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Characterization of Activated Sludge by Image Analysis Methods

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Abstract

The diploma thesis deals with the development of an image analysis procedure to characterize activated sludge coming from the wastewater treatment plant (WWTP). Morphological parameters and composition of the aggregations, which the activated sludge microorganisms create, are determined by means of Image Processing Toolbox in MATLAB environment. Results of the image analysis are compared with characteristics obtained by manual laboratory investigation to find any relations. Proposed image analysis method and the found relations can provide support for the classification of unwanted events in WWTP or it can help to control the treatment process better.

Introduction

Activated sludge process is one of the most widely used processes in the WWTP technology. In this case, a mixture of microorganisms creates structures called activated sludge flocs, see figure 1.

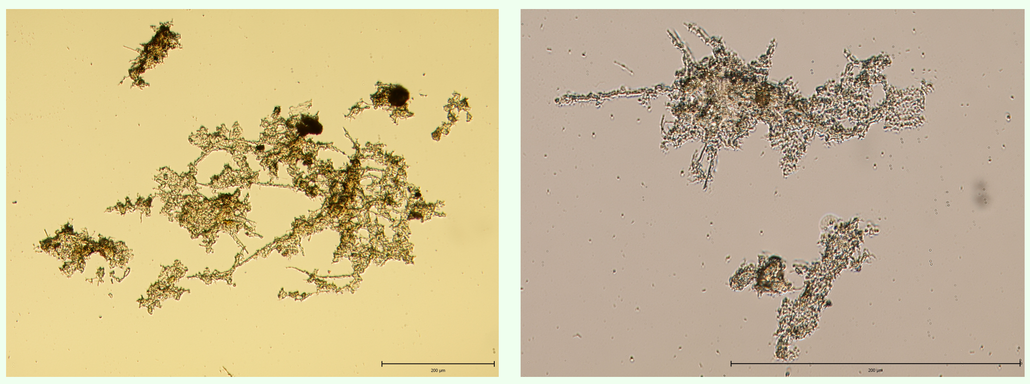

Figure 1. Activated sludge flocs in 200x (left) and 500x (right) magnification

These flocs and their characteristics, especially settling ability, have a direct influence on the whole plant efficiency. Problems with settleability can lead in the specific conditions to collapse of whole purification process. WWTP operators have to prevent this situation. They investigate the sludge by classical laboratory methods by hand including optical microscopy. As the methods are manual, they are very time-consuming and the evaluation is very slow. Moreover every operator has a different approach and view which introduces subjective interpretations which are undesirable.

Digital image processing can be used to make an automatic analysis of the activated sludge flocs. Several studies have verified that flocs morphology and balance between specific organisms (floc-forming bacteria and filamentous organisms) are directly related to settling properties of activated sludge. [1] As well the size of the flocs is an important parameter with respect to the settling properties. [2] Moreover digital processing brings objective evaluation in connection with efficiency and high speed processing of large amount of data.

From this reason, the main aim of the work is to use image analysis for determination of the morphological and composition parameters of the flocs. For example form factor, aspect ratio, fractal dimension as well as the ratio of the filamentous organisms and floc-forming bacteria are determined. These results from image analysis are compared with laboratory investigation to verify its functionality and to find any relationship which could help to used it as a support in WWTP process or substitution for laboratory investigation in the future.

Goals

- Collect and process activated sludge samples coming from WWTP in Liberec by classical laboratory methods and determine their basic characteristic – Sludge Volume Index (SVI)
- Develop a procedure to characterize activated sludge flocs by means of automatic image analysis.
- Apply proposed automatic procedure on microscope samples of activated sludge and determine morphological and composition parameters.
- Compare found SVI with image analysis results and find any relationship.

References

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[2] GRIJSPEERDT, K. Image analysis to estimate the settleability and concentration of activated sludge. *Water Research*. 1997, vol. 31, no. 5. ISSN 00431354

[3] WU, Qiang. *Microscope image processing*. [1st ed.]. Editor Fatima A Merchant, Kenneth R Castleman. Burlington: Academic Press, 2008, 548 p. ISBN 978-0-12-372578-3.

Experiments and methods

During 3 month time period, 8 samples of activated sludge have been collected from the WWTP in Liberec. Each sample has been processed in laboratory in accordance with Czech Standards to obtain its characteristics, especially SVI which shows quality of settleability. Range between 70 – 150 ml/g usually means normal condition – good settling flocs. Microscope slides of each sample have been also prepared and stained by Gram in order to contrast enhancement.

An image analysis procedure has been developed in the MATLAB with the help of Image Processing Toolbox. A sets of microscopic images in two optical magnification is an input of the procedure. It extracts morphological parameters in 200x magnification and composition parameters in 500x magnification.

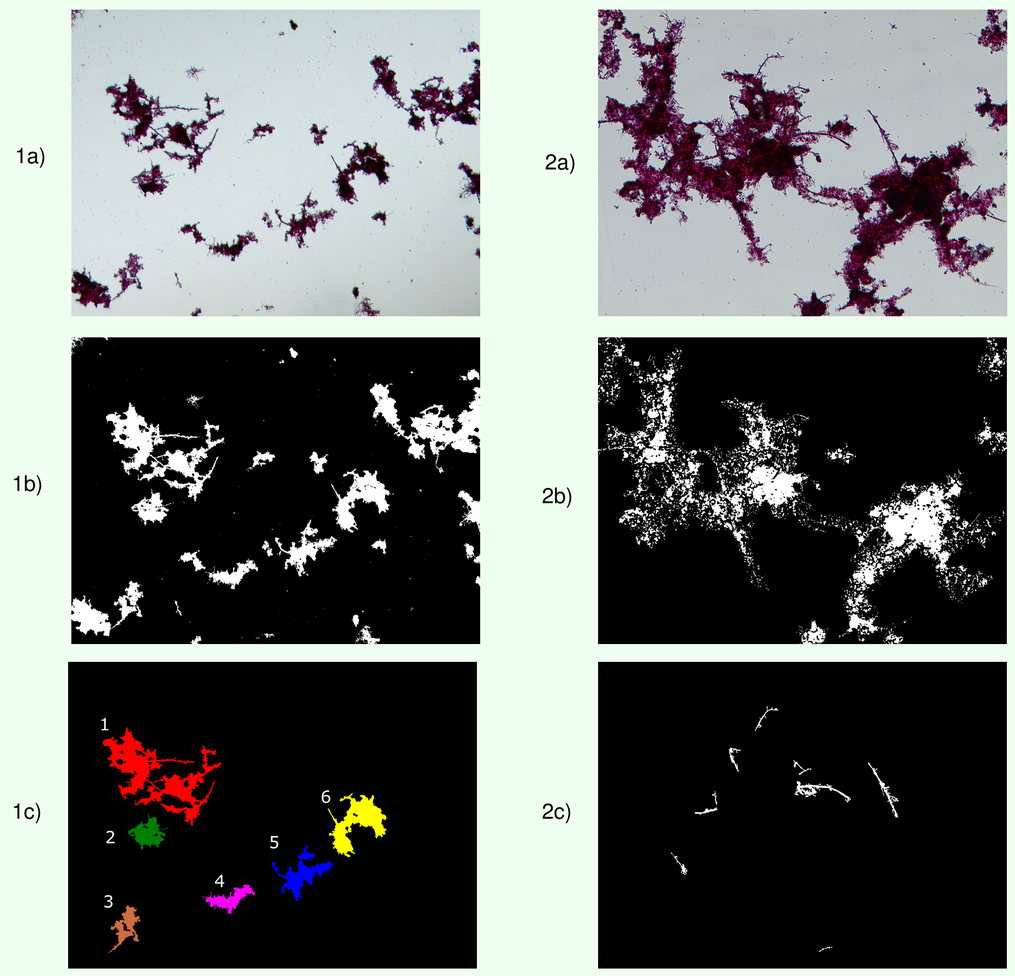

Figure 2. 1a) Activated sludge flocs (200x), 1b) Segmented binary image 1c) Labelled characterized flocs 2a) Activated sludge flocs (500x), 2b) Floc-forming bacteria area, 2c) Filaments area

Results

Total volume of digital images (approx 1,5 GB) has been analyzed by developed procedure. Computed parameters have been compared with SVI. Basic relationships have been found and some of them are presented in the graphs.

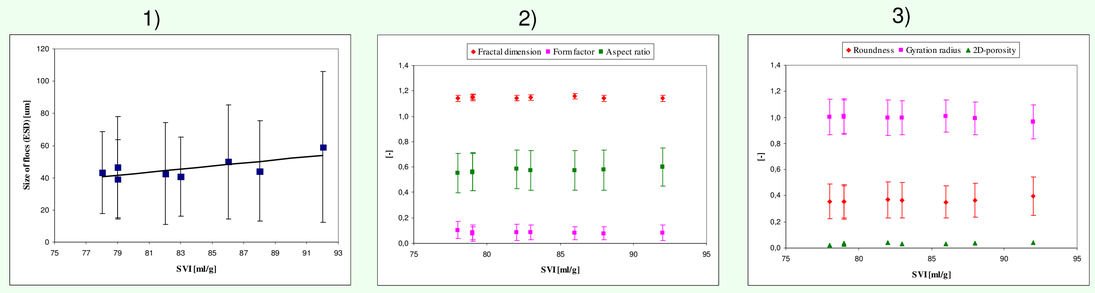

Figure 3. Various morphological parameters compared with SVI

Conclusion

Good operating situation in the WWTP in Liberec has allowed obtaining activated sludge only in good condition with narrow range of SVI (78–92 ml/g). In this case, it has not been possible to make complex comparison but on the other hand at least basic relations have been found. For example low SVI values indicate occurrence of small flocs and low ratio of filamentous organisms to the total area. This assumption has been satisfied by results coming from the comparison. Mainly the working procedure for automatic image analysis has been developed and its functionality has been verified. It is possible to use it for activated sludge characterization but further investigation is necessary.

Basic database of parameters (morphological, composition) corresponding approximately to SVI range 80 – 90 ml/g has been gained. As soon as more samples will be available, new parameters can be obtained and the more precisely relationships can be found. On this base, it will be also possible to select the parameters which can characterize the activated sludge in the best way.

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