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) in Liberec. 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.

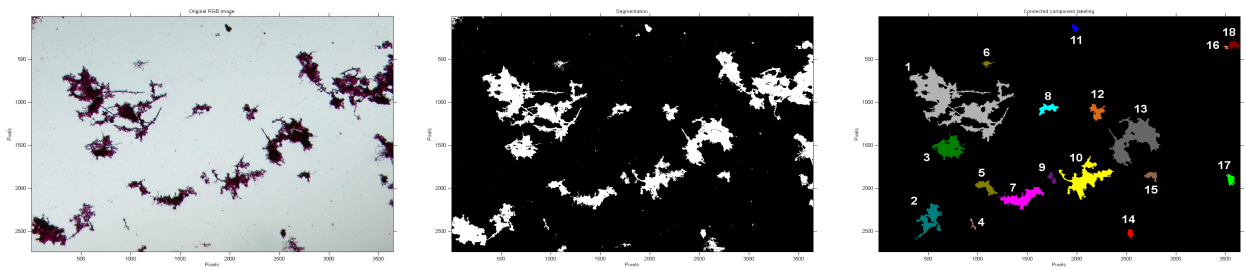
Introduction

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. These flocs and their characteristics, especially settling ability, have a direct influence on the whole plant efficiency. Problems with settleability can lead in 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 microorganisms 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] Digital processing brings objective evaluation in connection with efficiency and high speed processing of large amount of data.

Experiments and methods

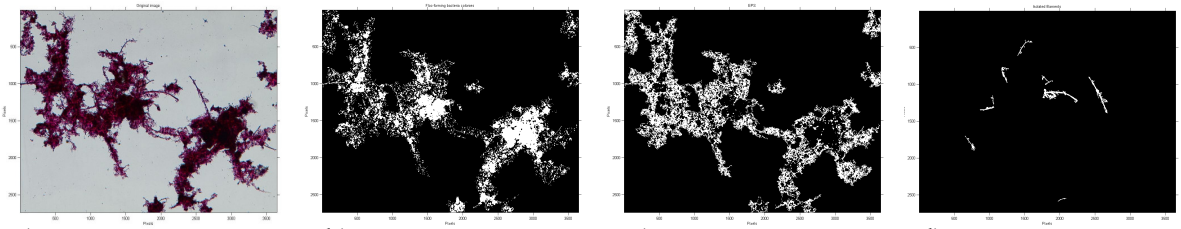
During 3 month time period, 8 samples of activated sludge have been collected from the WWTP in Liberec. Each sample has been processed in laboratory to obtain its characteristics, especially the most important one – Sludge Volume Index (SVI) which shows quality of settleability. Range between 70 – 150 ml/g usually means normal condition – good settling flocs. Microscope slides of each sample have been also prepared and stained by Gram for subsequent image analysis.



a) b) c)

Figure 1. a) Activated sludge flocs (200x), b) Segmented binary image, c) Labelled suitable flocs which have been characterized

An image analysis procedure has been developed to characterize activated sludge flocs. It consists of 2 parts. First, morphological characteristics such as equivalent circle diameter, form factor, aspect ratio, roundness, reduced radius of gyration and fractal dimension are determined for each suitable floc on the image in 200x magnification, Figure 1.



a) b) c) d)

Figure 2. a) Activated sludge flocs (500x), b) Floc-forming bacteria, c) EPS, d) Separated filaments

Second, composition parameters are determined in 500x magnification. As the flocs consist of 3 main parts – compact core formed by floc-forming bacteria, filamentous organisms and extracellular polymeric substances (EPS), it is necessary to decompose these parts to single components to find out their area representation ratio, Figure 2.

Results and discussion

At least 100 images for each collected sample have been acquired by microscope and digital camera. Eight image data sets have been obtained and put though the developed automatic image analysis procedure to find out corresponding parameters. Computed morphological and composition characteristics have been compared with SVI parameters, found by laboratory investigation. Basic relationships have been found and presented in graphs.

Conclusion

Good operating situation in the WWTP in Liberec have 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 relationships have been found. For example low values of SVI indicate occurrence of small flocs and low ratio of filamentous organisms to the total area of the flocs. This assumption has been satisfied by results coming from comparison. And mainly the program functionality has been verified. It is possible to use it for activated sludge characterization but other 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.

High resolution of the acquired images (9,98 Mpix) resulted in relatively high time spent by computations. In practical application, lower resolution can be used without loss of precision. Images with resolution of 4,32 Mpix have been tested and the average time decreased approximately 2,5-times. The procedure can be also rewritten in C++ which is quite faster than MATLAB script.

References

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