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Research Article

CAUSES, CONTROL, AND MISCONCEPTIONS OF FILAMENTOUS BACTERIAL BULKING IN THE AERATION TANK OF THE SWTP

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ABSTRACT. Filamentous growth in the aeration tank of the Secondary Water Treatment Plant (SWTP) can easily be detected by calculating the Sludge Volume Index 30 (SVI30). Once detected, 12.5% sodium hypochlorite @ 15 L/hour effectively reduced 71% of filamentous bulking after 12 days. It was recommended not to use sodium hypochlorite for more than 10-12 days because it will kill microorganisms present in the aeration tank of the SWTP. However, sometimes filamentous bulking is not the cause of high SVI30, and the increased value of SVI30 can be misleading due to the nitrification and denitrification processes in the aeration tank and the clarifiers. It was concluded after the 33 days trial that despite the fact SVI30 was high, no filamentous bacterial growth was seen under the compound microscope and SEM as well. High nitrate values (29 ppm) were found in the aeration tank and clarifiers, causing solids to float on the surface due to nitrification and denitrification. Nitrogen (N_2) gas pushed and assisted the solids to float up on the surface of the clarifier. At this stage, SVI30 of 136 mL/g was observed. Reduced airflow through the air blowers helped to reduce the nitrification process in the aeration tank of the SWTP. Almost no literature is available on the misconception that increased SVI30 is always due to filamentous bulking. It was found due to the denitrification and nitrification processes in the aeration tank.

Keywords: *aerobic sludge, aeration tank, filamentous bulking, sludge volume index, nitrification*

INTRODUCTION

Not only is filamentous bulking caused by the excessive growth of filamentous bacteria present in the aeration tank of the SWTP, but it also inhibits the sludge separation from the activated sludge [1] & [2].

Filamentous bulking in the aeration tank may be caused by excessive fat, oil, and grease coming through the paper mill water. The presence of abundant filamentous bacteria can reduce flock settling [3]. Normally, the additional discharge of sugar into the aeration tank could lead to rapid filamentous growth but with long-lasting effects [4]. Despite extensive research, preventing filamentous bulking and foaming is challenging [5]. Gas bubbles may also be trapped under the filamentous bacterial bulking mat, enhancing its floating. The activated sludge process is controlled by aerobic organisms using dissolved oxygen in the aeration tank of the SWTP. However, sludge bulking occurs due to the growth of filamentous bacteria when solids suspend and float out of the disposal or effluent water [6]. However, chlorine is one of the most popular methods to control filamentous bulking in the aeration tank [7]. Filamentous bulking and foaming are the most common settling problems experienced in activated sludge (AS) in wastewater treatment plants (WWTPs) [8]. The quality of the final effluent is poor during episodes of bulking and foaming, which is an environmental, human health and economic burden [8].

Filamentous growth in the aeration tank of the Secondary Water Treatment Plant (SWTP) can easily be detected by calculating the Sludge Volume Index 30 (SVI30). SVI30 index depends on the two values, such as the 30-minute settleability test result and the activated sludge Mixed Liquor Suspended Solids (MLSS) test result. The SVI30 values where the filamentous bulking begins vary from treatment plant to plant [9]. Filamentous growth causes major disruption and does not allow solids to settle down at the base of the clarifiers, thus causing the supernatant solution to be more turbid. Therefore, due to filamentous bacterial bulking, suspended solids-laden wastewater is a costly disposal option. A relative scarcity of available literature convinced us to research this topic. Therefore, the increased SVI30 due to the filamentous bulking may not always be true and sometimes is misleading. Instead, it may be due to the denitrification process in the aeration tank. Therefore, this study was planned to investigate whether the increased SVI30 was due to the filamentous bulking only or due to any other reason, such as N_2 gas produced as a result of denitrification, which pushed the solids up to float on the surface of the clarifier.

MATERIALS AND METHODS

MLSS (Mixed Liquor Suspended Solids) samples were collected from the aeration tank in a 1.0 L plastic container with a lid. MLSS was measured using [10] & [11]. SVI30 was measured using the Imhoff Cone method [12]. Calcium was analyzed using the EDTA titration method [13]. HACH [14] vials TNT 836 for Nitrate-N and TNT 832 for NH_3-N were used to analyze using the Spectrophotometer DR 3900. Photos were taken using the compound microscope in the Wet Chemistry Laboratory and the Scanning Electron Microscope (SEM) at Opal’s Melbourne Research Centre. All the analysis was conducted in the Wet Chemistry Laboratory of Opal Paper & Recycling Mill.

RESULTS AND DISCUSSION

Filamentous Bulking

Currently, the upper limit of SVI30 for Opal’s SWTP is 120 mL/g. The aeration tank's Sludge Volume Index (SVI30) is measured twice a week. However, if the SVI30 values are higher than 120 mL/g, it is monitored daily until the rectification of troubleshooting. Suppose we find the values of SVI30 are consistently higher than 120 mL/g for at least three days. In that case, microscopic analysis is conducted in Opal’s Wet Chemistry Laboratory to ascertain the stage of filamentous bacterial growth using the subjective scoring system [15]. After three days, filamentous growth reduction treatment is applied upon filamentous growth confirmation. For this purpose, 12.5% sodium hypochlorite @ 15 L/hour effectively overcame the excessive filamentous bulking in the aeration tank without killing the microbial population.

Filamentous bulking at the start of sodium hypochlorite dosing is shown in Fig. 1, and the reduction of filamentous growth after the one week of treatment application is shown in Fig. 2. It was 210 mL/g at the start and reduced to 50 mL/g at the end of hypo treatment. Fig. 3 shows the effectiveness of hypochlorite treatment after 12 days with the reduction of sludge volume index to 50 mL/g. Applying this dose through the sludge recirculation line and not directly into the aeration tank is suggested to avoid excessive disruption to the microbes. The application of sodium hypochlorite may prolong up to 2 weeks or more depending on the phase of the filamentous bulking in the aeration tank.

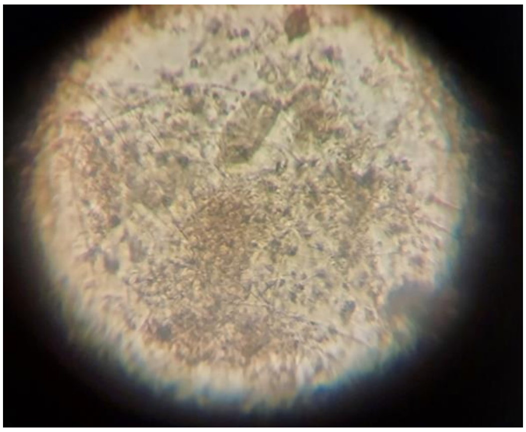

Fig. 1. *Filamentous bacterial growth in the MLSS sample under the compound microscope at the start of sodium hypochlorite treatment*

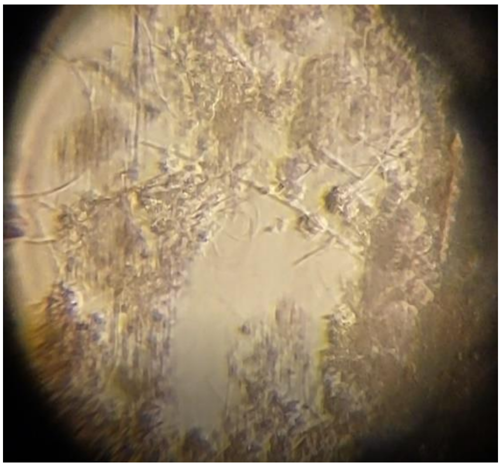

Fig. 2. *Filamentous bacterial growth in the aeration tank after one week of treatment*

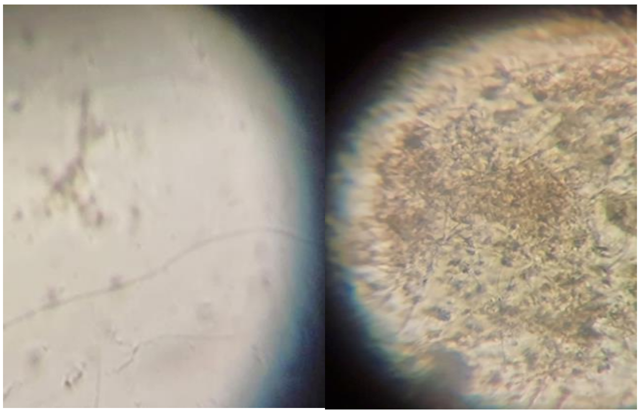

Fig. 3. *Scanty filamentous bacterial growth in the aeration tank after 12 days of treatment. SVI 30 reduced to 50 from 210 mL/g*

Scanning Electron Microscope (SEM) study further supported the results of effectiveness of sodium hypochlorite treatment. Before (I) and after (II) the treatment difference is shown in figure 3 a.

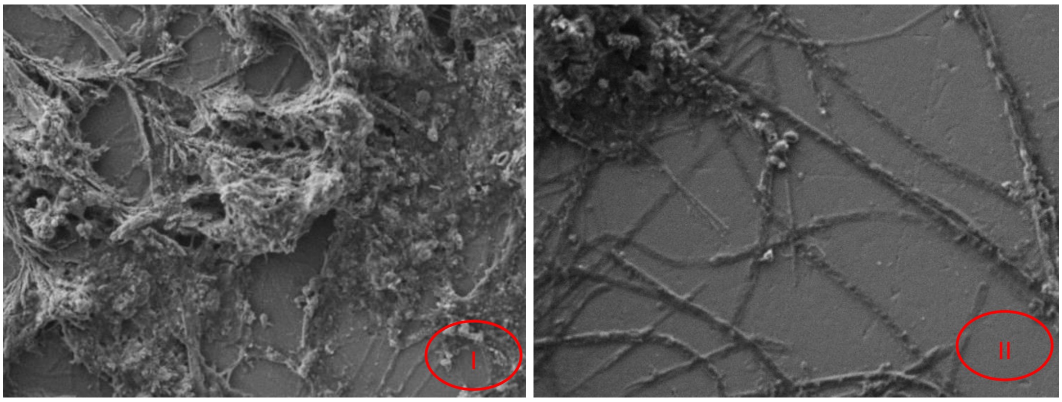

Fig. 3 a. *SEM study of filamentous growth (I) and control (II) zoomed @ size 50 µm*

Other signs of filamentous bacterial bulking include a misty odour from the aeration tank's surface and the clarifiers. Production of foam at the surface of the aeration tank may also indicate filamentous bacterial growth. Misty odour and foam formation issues were observed during filamentous growth in our aeration tank of the SWTP. Furthermore, the clarifier surface looked muddy, and the supernatant solution became turbid. The sludge at the base of the clarifier was difficult to see, especially when SVI30 was 210 mL/g, as shown in Fig. 4.

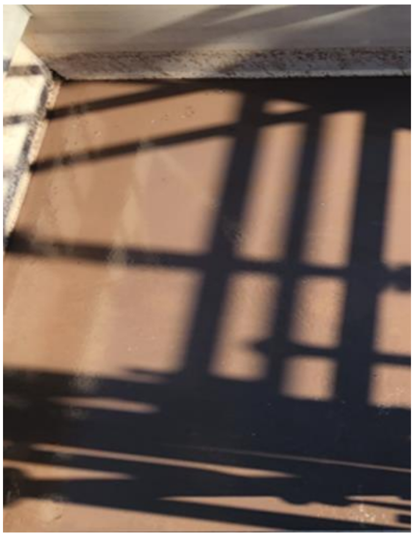

Fig. 4. *Muddy surface of Opal's SWTP Clarifier due to the filamentous bulking @ 203 mL/g SVI30.*

It is important to note that after the tenth day of the sodium hypochlorite treatment, suspended solids in the treated effluent or the disposal water were reduced to 528 ppm from 796 ppm (34% reduction) in the disposal water. The SVI30 reduced to 121 from 231 mL/g. The reduction in Sludge Volume Index30 (54%) showed the effectiveness of the treatment after ten days. The higher Total Suspended Solids (TSS) concentration may be due to the suspension in the mesh or nest-like filamentous structure, reducing the number of solids that settle down at the base of the clarifier. Sodium hypochlorite treatment effectively reduced the high cost associated with the disposal of wastewater containing more than 600 ppm solids. However, the effect of the degree of bacterial filament abundance in the aeration tank on the solid concentration in the disposal water is inconclusive and needs more research.

Misconceptions

Increased SVI30 may not be the reason for filamentous growth in the aeration tank of the SWTP. It could be due to the nitrification and denitrification processes, which caused total suspended solids to float on the surface of the clarifier because of denitrification if the SVI30 value does not decrease after the ten days of 12.5% sodium hypochlorite dose @ 15 L/hour. The problem could be due to the nitrification and denitrification processes in the clarifier and the aeration tank. Under such conditions, nitrification values exceeded 3.28 ppm. It is important to note that no literature is available on the increased SVI30 in the aeration tank due to the high levels of nitrate-N and denitrification.

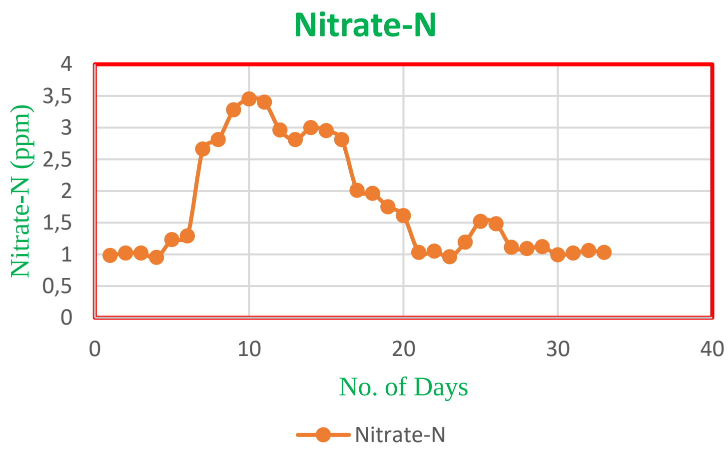

Fig. 5. *Nitrate -N levels during 33 days in the aeration tank*

Ammonia-N was found between 28.3 to 29.5 ppm in the aeration tank and the high concentration of ammonia-N combined with the O_2 blown in the aeration tank through the air blowers triggered the nitrification process as shown in Fig. 5. Furthermore, in the clarifiers and decanter, O_2 is liberated from the NO_3-N leaving behind N_2 gas only. This N_2 gas pushed the solids up in the clarifiers. Therefore, solids were found floating on the surface of the clarifier. To mitigate the nitrification in the aeration tank, reduce the airflow for not more than 24 hours. Reduction of airflow for an extended period caused odour or unpleasant smell around the SWTP and the clarifier, thus causing an environmental problem for the community. However, reduced airflow in the aeration tank may cause the death of microorganisms. Calcium (Ca) concentration in the treated effluent or the disposal water during the aeration tank's nitrification period was higher than normal. It is important to note that during the period of high SVI30, Ca concentration in the disposal water was high (352 ppm) but had no filamentous growth issues, despite the fact SVI30 was 130-147 mL/g as shown in Fig. 6.

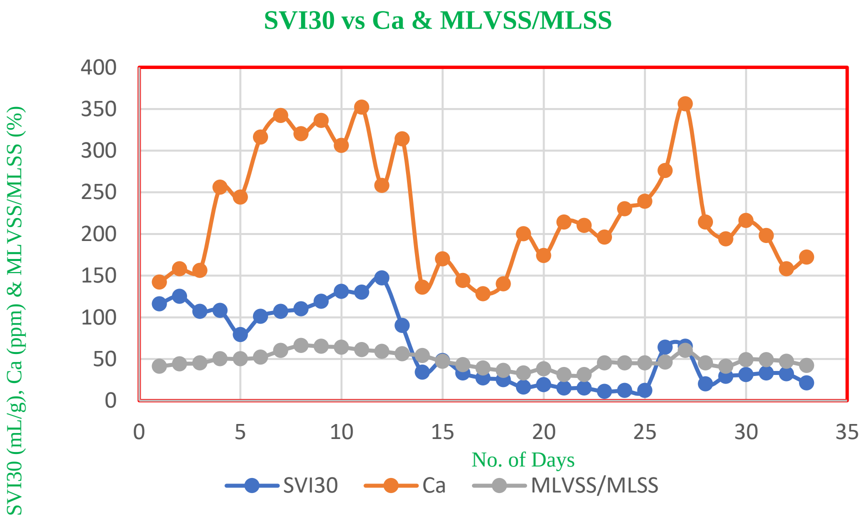

Fig. 6. *SVI30 vs. Calcium and MLVSS/MLSS during the 33 days.*

During the same period when SVI30 in the aeration tank was high. The Ca concentration in the disposal water was also high, and MLVSS/MLSS was higher (60-64%) as depicted in Fig. 6.

Overall, it showed that increased SVI30 might be misleading and may not be the filamentous growth issue in the aeration tank, as shown in Fig. 7.

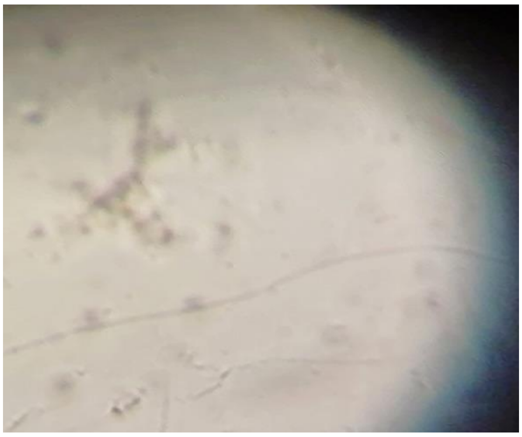

Fig. 7. *No filamentous bulking at 147 mL/g SVI30*

The floating of the suspended solids may not be due to the filamentous bulking in the clarifier. Still, it could be due to the nitrogen (N_2) gas bubbles produced due to the denitrification process. These N_2 bubbles carried the solids on the surface of the clarifier.

Do not overdose sodium hypochlorite for 10-12 days because it kills the short-chained filamentous bacteria, microflora & fauna. Due to the lack of short-chained filamentous bacteria, suspended solids did not get entrapped to settle down at the bottom of the clarifier.

CONCLUSION

12.5 % sodium hypochlorite @ 15 L/hour is recommended to control bacterial filamentous growth in the aeration tank. High Total Suspended Solids (TSS) in the clarifier supernatant solution can be reduced quickly to save money paid to Sydney Water due to the high TSS load in the disposal wastewater. It is a cost-effective method and a quick solution for the filamentous growth problem in the aeration tank of the SWTP. Do not overdose sodium hypochlorite for more than 10-12 days. Increased SVI30 may be due to the high rate of nitrification and denitrification in the aeration tank if it sustains after the hypochlorite treatment for more than 10-12 days. Reduce the airflow in the aeration tank to stop the nitrification, but not for more than 24 hours.

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