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OULUN YLIOPISTO

FOULING AND CONTAMINATION OF SENSORS

MMEA 4.2.1
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INTRODUCTION

Fouling and contamination of sensors

- Unwanted deposition or contamination from the fluid contact with sensor element that causes signal noise, drift or delays leading to error in measurement
- Classification on mechanism: crystallization, solidification, particle deposition, microbial growth etc. on surface or contamination of electrolyte in ISE electrodes.
- Classification on type of sensor: optical window, metal electrode, membrane fouling or contamination in ISE electrodes

MITIGATION OF FOULING

Maintenance and cleaning interval, is this acceptable?
- Discrete or continuous measurement
- Manual or automatic cleaning and calibration
- Sensor installation position

Mitigation and cleaning techniques
- Mechanical: brushers, water or air jets
- Chemical: cleaning solutions
- Physical energy: magnetic, radiation, ultra sound
- Material and coating selection

Compensation of signal drift due to fouling and contamination
- Calibration
- Compensation

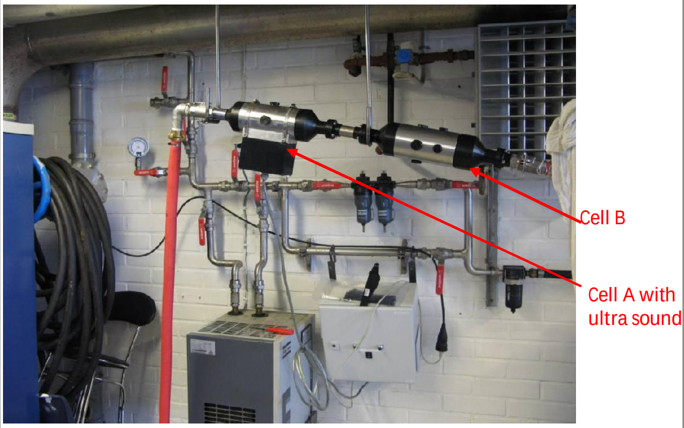
TEST CASE IN TASKILA

- Surface material and ultra sound tests at Taskila waste water plant in Oulu
  - Reject water from sludge centrifuges
  - 10 coatings: 9 for metals, 1 optical for sapphire glass
  - Test with and without ultrasound
  - Measurement of fouling after a test period c.a. 2,5h: visual, microscopy, and absorbance measurement for fouling detection

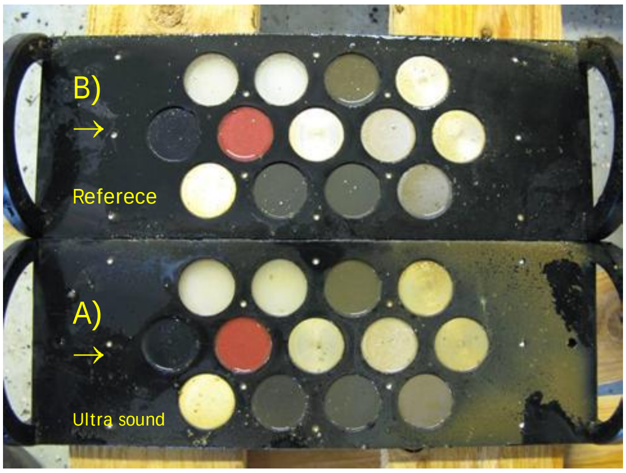
- Chemical analysis from deposited material: SEM-EDS (microanalysis for elements), IR-DRIFT (chemical identification)

TASKILA SET-UP

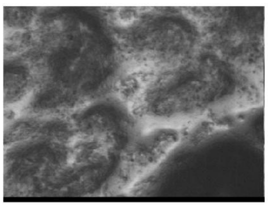
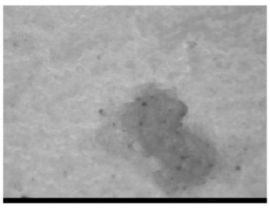


TASKILA VISUAL OBSERVATIONS



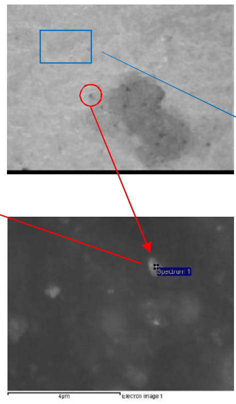
- All material fouled
- More fouling with ultra sound (A)
- YO safir fouled more than ref
- YO metal fouled more than ref
- ATV fouled equally to ref
- AR226 and 229 fouled the least and cannot make difference
- All CVD coatings fouled markedly particle or growth crystals observed

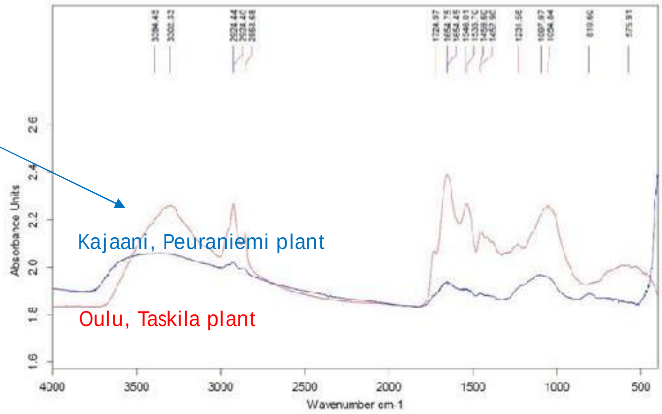



- Deposited material consist of pale transparent deposit containing dark particles

CHEMICAL ANALYSIS OF DEPOSITED MATERIAL

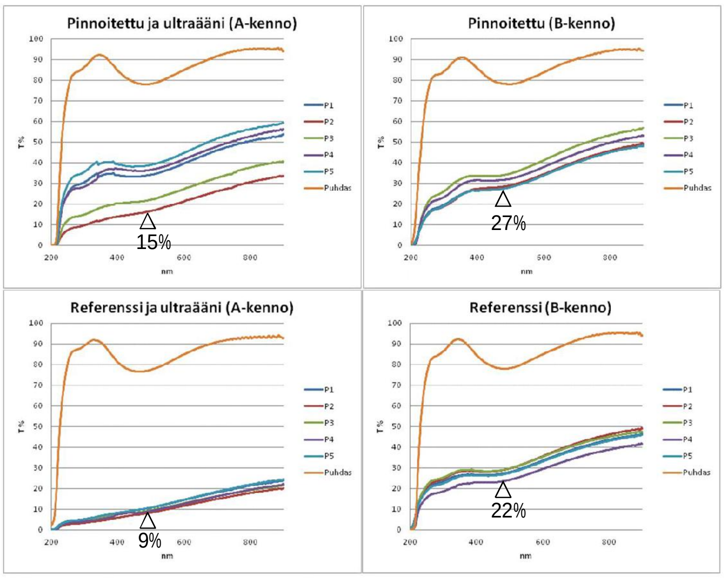
Element	Weight %	Atomic%
O K	8.82	71.76
Al K	0.41	2.00
P K	0.34	1.44
S K	0.12	0.48
Ca K	0.27	0.87
Fe K	10.07	23.45
Totals	20.03	





- Particles, X-ray microanalysis → Iron oxides
- Transparent deposit, IR-FTIR → waxes and fatty acids

TRANSMITTANCE



- With ultrasound transmittance dropped more than in ref
- With optical coating transmittance dropped less both with ref and ultrasound

TASKILA OUTCOME

- Optical windows and metal pieces were tested in reject water of sludge centrifuges
- Fouling was mainly due to fat/wax and oxidized iron particles depositing on sample surfaces

- Aim was to make difference between
  (1) coatings on fouling susceptibility
  (2) effectiveness of ultrasound

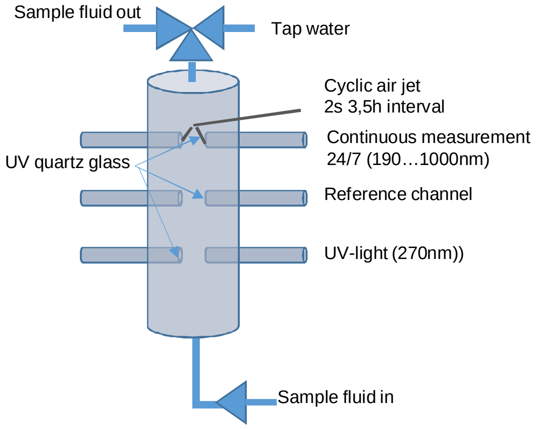
- In the tests, all surface fouled in 2,5 h
- Deposited material was found to be mostly fatty acids/wax with iron oxide particles
- Ultrasound did not mitigate fouling, probably induced fat droplet coalescence leading to heavier fouling
- Fouling was mitigated by some coating, marked benefit was found with AR 226 and 229 coatings (fluoropolymer coatings)

TEST CASE IN PEURANIEMI

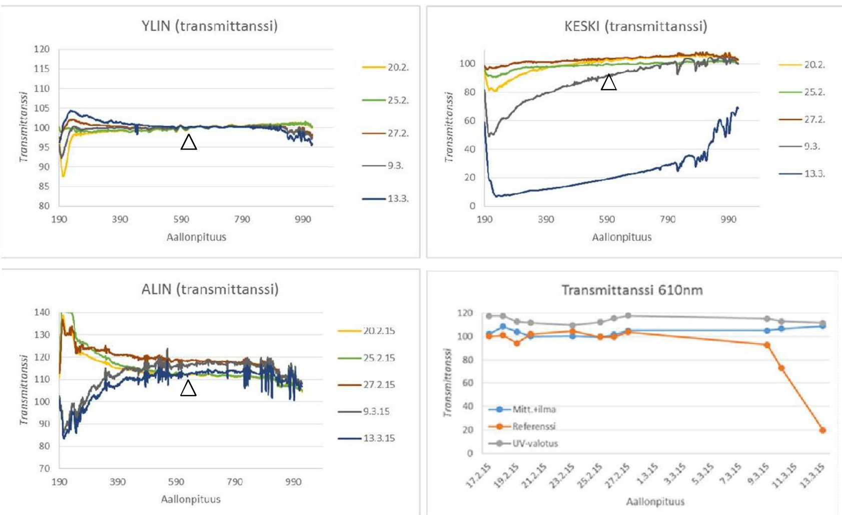
Optical measurements at Peuraniemi waste water plant in Kajaani

- Waste water after biological filtration, treated plant effluent
- 3 optical cells with quartz windows:
  (1) air jet (top position),
  (2) spectrum measurement as reference (middle),
  (3) continuous UV-light (bottom)
- Fouling detection from spectrum through optical cell trough tap water
- Chemical analysis from deposited material:
  SEM-EDS (microanalysis for elements),
  IR-DRIFT (chemical identification)

PEURANIEMI TEST SET-UP

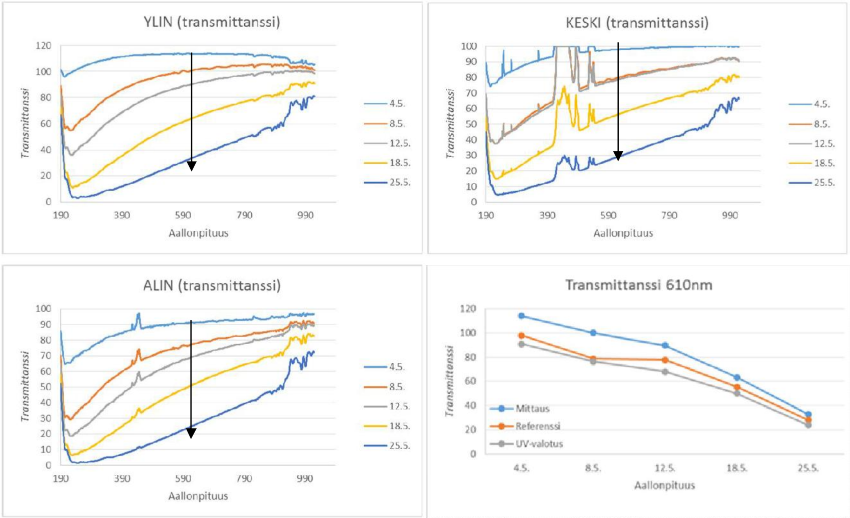


TEST 1 PEURANIEMI PLANT IN KAJAANI



- Top (air-jet) and bottom position (UV light) have small drop in transmittance
- Reference has marked drop especially after 3 weeks

TEST 2 PEURANIEMI PLANT IN KAJAANI



- During test period 2 fouling was weak and difference between UV, air-jet and reference could not be made
- Test period 2 was during spring having flood waters: high flow and low P

PEURANIEMI OUTCOME

- Aim was to find optical window fouling in plant effluent conditions
- Mitigation of fouling was tested using (1) UV light and (2) air jet
- Test periods (2) were during the spring 2015
- In the first test period UV light and air jet was found to mitigate fouling
- In the second test fouling was slow and no clear differences
- Further testing of UV light could be beneficial because in normal operation of waste water plant it was found to mitigate fouling effectively

CONCLUSIONS

- Ultrasound seem not to be option in fouling mitigation
  - Not effective in waste water application
  - Expensive structure if integrated to a sensor
- Coatings and especially UV light are promising techniques to mitigate fouling in optical measurements
  - UV led gives low-cost source of radiation to be used in connection with optical measurements
  - Optical coatings are demanding to find, most existing ones are anti-reflection coatings and are not optimized for non-fouling
  - Photo catalytic coatings (non-fouling) for windows are known but was not unfortunately tested yet in this work

- In further studies, combination of photo catalytic coating and UV-light would be beneficial to be studied