AMSTERDAM INTERNATIONAL WATER WEEK

Abstract Title	**Use of high-precision laser nephelometry for particulate monitoring and SDI parameter**
Topic	x Improving water quality O Resilient water systems O Circular solutions: Reuse, Recover and Recycle O Transitions in water, agro/food and energy
Challenges and Solutions	Whether colloidal, particulate, or microbiological, fouling represents the most significant challenge in reverse osmosis (RO) membrane management. High-precision laser nephelometry (HPLN) based on a 360-degree detection window has exhibited a significant potential solution for fouling detection for pre-R as surrogate for the silt density index (SDI)
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Abstract	INTRODUCTION Physical fouling (particulate-based fouling) represents the most important vector in reverse osmosis membranes performance and efficiency loss. Substances involved with physical fouling are: - **Colloidal and suspended particles** - **Microbiological** - **Coagulation chemistry** - **Macro-debris**

Particles of concern. A deeper view of traditional SDI.

In figure.1, it is shown that silt density index (SDI) and Turbidity are parameters coexisting in the colloid and fine dispersion range.

The SDI is determined by the ASTM Test Method D 4189-95, used to determine the particulate contamination in water. Also, routinely used to predict the colloidal and particulate fouling potential of RO membranes.

As a general indication rule, SDI<1 means several years without fouling events, an SDI between 1 to 3 indicates several months between cleanings, and SDI between 3 and 5 will lead to particulate fouling with frequent cleanings

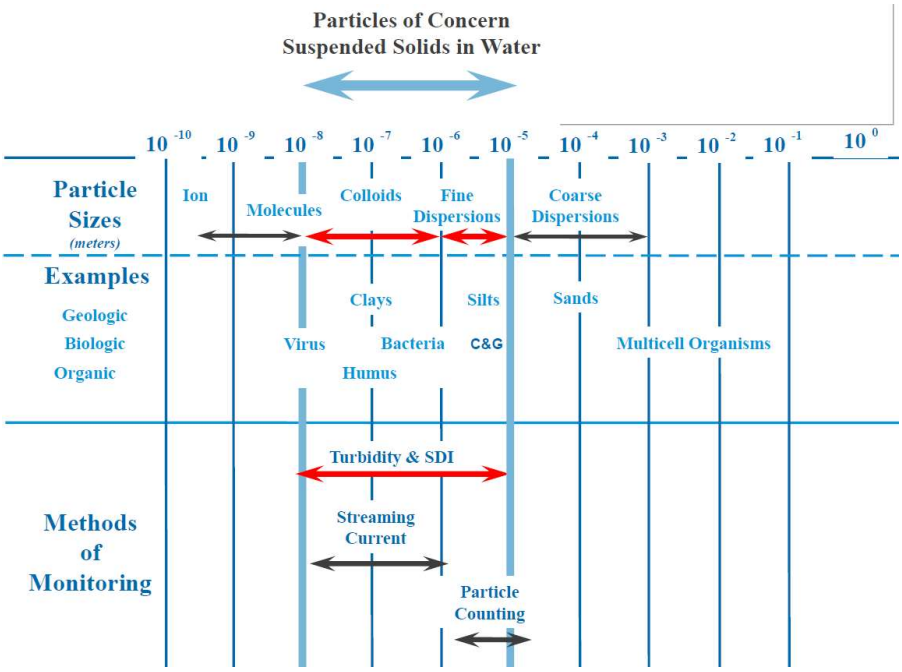

Fig.1. Type of particles and technology of measurement

SDI is:

- **Time intensive**
- **Imprecise at the low end of the index**
- **Non-continuous. It's a grab sample test and thus prone to miss transient events (even with an online SDI instrument)**

SDI requires:

- **A person to run the test (there's no online measurement availability always. Expensive instruments and intensive mechanical maintenance)**

SDI does not:

- Guarantee trouble-free operation

Parameters of concern. A deeper view into turbidity measured through laser nephelometry.

Laser nephelometry (LN), and in particular, high-precision laser nephelometry (HPLN) is a potential solution for detection of pre-RO fouling. Theoretically using HPLN:

- **1 mNTU equals 1 ppb total solids (as kaolin standard)**
- **LOD is 0.3 mNTU**
- **Particle sizes <1 micron are detected when the concentration of particles is such that the sum reflectance can increase photodetector response above 7 mNTU**

In figure 1, also particle counting is a technology providing particle information in the silts range and could provide a similar response but would miss particles under the 2-micron size. Furthermore, a particle-counting instrument is difficult to calibrate and verify and requires a dedicated computer for metadata processing.

A nephelometer requires minimal maintenance, and calibration/validation is an easy procedure with standards. Also, it can be set up to divert a stream of water during an upset until the particle concentration returns to normal.

STUDY

Background

In a study at a power plant in the Southwest (USA), data taken from the nephelometer indicated that the instrument easily and quickly responded to and detected particle events in the feed water sample.

The study was conducted at the request of the power plant because they were experiencing fouling of their RO membranes, although SDI values were well within expected limits.

Results

A laser nephelometer TU5400 was used for the study. It has demonstrated an accurate visualization of particulate (turbidity) excursions out of stability periods with shallow SDI values. In addition, these excursions have been identified with fouling events by operators.

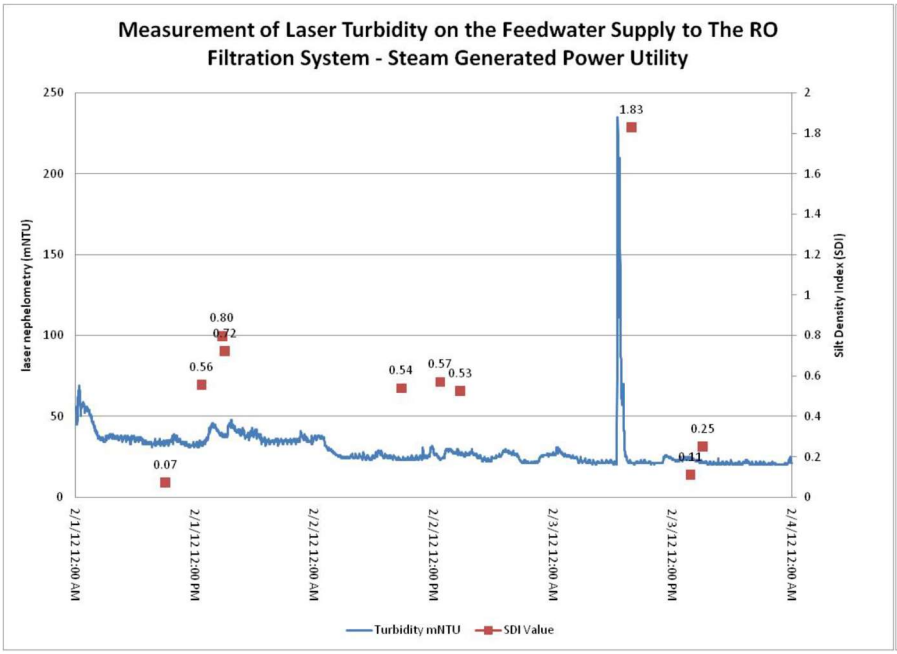

Fig.2. Laser nephelometry correlates well with SDI measurements and detecting peaks. Turbidity in the mNTU baseline window of 25 to 50 mNTU equals a window range of SDI from 0.07 to 0.8 (<1). A fast peak is identified (240 mNTU)by the laser nephelometer corresponding to a SDI excursion of 1.83.

Considering that an SDI of <3 indicates no fouling of RO membranes, the measurements demonstrated that no fouling was occurring. However, plant operators knew the RO membranes were being fouled based on loss of efficiency in water production, and visual inspection.

SDI and Laser Nephelometry correlation

The study considers the particulate matter in the range of colloidal and supracolloidal particle sizes, affecting to membrane fouling.

	Classification of Particulate Matter - **Settleable solids: >100um** - **Supra-colloidal solids: 1um-100um** - **Colloidal solids: 0.001um-1um** - **Dissolved solids: <10A** The testing materials are 70% of deposits are aluminosilicates, iron oxides, and organics: - **Colloidal kaolinite ($Al_2Si_2O_5(OH)_4$)** - **Colloidal montmorillonite ($(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$)** - **Supra-colloidal aluminum oxide** - **Colloidal hematite** - **Supra-colloidal hematite** - **Supra-colloidal calcium carbonate** CONCLUSIONS From the field and laboratory studies, it is concluded that: - **An online nephelometer can detect excursions in SDI and may be able to predict fouling better (continuous vs. periodic data)** **1.** - **Additional research needs to be done to create a pseudo "SDI" scale** **2.** - **Results indicate that the use of a laser nephelometer provides a qualitative alternative to SDI** **3.** - **Nephelometry can be used to monitor particulate fouling, but a universal correlation is not possible. Something more sophisticated will be necessary.** **4.** - **Particulate fouling is only a part of the story** **5.** - **SDI is a start, but SDI plus HPLN is better, and SDI plus HPLN plus "TOC, SUVA, etc." is probably even better**
Figures/diagrams/illustrations	Up to 2 (in abstract)

Chart Shows that the colloidal clay and hematite particles over their range of concentration and size closely follows the correlation.