On-line optical monitoring of activated sludge floc morphology

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Background

- Activated sludge process is the most common method in municipal and industrial wastewater treatment

- The efficiency of the ASP is highly dependent on the solid-liquid separation which is affected by the structure and the strength of the flocs

- Evaluation and modeling of the wastewater treatment process by image analysis methods will bring new horizons in the monitoring and control approaches

Background: Activated sludge process

- Municipal and industrial wastewater contain usually high amounts of COD, nitrogen and phosphorous, which can be removed by biological processes

- Biological flocs are formed in aeration tanks and removed by settling in settling tank
Background: Floc formation

- The floc formation is a complex phenomenon whose mechanisms are still poorly understood.
- Flocs are comprised of a variety of microorganisms as well as organic and inorganic particles.
- Different disturbances in the process have effects on the floc structure.
- Unsatisfactory floc formation is a common problem in activated sludge plants worldwide, which have both environmental and economic consequences.

Background: Floc morphology in different situations

- Lots of filaments
- Small flocs
- Big flocs, enough filaments
Background

- Floc formation and settling properties of activated sludge are critical for the purification process.
- There is still lack of a proper on-line measurement of flocculation.
- Optical monitoring of flocs would enable better control of the whole activated sludge process.

Floc imaging device - MOFI

- From laboratory scale to in situ scale.
- Basic principle is the same in both: "Only needed pre-treatment is dilution."
- Image size is 5.01mm x 3.74mm and imaged pixel size is 3.6µm.
(1) the original image; (2) background removal; (3) adjustment of image intensity values to increase contrast; (4) creating negative image; (5) median filtering; (6) thresholds to create binary images; (7) filling holes; (8) dilation; (9) filament image; (10) floc image; (11) processed floc image; and (12) processed filament image.

Blue: Accepted flocs
Green: Too light
Red: Small particle
Purple: Air bubble
Image analysis

Analyzing:
- Form factor
- Roundness
- Equivalent diameter
- Aspect ratio
- Total filament length/total floc area
- Mean area of particles
- Amount of small particles (<25 µm)
Preliminary tests

Two different situations were compared.
- Bigger flocs, less filaments → better settling properties

Evaluation of the floc morphology in the industrial wastewater treatment plant
On-line optical monitoring
At Viikinmäki

- Sludge is taken from the process line into deairing container
- From the container the sample is diluted and pumped through cuvette of imaging unit
- The sample dilution, pumping, image grabbing and cuvette flushing is controlled by PC software and control electronics

- 1000 images/film (4 films/day)
- 100 individual flocs/image

→ 400 000 individual flocs are analyzed daily
On-line optical monitoring

- Imaging unit consists of flow through cuvette, standard machine vision camera and LED lighting
  - The imaging unit captures floc images 30 frames/second
  - Image size is 5.01mm x 3.74mm and imaged pixel size is 3.6µm
  - Floc images are analyzed and several morphological features calculated in floc analysis
Results

Possibilities and challenges

- Would enable better control of the activated sludge process
- Early warning system
- Challenges:
  - Outdoor conditions
  - Representative sampling
Thank you!

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