INVESTIGATION ON FILAMENTOUS MICRO-ORGANISMS IN SLUDGE FOAMING FROM PULP & PAPER MILL WASTEWATER TREATMENT PLANT

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ABSTRACT

Filamentous and non-filamentous micro-organisms digest organic matters in wastewater for living. Some of micro-organism is an index of the water quality if found some types of micro-organism that have high efficiency digesting organic matter in wastewater. The environment in wastewater have effected to filamentous and non-filamentous micro-organism such as chemical substances, pH, temperature and organic loading. The purposes of this research are: to classify filamentous micro-organism taken from wastewater treatment plant of Double A Pulp & Paper Mill in Thailand, to determine the index of water quality by numerical scoring and verbal scoring filamentous organisms in activated sludge bulking and to select the best indicator for water quality of Double A Pulp & Paper Mill wastewater treatment plant. The results of testing found the microorganisms in sludge foaming such as S. natans, Types 021N, Thiothrix and Beggiatoa. The numerical scoring and verbal scoring filamentous organisms from the experiment showed that the dominant type of filamentous bacteria was S. natans in excessive verbal scoring.

KEY WORDS: filamentous bacteria, Activated Sludge, wastewater treatment, sludge foaming

INTRODUCTION

The activated sludge process is a wastewater treatment method in which the carbonaceous organic matter of wastewater provides and energy source for the production of new cells for a mixed population of microorganisms in an aquatic environment[1]. In addition, activated sludge is a microbiological culture consisting of microorganisms that metabolize wastewater inorganics and organics [2]. Typically, the developed biomass is comprised of approximately 95% bacteria and 5% higher organisms (protozoa, rotifers, flagellae). The basis of activated sludge process is the growth of floc forming bacteria on wastewater organics which settle under gravity in the secondary clarifier, leaving a clarified final effluent and a thickened return sludge [3]. Early microbiological investigations into filamentous organisms found in activated were hampered by a lack of knowledge concerning the types of filamentous organisms that may occur. It is now known that approximately 20 different filamentous organisms commonly occur in activated sludge and each may lead to operational challenges [4]. Excessive growth of filamentous bacteria is responsible for most severe operational problems like bulking and foaming in most of the activated sludge plants around the world [5]. The thick scum layer is formed during foaming on the surface of setting sludge by the mycolic acid producing filamentous bacteria and this can lead to various operational problems during sludge dewatering and disposal [6]. The bacteria prey to larger microorganisms including amoeba(Sarvordina), free swimming ciliate(Ciliata), stalked ciliates(Vorticella) and Suctoria. There are also multicellular rotifer organisms in the activated sludge[7]. Jenkin, et al. mentioned about the network of filamentous organisms provided-sludge flocs with strength and the attainment of large size. As a consequence, their integrity is preserved in the aeration basin, where condition if increasing shear occur in a turbulent environment. The aims of this research is to describe the biodiversity of filamentous microorganisms and develop tools for monitoring the dynamics filamentous bacteria population in Advance Agro Pulp & Paper Mill Company.

MATERIALS AND METHODS

The samples were taken from the wastewater treatment plant (Activated Sludge system:AS) at Double A Pulp & Paper Mill Company in Srakaew Province, Thailand. The company has two paper mills having a total capacity of 600,000 tons per year. The machine can produce paper with 6.9 meter width at the speed of 1,250 meters per minute[6]. The scenery of company is shown in Figure 1.
AS is a completely mixed process with biomass recycle after treatment. The development of colonies of flocculated bacteria are crucial to allow the successful separation of the biomass or sludge by settlement. The activated sludge (AS) is a wastewater treatment system using for treating wastewater in agro-industries. The characteristics of Advance Agro company was violent acid and contaminated with chemical substances from the processing.

To identify filamentous organisms by using a phase contrast the microscope Novex microscopes have 100 x power objectives for low power work (filamentous counts, observing floc structures) and a 1,000 x power objective for identification of filamentous organisms. Two staining procedures are used routinely in filament identification - the gram stain and Neisser staining were performed according to usual biological procedure [8]. The abundance of filamentous organisms can be quantified by a subjective scoring system that is generally reproducible. Filamentous organisms are observed at 100x power phase contrast and subjectively related for overall abundance on a scale from none (0) to excessive (6). Filamentous Organism Abundance Subjective Scoring System Practical Control Methods for Activated Sludge Bulking is shown in Table1.

### RESULTS AND DISCUSSION

**General description of operational conditions of the plant**

Advance Agro Pulp & Paper Mill Company or Double A uses state of the art of biological treatment system called the “bacteria digestion process” in treating contaminated water. The process is compatible with Scandinavian standards.

Preliminary process: First, foreign materials (such as pieces of wood) from the waste water is removed by using a golden sieve. Second, the filtered water is put into a mixing pond to adjust the alkaline content (fit for bacteria operation and pulp precipitation). Lastly, the temperature is adjusted and Urea Phosphate is added (a special compound which increases the efficiency of bacteria to digest contaminated water). The filtered water from the first process is delivered to an air accumulation pond wherein the oxygen content is increased. It will then digest all the contaminated substances and exhaust it. Lastly, dregs are separated through the sediment tanks, and thus produce clean water (with the right BOD and COD level compatible with regulated standard from the Factory BureNL) as a finished result [9]. Schematic diagram of activated sludge system at Double A Pulp & Paper Mill Industry is shown in Figure 2.

### Table 1: Filamentous Organism Abundance Subjective Scoring System Practical Control Methods for Activated Sludge Bulking

<table>
<thead>
<tr>
<th>Numerical Scoring</th>
<th>Verbal Scoring</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
<td>Filamentous organisms observed only in an occasionally floc.</td>
</tr>
<tr>
<td>1</td>
<td>Few</td>
<td>Filamentous organisms observed in approximately half the flocs.</td>
</tr>
<tr>
<td>2</td>
<td>Some</td>
<td>Filamentous organisms observed in all flocs but at low density (1-5 filaments per floc).</td>
</tr>
<tr>
<td>3</td>
<td>Common</td>
<td>Filamentous organisms observed in all flocs at medium density (5-20 filaments per floc).</td>
</tr>
<tr>
<td>4</td>
<td>very common</td>
<td>Filamentous organisms observed in all flocs at high density (&gt;20 filaments per floc).</td>
</tr>
<tr>
<td>5</td>
<td>Abundant</td>
<td>Filamentous organisms dominate-found growing profusely free of flocs</td>
</tr>
<tr>
<td>6</td>
<td>Excessive</td>
<td>-</td>
</tr>
</tbody>
</table>
The company uses the latest bleaching process that is Elementary Chlorine Free (ECF). The method is said to be Chlorine gas free and does not produce dioxin which is said to be harmful to the environment.

**Identifying filamentous bacteria in sludge foaming**

The sludge foaming samples were taken from secondary settling tanks have shown various filamentous organisms in Figure 3 such as *Thiothrix*, *Type 021N*, *Beggiaota* and *S. natans*. These filamentous organisms can cause the development of a stable, viscous, brown coloured foam that is difficult to break mechanically and does not respond to defoamers. Two of the most common sludge quality problems are bulking and foaming.

![Figure 3 Average filament types in sludge foaming samples](image)

*Fig 3. showed the main microorganism in wastewater process was S.natans that found truly in both of aeration basin and secondary clarifiers. The dominat filamentous becteria was shown in Figure 4.*

![Figure 4. Dominat filamentous becteria observed in sludge sample(100µm and 1000x)](image)
Filamentous Organism Abundance Subjective Scoring System
Practical Control Methods for activated sludge bulking were experimented and identified the number of microorganisms in sludge that taken from Double A Pulp&Paper Mill Industry. The result of identifying filamentous bacteria is shown in table 2.

Table 2 Occurance of filamentous bacteria in sludge foaming samples

<table>
<thead>
<tr>
<th>Types</th>
<th>None</th>
<th>Few</th>
<th>Some</th>
<th>Common</th>
<th>Very Common</th>
<th>Abendent</th>
<th>Excessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiothrix</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 021N</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beggiatoa</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.Natans</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

✓ = found filamentous bacteria follows by the Scoring System
- = not under the Scoring System

*Sphaerotilus natans* (*S. Natans*) is chemoorganotrophic aerobic organism able to degrade low molecular organic substracts. Normally, *S. Natans* is a Gram negative and the excessivie growth of *S. Natans* leads to altered settling capacity of sludge. In this experiment showed that was the dominant specie in sludge bulking in aerobic process of wastewater treatment. This fact guide to the other factors of the large flocculation of oxygen content in the aeration tanks. Then, if the filamentous bacteria are controlled by oxygen supplied or nutrient provide should be reduce the bulking problem in wastewater treatment.

**CONCLUSION**

This study showed that *S.Natans* was the dominant bacteria in the sludge foaming that taken from Double A Pulp and Paper Mill Industry in Srakaew Province at the eastern part of Thailand. The abundance of filamentous organisms could be quantified by a subjective scoring system that is generally reproducible. Filamentous organisms were observed at 100x power phase contrast and subjectively related for overall abundance on a scale from none (0) to excessive (6). This study used only sludge foaming from settling tank for studying just only the amount of filamentous bacteria occouring. The other conditions that effected to the types of filamentous bacteria should be tested in the critical environments such as in low dissolved oxygen, in low organic loading, in low pH and in septic wastes or sulfides.

**ACKNOWLEDGMENTS**

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**REFERENCES**