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SHORT TERM CHEMICAL TREATMENT OF BIOLOGICAL SLUDGE WITH FILAMENTOUS ORGANISM TYPE 021N

Korttidsverkan av kemikalier på biologiskt slam innehållande filament Typ 021N

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Abstract

When sludge bulking occurred in the new wastewater treatment plant for the abattoir in Kalmar, a quick solution to inhibit and harm the filamentous organism Type 021N was to be found. Five different kinds of chemicals (NaOCl, H_2O_2, $FeCl_3$, PAX-XL60 and Ecofloc) were tested in two short term lab-tests. Each chemical was first tested with five different dosing rates and an exposing time of one hour then with one dosing rate and an exposing time of 14 hours. Both test series were carried out with pH-adjustment if necessary and with continuous aeration. The samples were analyzed with a phase-microscope and pictures of all samples were taken with 100, 200 and 400 times enlargement.

The evaluation gave no satisfying results because the filamentous bacteria were either not harmed at all or they were harmed while at the same time most of the indicating organisms were severely damaged. The chemical PAX-XL60 gave, however, negative effect on the filamentous organisms, positive flocculation and did not harm the indicating micro organisms as severe as the other chemicals.

Key words – Type 021N, filamentous bacteria, NaOCl, H_2O_2, $FeCl_3$, PAX-XL60, Ecofloc, sludge bulking, abattoir wastewater.

Sammanfattning

När det nya reningsverket som renar vatten från slakteriet i Kalmar drabbades av slamsvällning behövdes en snabb åtgärd för att skada de filamentösa bakterierna av Typ 021N. Fem olika kemikalier (NaOCl H_2O_2, $FeCl_3$, PAX-XL60 och Ecofloc) testades i två olika korttidsförsök. Först testades varje kemikalie i fem olika koncentrationer under en timme, sedan testades alla kemikalier med en enda koncentration i 14 timmar. Båda testerna pH-justerades vid behov och luftades under hela försöket. Proverna analyserades sedan med ett fasmikroskop och fotograferades med 100, 200 och 400 gångers förstoring.

Utvärderingen visade att målet inte uppnåtts eftersom filamenten antingen inte skadades alls eller skadades samtidigt som indikator organismer drabbades hårt. Kemikalien PAX-XL60 gav emellertid negativa effekter på de filamentösa bakterierna och resulterade samtidigt i god flockbildning men skadade inte indikatororganismerna lika mycket som de andra kemikalierna.

Introduction

In December 2003, a new wastewater treatment plant for the abattoir in Kalmar was taken into operation. The plant is an SBR-process with biological nitrogen reduction and precipitation of phosphorous. In October, sludge bulking due to excessive appearance of filamentous bacteria Type 021N (6 of 6; Jenkins et al., 2004) led to sludge withdrawal during decanting. Under such circumstances, supernatant can neither be led to the recipient (Baltic Sea) due to high organic loads nor to the municipal WWTP because of risk for infection with filamentous organisms.

The aim was to find a fast solution by adding a chemical. This chemical was supposed to damage the filamentous bacteria without killing the biological sludge. The necessity of a short term solution comes from the requirement to minimize operational disturbances and prevent extra costs.

From now on, the term "micro organisms" will be used for those organisms that serve as indicating organisms in microscopic analysis.

Five different chemicals were tested in lab scale tests. Two chemicals were oxidizing agents (NaOCl and H_2O_2), and three chemicals were precipitation-flocculation agents (2 different polyaluminum chlorides [PAX-XL60, Ecofloc] and $FeCl_3$). Oxidizing agents destroy organic structures and are thus capable of cutting the filamentous strings in smaller pieces. Since several kinds of Type 021N exist and at least one of these has shown to be chloride resistant (Nielsen, et al, 1998; Séka et al, 2001), two oxidizing agents were tested. According to Kemira,

Table 1. *List of used chemicals for one-hour test and their dosing rates.*

Chemical	Unit	Sample 1	Sample 2	Sample 3	Sample 4
NaOCl	gCl/kgSS	2,4	6	12	24
H_2O_2	g active H_2O_2/kgSS	11	43	86	129
$FeCl_3$	gFe/kgSS	2	6	11	17
PAX-XL60	gAl/kgSS	2	6	11	17
Ecofloc	gAl/kgSS	2	6	11	17

polyaluminum chloride (PAX) can be used to inhibit Type 021N and was therefore of interest. Ecofloc was used in order to compare two different polyaluminum chlorides, and iron chloride was chosen because it was used as a precipitation agent on the plant.

Method

1-h test

One litre of biological sludge from the full-scale SBR with a sludge content of 2.2g SS/L was used for the lab-tests.

Table 1 shows the chemicals and their dosing rates that were tested.

Each chemical solution was added to the biological sludge samples in 4 different dosing rates. A standard sample of biological sludge was also taken for each series in order to be able to evaluate the effect of the chemical in comparison to the untreated biological sludge.

After addition of the chemical solutions, pH was adjusted with NaOH where necessary, in order to keep the pH value above 5.5. Then, the samples were aerated with pressurized air during one hour.

Each sample was analysed with the phase-microscope (Olympus BX 50) after one hour. A record for each microscopic analysis was written. Pictures of the microscopic samples were taken with approximately 100, 200 and 400 times enlargement using Olympus camera DP 50. These five 1-h test-series were carried out on two consecutive days.

Figure 1. *Aeration during treatment.*

14-h test

The same biological sludge was used for the 14-h test as for the 1-h test. The chemical was added to 1L of sludge and fed with approximately 4g of refined sugar at the beginning of the test. Two standard samples of biological sludge were also taken.

Table 2 shows the chemicals and their dosing rate that was tested.

The choice of the dosing rates of the five chemicals for this test was as follows, based on the results from the 1-h test series.

2,4g NaOCl/kgSS (lowest rate) because it had already shown a negative effect on micro organisms during the 1-h test.

129g H2O2/kgSS (highest rate) because it had not shown sufficiently negative effect during the 1-h test.

17g Fe/kgSS because it was the only rate during the 1-h test that showed a significant effect on floc structure.

17g Al/kgSS because a correlation to Fe should be made.

All samples were aerated during 14 hours before microscopic analysis was performed. A record for each micro-

Table 2. *List of used chemicals for fourteen-hour test and their dosing rates.*

Chemical	Unit	Dosing rate
NaOCl	gCl/kgSS	2,4
H_2O_2	g active H_2O_2/kgSS	129
$FeCl_3$	gFe/kgSS	17
PAX-XL60	gAl/kgSS	17
Ecofloc	gAl/kgSS	17

scopic analysis was written. Pictures of all samples were taken with approximately 100, 200 and 400 times enlargement.

Results

1-h test

NaOCl

Sample 1 (2,4g Cl/kgSS): rotators had hidden themselves in the interior of flocs. Less micro organisms were found alive than in the standard sample.

In sample 2 (6g Cl/kgSS), no micro organisms could be found alive, and some floc destruction could be observed.

Sample 3 (12g Cl/kgSS) showed a significant destruction of the flocs, many small particles could be found that did not exist in the standard sample.

In sample 1–3, no negative effect on filamentous bacteria could be observed.

Sample 4 (24g Cl/kgSS) showed effect of NaOCl on the filamentous bacteria. The strings had partly been cut.

It can be concluded that the short term effect of NaOCl was noticeable already at low dosing rates. Before significant effect on the filamentous organisms could be observed, all other micro organisms were considered dead. That means that treatment of the biological sludge with NaOCl can result in cutting of filamentous organisms but not without severe negative effects on micro organisms.

H_2O_2

Analyses of samples 1–3 (11–86g H_2O_2/kgSS) showed similar effects in comparison to each other regarding the state of micro organisms, length of strings of filamentous bacteria and floc structure. These samples showed some less active micro organisms than the standard sample. Only in sample 4 (129g H_2O_2), a significant effect on micro organisms could be observed. No effect was found regarding filamentous bacteria or floc structure in any of the four samples.

It can be concluded that with a dosing rate of up to 129g H_2O_2/kgSS, no significant effect on the length of filamentous bacteria could be observed while other organisms were negatively affected.

$FeCl_3$

All samples needed pH-adjustment with NaOH.

It could be observed, that micro organisms became less and less active from sample 1 (2g Fe/kgSS) to sample 4 (17g Fe/kgSS). In sample 4, small particles were flocculated to larger flocs. That resulted in a clear water phase with less filamentous organisms which instead were bounded to the flocs.

It can be concluded that dosing of $FeCl_3$ can result in flocculation of organic material without to seemingly affect filamentous organisms or to damage other micro organisms.

PAX-XL60

Sample 1 (2g Al/kgSS) showed a tendency of flocculation of small flocs.

In sample 2 and 3 (6g Al/kgSS, 11g Al/kgSS), distinct flocculation to larger floc-aggregates could be observed.

Sample 4 (17g Al/kgSS) had a clear water phase. All small particles had been flocculated to larger floc-aggregates. No significant effect on micro organisms could be observed. The effect on filamentous organism 021N was not definite. Some strings appeared to be bent in samples 2–4. The picture taken of sample 2 confirms bent filament strings. Pictures of samples 3–4 do not confirm bent filament strings.

It can be concluded that PAX was a very effective flocculating agent for this water. No distinct effect on filamentous organisms could be observed. No negative effect on micro organisms could be found.

Ecofloc

In samples 1–3 (2, 6 and 11g Al/kgSS) no effect on filamentous organisms, micro organisms or flocs could be seen.

Sample 4 (17g Al/kgSS) showed that flocculation of small particles and filamentous organisms had started.

14-h test

The results from the 14-h test are summarized in table 3.

NaOCl (2,4g Cl/kgSS)

Destruction of flocs and negative effects on micro organisms could be observed. Only a slight negative effect on filamentous organisms could be detected.

H_2O_2 (129g H_2O_2/kgSS)

Little negative effect on micro organisms and on floc structure could be analysed. No negative effect on filamentous organisms could be detected.

$FeCl_3$ (17g Fe/kgSS)

Flocculation effects could be observed. No effect on micro organisms or filamentous organisms could be detected.

PAX-XL60 (17g Al/kgSS)

Significant flocculation had taken place. A clear water phase was visible. Micro organisms had been affected

negatively and filamentous organisms had partly been bent.

Ecofloc (17g Al/kgSS)

Negative effects on micro organisms and a few cut filamentous organisms could be found. Flocculation had taken place.

Discussion

The aim of the lab-tests was to find a chemical solution that had a distinct negative effect on filamentous organism Type 021N after short term treatment of the bulking sludge without showing severe negative effects on micro organisms.

NaOCl was the only chemical solution that had clearly harmed the filamentous organisms after 1-h treatment, but all micro organisms were considered to be dead. This was the effect of the highest dosing rate.

Since NaOCl in the 14-h test (with the lowest dosing rate) did not result in distinct effects in regards to filamentous organisms while micro organisms were negatively affected, the aim was not fulfilled by using NaOCl.

Since this was a short term test, nothing can be said about the long term effects of NaOCl.

H_2O_2 did not show the desired effect with the tested dosing rates in the 1-h test. The result of the 14-h test was not satisfying either, because filamentous organisms were not harmed while micro organisms were affected negatively. Thus, H_2O_2 was not an alternative for short term treatment for this plant.

Tests with $FeCl_3$ resulted in flocculating effects. Filamentous strings were bounded to the flocs. This fact might result in better dewatering characteristics where the filamentous organisms could be removed with the excess sludge.

Addition of PAX-XL60 resulted in very good flocculation without definite negative effects on filamentous or micro organisms in the 1-h test.

14 hours after addition of PAX, the sample showed negative effects on filamentous organisms as well as on micro organisms and good flocculating characteristics.

The results from the two PAX-tests were ambiguous. PAX-XL60 might be a chemical that can be used to fulfill the objective of negative effects on filamentous organisms without severly damaging other micro organisms. But this should be verified by analysing sludge volume index in future tests.

Table 3. *Results from the fourteen-hour test.*

Chemical	Floc structure	Micro organisms	Type 021N
NaOCl	– – –	– – –	– –
H_2O_2	–	–	0
$FeCl_3$	+	0	0
PAX-XL60	+++	– –	–
Ecofloc	++	– –	–

– negative effect
+ positive effect
0 no effect

Since the 14-h test of Ecofloc resulted in a slight effect on filamentous organisms and micro organisms, even this chemical might be used to achieve the goal. But the effect on filamentous organisms or the flocculating characteristics was not as good as those of PAX-XL60. Thus, the use of Ecofloc does not appear relevant.

Conclusion

The results were not satisfying. NaOCl was too strong an oxidizing agent with the tested dosing rates. H_2O_2 was too weak an oxidizing agent to result in the desired effect with the tested dosing rates. $FeCl_3$ and Ecofloc did not show any or too little negative effects on filamentous organisms. The filamentous bacteria were only bounded to flocs due to flocculation. PAX-XL60 showed negative effect on filamentous organisms after 14-h treatment. Further PAX-tests should be carried out. Negative effects on filamentous organisms should then be verified by sludge volume index analyses.

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