Nanofiltration for the removal of NOM/humic substances
Survey on NF operational strategies

Introduction

Nanofiltration (NF) for the removal of natural organic matter (NOM)/humic substances has been used for about 20 years in Norway. In 2006, 98 plants serving more than 50 people used this process, and approximately 120 000 people were supplied from waterworks using NF. The largest of these plants was serving almost 9000 people. Similar plants are in operation also in Scotland and Ireland.

Importance

In the last two decades, surface water treatment with NF membranes has become an attractive alternative to conventional treatment for the removal of humic substances. Nanofiltration 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. With the exception of the NF concentrate and possible sludge/backwash water from possible pre- and/or post treatment units, there is no sludge or waste production. Nanofiltration is a compact process, and easy automation is one of the advantages of this process compared to conventional treatment processes.

Although NF is now applied in approximately 100 Norwegian waterworks, there is still room for improvement with respect to both design and operational issues. Full-scale experiences include inadequate pre-treatment, fouling incidents and failure in the treatment barrier efficiency.

The main goals of this survey were to collect in-depth information on operational strategies and experiences of existing nanofiltration water treatment plants, to identify challenges and needs for improvements and to give recommendations with regard to operation, pre-treatment and design.

Approach

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

Results

Design and operational strategies are to a large extent standardised for all the Norwegian NF plants. However, both due to operational experiences and the need to increase the treatment barrier efficiency, several waterworks have modified the treatment processes. The most frequent modifications are renewal of prefilters and addition of post-disinfection with UV.

The treated water quality is satisfactory at the majority of the treatment plants, but during the last years approximately 30 % of the plants have at least once a year measured colour > 10 mg Pt/l.

In addition, 30 % have detected total coliforms in treated water at least once a year and 31 % have detected *E.coli* in the treated water once or more in the period 2001-2005.

The reported operational problems experienced at NF plants are:

- Fouling/scaling on the prefilter, or insufficient hydraulic prefilter capacity (46 % of the plants)
- Membrane fouling (40 % of the plants)
- Failure of the treatment barrier efficiency (27 % of the plants)
- High plate count numbers in permeate (30 % of the plants)

The proposed actions to improve the operational performance include:

- Choose an appropriate pre-treatment based on raw water quality, not just on what is most common
- Reduce the fouling potential by using a reasonable membrane material, with reasonable flux, cross-flow and permeate recovery rates. The pre-treatment should of course be chosen to give a sufficient reduction in the fouling potential.
- Introduce routines to validate the hygienic treatment barrier efficiency, and have a toolbox available for actions to restore the barrier when needed.

Several of the proposed actions may include some redesign of the plants. These actions should also be considered in the design of new NF plants.

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									