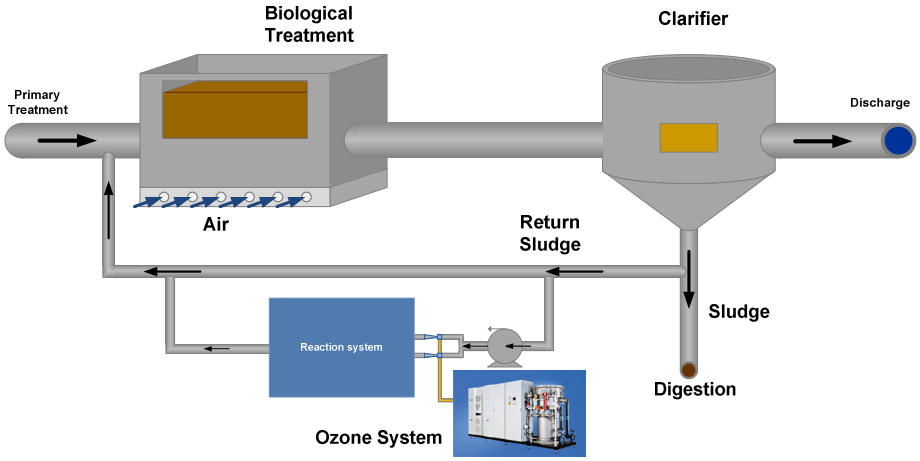

Figure 1: Principle scheme for Sludge removal process by ozone

2. BULKING AND FOAMING CONTROL ON ACTIVATED SLUDGE SYSTEMS

The effectiveness of solid-liquid separation in wastewater treatment operations can be affected by bulking and foaming [8, 12]. Bulking and foaming problems can be pervasive, affecting up to 50% of biological wastewater treatment facilities [8]. It has always been recognized that poor settleability and bulking is associated with the presence of filamentous organisms. A wide variety of filamentous organisms such as Microthrix parvicella, Eikelboom types 0041, 021N, 0092, 0675, Thiothrix, and norcadiaforms actinomycetes have been found in wastewater treatment systems. Microthrix parvicella is extremely pervasive. In a survey of 167 plants in Italy [8] found Microthrix parvicella to be the most common filamentous organism, and its presence was highly correlated with the incidence of both bulking and foaming problems. A variety of factors such as low DO, low F/M, complete mix reactor conditions, septic wastewater and sulfide availability, nutrient deficiency and low pH have all been associated with filamentous bulking [3].

3. EFFECTS OF OZONATION ON FILAMENTS

Filaments have a high surface area to volume ratio, which allows them to thrive under nutrient deficient conditions. However, the high surface area of filaments also makes them particularly susceptible to chemical attack. When ozone is applied to sludge, the lysis process occurs through the oxidation of the cell wall of the bacterial cells by ozone. It is well known that the rate of chemical reactions is enhanced by reaction systems that have large surface areas. The high surface area to volume ratios of filaments makes them especially susceptible to ozone attack. Also, even where the absolute number of filaments might be lower than that of the floc formers in a system, filaments form extensive bridging networks within and across flocs. This implies that not only single, free floating filaments are susceptible to ozone oxidation, they are also likely to be attacked by ozone molecules that penetrate the interior of the floc.

The technical process of bulk control with ozone is comparable with the disintegration process. The technical integration on WWTP is similar to Figure 1. The major impact is the size of the ozone generator due to lower dosages. The ratio of RAS_{ozoned} / RAS_{total} is in the range of 0.05 – 0.1 depending on the gas flow of the ozone generator and treatment effects.

4.1 CASE STUDY I: OZONE FOR SLUDGE REDUCTION AND FOAMING CONTROL IN ITALY

The effect of sludge ozonation on filament control was tested at full scale as part of a sludge minimization project at the Lariana WWTP (25,400 m^3/day) located in Bulgarograsso / Italy [4]. The raw water is a mixture of industrial (mainly textile) and municipal waste water. The facility had been plagued by a significant foaming problem (see figure 2). Microbiological tests indicated that the filamentous organisms at the facility included Microthrix parvicella, Nocardiaforms, Thiotrix, Sphaerotilus and Nostocodia. The foam was stable and measured about 20 cm in height.

Figure 2: Foam on aeration tank in Lariana before (left) and during (right) ozonation [4]

The ozonation step was installed by Praxair (Lyso) in the RAS line and the ozone was mixed via a venturi pipe. The ozonated sludge was returned to both nitrification basins. The dosage for this project is 0.05 - 0.07 $kgO_3/kgTS_{reduced}$ which is lower than former studies. The following figure 3 shows the effect of the ozonation on the abundance of different filament in the biological treatment step.

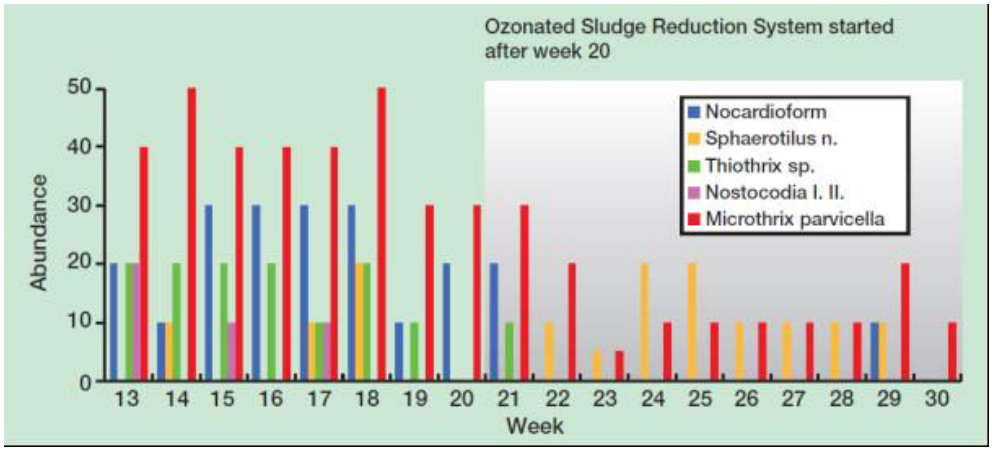

Figure 3: Reduction of filaments during ozonation at Lariana WWTP [4]

Nostocodia was completely eliminated in the system and did not recur throughout the test period. In the 10 week period following the commencement of the sludge ozonation tests, the average abundance levels of Microthrix parvicella, Thiotrix and Norcadiaforms were reduced by 66%, 94%

and 87% respectively. The operator observed significant reduction of foaming in the aeration basin process of the wastewater treatment operation as a result of the ozonation process. The foam layer was consequently reduced.
Additional effects were observed like decrease of SVI, the improvement of dewaterability of the excess sludge and no changes in the overall COD and TN removal.

5. CASE STUDY II: OZONE FOR BULKING CONTROL IN GERMANY

Lyko et al [7] describes the use of ozone for bulking control at one of largest WWTP in Germany. The WWTP of Bottrop was sized for 1.300.000 PE and has an inflow at dry weather of 4.25 m³/s (mixture of municipal and industrial waste water). The problem of bulking is a seasonal problem which happens during periods with low temperature.
The design includes three parallel activated sludge lanes. One of these lanes was equipped with an Ozonation step to treat approx. 6% of RAS with ozone. The RAS was pumped in the ozone plant where the ozone was mixed in by a venturi pipe. The treated RAS was returned to the denitrification basin. The most important process parameters are summarized in Table 1.

Table 1: Process parameter of ozonation at WWTP Bottrop [7]

Parameter	Unit	Value at line 3 of WWTP Bottrop
Ozone in process gas	wt%	8
Ozone load	Kg O_3/h	3
Gas flow	Nm³/h	25
RAS for ozonation	m³/h	300
RAS total	m³/h	5,000
Operation time	-	1 or 2 week(s) per month

The applied ozone dosage was according to Table 1 approx. 0.00167 $gO_3/gTSS_{ozoned\ RAS}$. The operation of the ozone plant was discontinuously one week in operation and two weeks without operation.
Figure 1 shows the changes in lane 3 and the two reference lines before and after the implementation of an ozonation step.

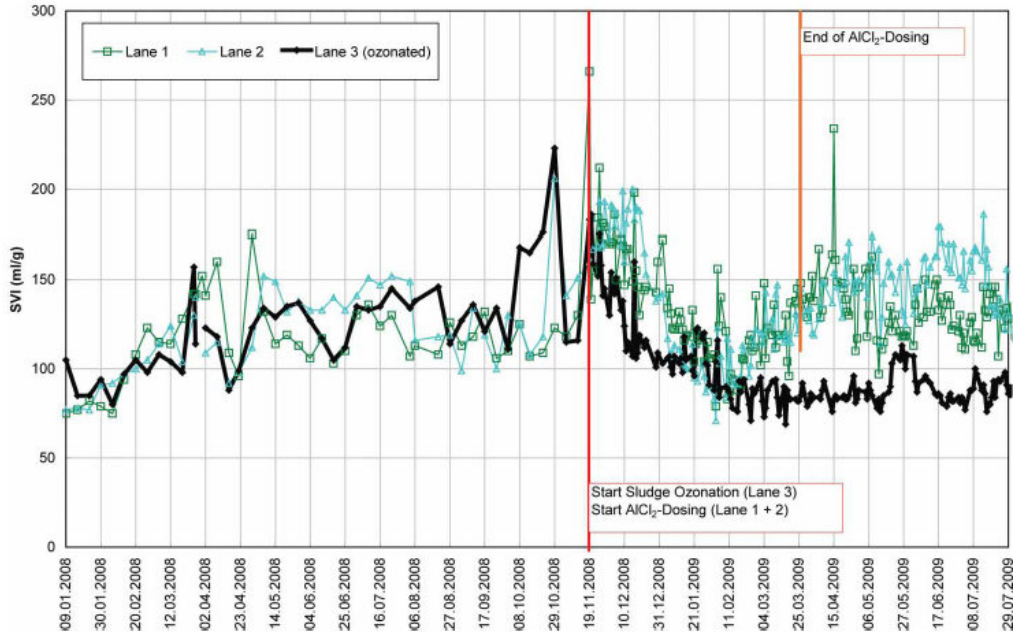

Figure 4: SVI changing during ozonation at WWTP Bottrop [7]

After the start of the ozonation the SVI level in lane 3 is on a constant level below 100 mL/g compared with the reference line where the SVI increases at the end of $AlCL_3$-Dosing. Comparing

ozone and $AlCl_3$-Dosing the first effect on the sludge could be observed at the ozone treated lane after only two days. The effect of $AlCl_3$-Dosing could be observed after 7-10 days. Additionally the MLSS in lane 3 could be increased to 3.5 g/L compared to 2.5 g/L in the reference lines. Since the sludge retention time of lane 3 is 17 days 14 days without ozonation are quite enough to control filamentous bacteria. The ozone generator was 1 week in operation and one week out of operation. The operating costs with ozonation are 50% less compared to the $AlCl_3$-Dosing.

6. CONCLUSION

Although a variety of methods exist which can potentially be utilized for foaming and bulking control, sludge ozonation can be an extremely effective means for mitigating foaming problems in wastewater treatment facilities. The case studies summarized in this paper have demonstrated the effectiveness of ozone for controlling foaming and bulking problems at wastewater facilities.
The continuous application of ozone in a wastewater treatment facility constitutes both a corrective and preventative measure. When applied to a plant that already suffers from bulking and foaming problems, ozone addition eliminates filamentous organisms that are already within the process. However, once that baseline is addressed, the further application of ozone serves to provide a strong selection pressure in the system for floc formers.
One full scale operation proved the prevention of bulking even with discontinuous ozone dosing (1-2 weeks operation during a month). The effect on the settling behavior can be observed in a short time and the overall treatment process is not negatively influenced.
The ozonation technology is quite easy in operation and the operational costs are comparable or even lower than the use of chemical.
The specific operation conditions for bulking and foaming control (low ozone doses and the option of discontinuous operation) offers the operator of a waste water treatment plant a safe and economical attractive option to manage the plant in case of bulking and foaming problems.

REFERENCES

[1] Böhler M., Siegrist H. (2004). Partial ozonation of activated sludge to reduce excess sludge, improve denitrification and control scumming and bulking. *Water Science & Technology*, 49(10), 41–49.

[2] Chudoba, J., Cech, J. S., Farkac, J., and Grau, P. Control of Activated Sludge Filamentous Bulking – Experimental Verification of a Kinetic Selection Theory. *Water Res. Vol 19*, No. 2 pp 191-196, 1985

[3] Eikelboom D.H. (1975), Filamentous Organism in Activated Sludge. *Water Research 9*, 365ff

[4] Fabiyi M., Novak R., Ried A., Wieland A., Capra R., Sandon A. (2007) Sludge reduction using ozone induced lysis. Published in conference report at *IOA+IUVA World Congress in Los Angeles 2007*

[5] Lakay, M. T.,Wentzel, M. C., Ekama, G. A. & Marais, G. v. R. (1988). Bulking control with chlorination in a nutrient removal activated sludge system. *Water SA 14 (1)*, 35–42

[6] van Leeuwen, J. (1988). Bulking control with ozonation in a nutrient removal activated sludge system. *Water SA 14 (3)*, 119–124

[7] Lyko S., Teichgräber B., Kraft A. (2012). Bulking control by low-dose ozonation of returned activated sludge in a full-scale wastewater treatment plant. *Water Science & Technology 65(9)*, 1654-1659

[8] Madoni P., Davoli D., Gibin G. (2000). Survey of filamentous microorganisms from bulking and foaming activated sludge plants in Italy. *Water Research 34(6)*, 1767-1772

[9] Nilsson F., Jönsson K., Dimitrova I. (2012). Full-scale ozonation to reduce filamentous sludge at Klagshamn WWTP. *Published in conference report at IOA-EA3G conference in Toulouse 2012*, 9.1-1 – 9.1-6

[10] Sievers et al. (2004). Sludge treatment by ozonation – Evaluation of full-scale results. *Water Science & Technology 49(4)*, 247 – 253

[11] Tchobanoglous, G., Burton, F., & Stensel, H. D (2003). Metcalf & Eddy Wastewater Engineering: Treatment and Reuse. McGraw Hill, NY

[12] Wanner J. (1994). Activated Sludge Bulking and Foaming Control. Technomic Publishing Company Inc., USA

[13] Yasui et al. (1996). A full-scale operation of a novel activated sludge process without excess sludge production. *Water Science & Technology 34* (3-4) 395-404