Nanofiltration as a treatment barrier against pathogens

Introduction

Nanofiltration (NF) for the removal of humic substances/Natural Organic Matter (NOM) has been used for almost 20 years in Norway.
Nanofiltration has been regarded as a hygienic barrier against pathogens. Recent experiences indicate however that the NF barrier may not always be as efficient as previously assumed.

Importance

In the last two decades, surface water treatment with NF membranes has become an attractive alternative to conventional treatment for the removal of natural organic substances (NOM). Nano filtration has no need for chemical additives during routine operation, and a good treated water quality is normally obtained independent of feed water quality. In addition, NF can provide high treatment barrier efficiency towards micro-organisms.

In Norway, the drinking water regulations state that all water supply systems must contain at least to hygienic (safety) barriers. For a water treatment process to be credited as one barrier, the required removal or inactivation rate is defined as 99.9 % for viruses and bacteria and 99 % for protozoa.

For membrane filtration to be credited as a hygienic barrier a set of operational requirements are given:

- The permeate production, or recovery, in a membrane shall not exceed 20 % of the raw water flow into the membrane. With 4 membranes in series in a tube the recovery shall then not exceed 80 %.
- Particle number, turbidity, colour or TOC are listed as possible indicators for membrane integrity and performance, but such monitoring is not stated as a explicit requirement in the national water regulations or guidelines.

The main goals of this survey were to collect in-depth information on the ability of nanofiltration plants to be a barrier towards pathogens, and to identify reasons for failures in this barrier.

Approach

Within this survey a questionnaire were sent to about 100 Norwegian water treatment facilities using NF. In addition, existing reports about operational results of NF in the field of drinking water production were evaluated and integrated into the survey.

Results

Almost 1/3 of the nanofiltration plants have reported failure in the hygienic barrier. The failures in barrier efficiency were not discovered before coliform bacteria were detected in the treated water, showing the lack of reliable indicators for the performance of the NF barrier. Several reasons are

identified for the NF barrier failures, including leakages through the contactors between the membranes because of defect gaskets, leakages through the membranes because of breakage, as well as raw water accidentally by-passing the membranes modules. However, the reasons were often unknown. Some plants indicate that failure in the pre-filter unit was the indirect reason, since this caused fouling, high pressure loss and finally breakages. Inappropriate plant design, like intermittent pre-filter designs that caused frequent variations in the inlet pressure, did also cause breakages.

Strategies to avoid unsatisfactory treated water quality and failures in nanofiltration barrier efficiency include development of improved methods to detect failures and actions to prevent failures. Of the latter, improved pre-treatment to avoid an operation that can damage the membranes is of major importance.

More information

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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	X	- Settlement		- Raw water (source)	X	- Recycle	
- Groundwater		- Bankside storage		- Thickening		- Treated water	X		
- Surface water	X	**Pretreatment**		- Dewatering		**Chemical**			
- Spring water		- Screening		- Disposal		- Organic compounds	X		
- Storm water		- Microstraining		**Chemical dosing**		- Inorganic compounds	X		
- 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	X	**Secondary treatment**		- Flow	X	- Parasites			
- Primary treatment		- Coagulation/flocculation	X	- Pressure	X	- Bacteria	X	**Trust**	
- Secondary treatment	X	- Sedimentation		- pH		- Fungi		- In water safety/quality	
- Sludge treatment		- Filtration		- Chlorine		**Aesthetic**		- In security of supply	
Treated water storage		- Dissolved air flotation(DAF)		- Dosing		- Hardness / alkalinity		- In suppliers	
- Service reservoir		- Ion exchange		- Telemetry		- pH		- In regulations and regulators	
Distribution		- Membrane treatment	X	**Analysis**		- Turbidity	X	**Willingness-to-pay/acceptance**	
- Pumps		- Adsorption		- Chemical	X	- Colour	X	- For safety	
- Supply pipe / main		- Disinfection		- Microbiological	X	- Taste		- For improved taste/odour	
Tap (Customer)		- Dechlorination		- Physical	X	- Odour		- For infrastructure	
- Supply (service) pipe		**Treated water storage**						- For security of supply	

- 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	X			**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		Low cost		*Lars J. Hem* *Thor Thorsen*					
Database		Simple technology		*SINTEF*					
Spreadsheet		No/low skill requirement		*Lars J. Hem*					
Model		No/low energy requirement		*Lars.hem@sintef.no*					
Research		No/low chemical requirement	X						
Literature review		No/low sludge production		*SINTEF*					
Trend analysis		Rural location		Source					
Case study / demonstration	X	Developing world location							
Financial / organisational									
Methodology									
Legislation / regulation									
Benchmarking									