Development of a toolbox for identifying and quantifying membrane biofouling in drinking water treatment. Validation report

Introduction

Biofouling is a large problem in environmental membrane separation processes for several reasons: it leads to higher operating pressures, frequent need for chemical cleanings, membrane deterioration, and compromised water quality. Biofouling is more complicated than other membrane fouling types e.g. non microbial colloidal and particulate fouling, which can be controlled by effective pre-treatment. Microorganisms can reproduce on the membrane even if their numbers in the water is reduced by pre-treatment.

Importance

Biofouling mitigation and control is a necessity for sustainable operation of membrane processes in drinking water treatment. Both reduction of fouling development and membrane cleaning are central elements. Understanding biofouling behaviour and responses will enable choice of optimal operating conditions, e.g. flux rates, cleaning protocols, backwashing strategies. The conventional approach for membrane fouling monitoring is the use of normalised pressure development (NPD). It is assumed that cleaning can be more efficient when biofouling is in an early stage of colonisation. NPD is not specific for biofouling or sensitive.

Approach

We will develop a toolbox that can be used to understand and predict the behaviour of membrane filtration reactors when exposed to different conditions, in order to control biofouling processes. A new methodology for characterising of biofouling on curved surfaces, based on CLSM and image analysis (CMem) is developed (Techneau deliverable D3.3.4), and has been validated by three approaches:

1. The applicability of the methodology for PVDF membranes
2. The applicability of a membrane filtration test unit to be run in parallel with the membrane filtration pilot in Techneau WA2, at similar operational conditions
3. Potential correlation between results of CLSM/IA and traditional chemical and microbiological methods, for quantification of biofouling components

Result

The applicability of the methodology for use in parallel with a membrane filtration pilot (Zenon ZW10), applied within Techneau WA2, has been validated. A second generation CLSM/IA software has been developed to enable characterisation of biofouling on PVDF membranes. The test unit has been redesigned to improve its operational parameters compared to the pilot plant, and the sampling procedure is simplified in the last test cell version. The validation of CLSM/IA results of extracellular polymeric substances (EPS) in the membrane biofouling was not successful because of small sample quantities. This part of the validation is not regarded as critical for the continued activities within the current project.

More information

Full details on this deliverable can be found under D3.3.12. Further information can be requested from:

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TECHNEAU Knowledge Integrator (TKI) categorisation

Categorisation of Knowledge Packages

Categorisation (i.e. classification, contains and constraints) of knowledge packages (KPs) can be carried out by 'checking' the appropriate boxes in the attached tables. For example, for a KP investigating point-of-use treatment suitable for a developing world country, the following might be checked:

Classification: Process chain – Tap (Customer) – Point-of-use (POU).
Contains: Report; Literature review.
Constraints: Low cost; Simple technology; No/low skill requirement; No/low energy requirement; No/low chemical requirement; No/low sludge production; Developing world location.

Note that only the lowest level classification needs to be checked, e.g. Point-of-use (POU) in the above example.

Meta data can be included under the 'More Information' section of the Executive Summary Report, i.e. Author(s), Organisation(s), Contact details (name and email), Quality controller (name and organisation) and Date prepared. (The TKI administrator can enter Source (= TECHNEAU), Date submitted (TKI) and Date revised (TKI)).

TKI Categorisation

Classification									
Supply Chain		**Process Chain**		**Process Chain (cont'd)**		**Water Quality**		**Water Quantity (cont'd)**	
Source		**Raw water storage**		**Sludge treatment**		**Legislation/regulation**		- Leakage	
- Catchment		- Supply reservoir		- Settlement		- Raw water (source)		- Recycle	
- Groundwater		- Bankside storage		- Thickening		- Treated water	x		
- Surface water		**Pretreatment**		- Dewatering		**Chemical**			
- Spring water		- Screening		- Disposal		- Organic compounds			
- Storm water		- Microstraining		**Chemical dosing**		- Inorganic compounds			
- Brackish/seawater		**Primary treatment**		- pH adjustment		- Disinfection by-products			
- Wastewater		- Sedimentation		- Coagulant		- Corrosion			
Raw water storage		- Rapid filtration		- Polyelectrolyte		- Scaling			
- Supply reservoir		- Slow sand filtration		- Disinfectant		- Chlorine decay			
- Bankside storage		- Bank filtration		- Lead/plumbosolvency		**Microbiological**			
Water treatment		- Dune infiltration		**Control/instrumentation**		- Viruses		**Consumers / Risk**	
- Pretreatment		**Secondary treatment**		- Flow		- Parasites			
- Primary treatment		- Coagulation/flocculation		- Pressure		- Bacteria	x	**Trust**	
- Secondary treatment	x	- Sedimentation		- pH		- Fungi		- In water safety/quality	x
- Sludge treatment		- Filtration		- Chlorine		**Aesthetic**		- In security of supply	x
Treated water storage		- Dissolved air flotation(DAF)		- Dosing		- Hardness / alkalinity		- In suppliers	x
- Service reservoir		- Ion exchange		- Telemetry		- pH		- In regulations and regulators	
Distribution		- Membrane treatment	x	**Analysis**		- Turbidity		**Willingness-to-pay/acceptance**	
- Pumps		- Adsorption		- Chemical		- Colour		- For safety	x
- Supply pipe / main		- Disinfection		- Microbiological	x	- Taste		- For improved taste/odour	
Tap (Customer)		- Dechlorination		- Physical	x	- Odour		- For infrastructure	x
- Supply (service) pipe		**Treated water storage**						- For security of supply	x

- Internal plumbing		- Service reservoir				**Water Quantity**		**Risk Communication**	
- Internal storage		**Distribution**						- Communication strategies	
		- Disinfection				**Source**		- Potential pitfalls	
		- Lead/plumbosolvency				- Source management		- Proven techniques	
		- Manganese control				- Alternative source(s)			
		- Biofilm control				**Management**			
		Tap (Customer)				- Water balance			
		- Point-of-entry (POE)				- Demand/supply trend(s)			
		- Point-of-use (POU)				- Demand reduction			

TKI Categorisation (continued)

Contains		**Constraints**		**Meta data**					
Report	x	Low cost		*Author(s)*		Liv Fiksdal, Astrid Bjørkøy			
Database		Simple technology		*Organisation(s)*		NTNU			
Spreadsheet		No/low skill requirement		*Contact name*		Liv Fiksdal			
Model		No/low energy requirement		*Contact email*		liv.fiksdal@ntnu.no			
Research	x	No/low chemical requirement		*Quality controller name*					
Literature review		No/low sludge production		*Quality controlerl organisation*					
Trend analysis		Rural location		Source					
Case study / demonstration		Developing world location		*Date prepared*		30-06-2007			
Financial / organisational				Date submitted (TKI)		02-07-2007			
Methodology	x			Date revised (TKI)					
Legislation / regulation									
Benchmarking									