

Use of high-precision laser nephelometry for particulate monitoring and SDI surrogation

Authors: Denton Slovacek, HACH; Bart Verdonk, HACH

Presenter: Bart Verdonk, HACH



Fouling. The greatest challenge in

RO membranes management

Membrane Fouling Mechanisms:

- **Particulate**
- Organic (dissolved)
- Inorganic (dissolved)
- Microbiological

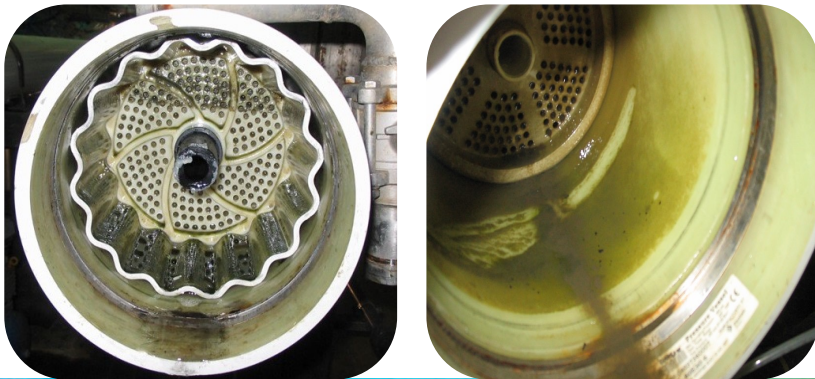
Physical fouling (particulate-based fouling) represents the most important vector in reverse osmosis membranes performance and efficiency loss.

Particles involved in physical fouling are:

- Colloidal/ suspended particles
- Microbiological
- Coagulation chemistry
- Macro-debris, Micro-plastics

Silt Density Index (SDI) is a prediction parameter for membrane fouling potential by **colloidal and particulate matter**.

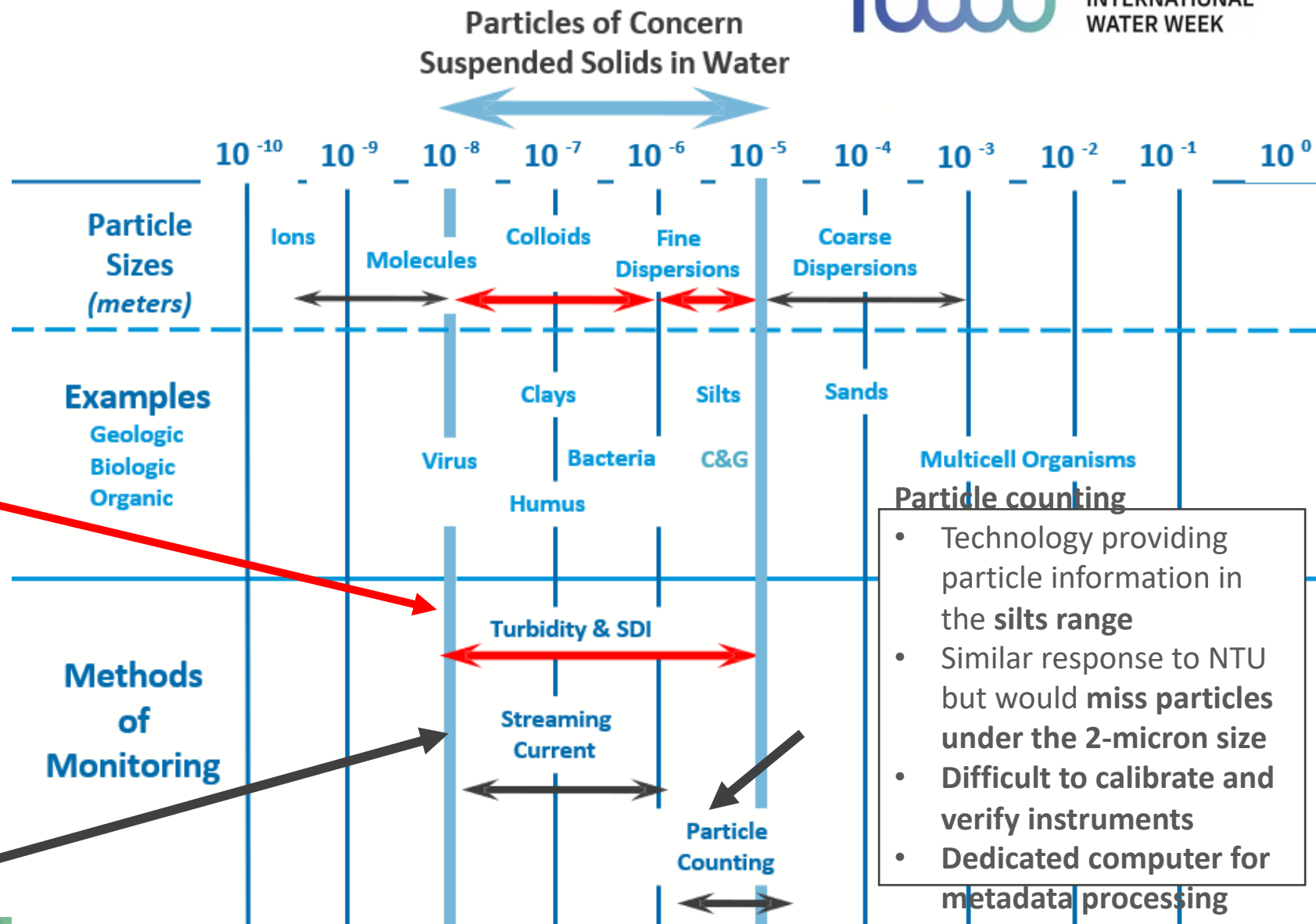
- **SDI** recommended/required by membrane manufacturers
 - <1 year without fouling
 - 1-3 Months between cleanings
 - 3-5 particulate fouling with frequent cleanings
- SDI is an **ASTM standard – D4189**
 - Used to indicate the quantity of **particulate matter** in water and applies to **relatively low (<1.0 NTU) turbidity waters** such as well water, filtered water, or clarified effluent samples.
 - Since the size, shape, and nature of the particulate matter in water may vary, this test method is **not an absolute measurement of the quantity of particulate matter**.



Type of particles & technology of measurement

- A nephelometer**
- Covers SDI range
 - Easy Calibration/validation procedure with standards
 - Extremely fast response
 - Requires minimal maintenance
 - Cost-effective solution

- Streaming Current & Zeta-meters:**
- Scope in **colloid range**
 - Frequent calibrations
 - Salinity affected
 - Requires stable matrix



- Particle counting**
- Technology providing particle information in the **silts range**
 - Similar response to NTU but would miss particles under the 2-micron size
 - Difficult to calibrate and verify instruments
 - Dedicated computer for metadata processing

Use of Laser Nephelometry to Supplement/Complement the Recommended SDI

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)
- Online SDI requires significant investment and intensive mechanical maintenance

SDI does not:

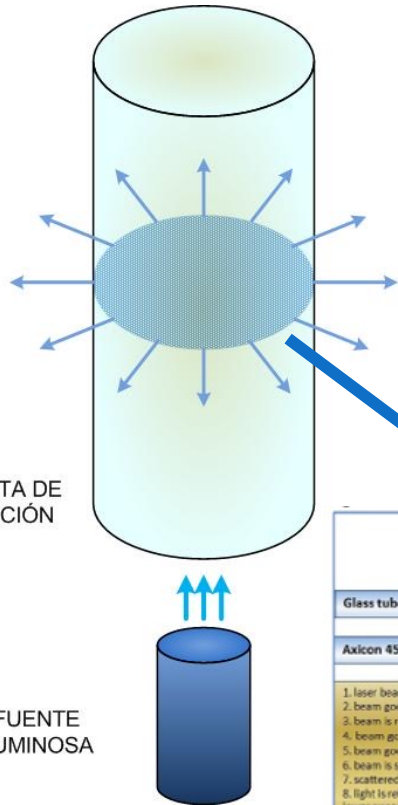
- Guarantee trouble-free operation



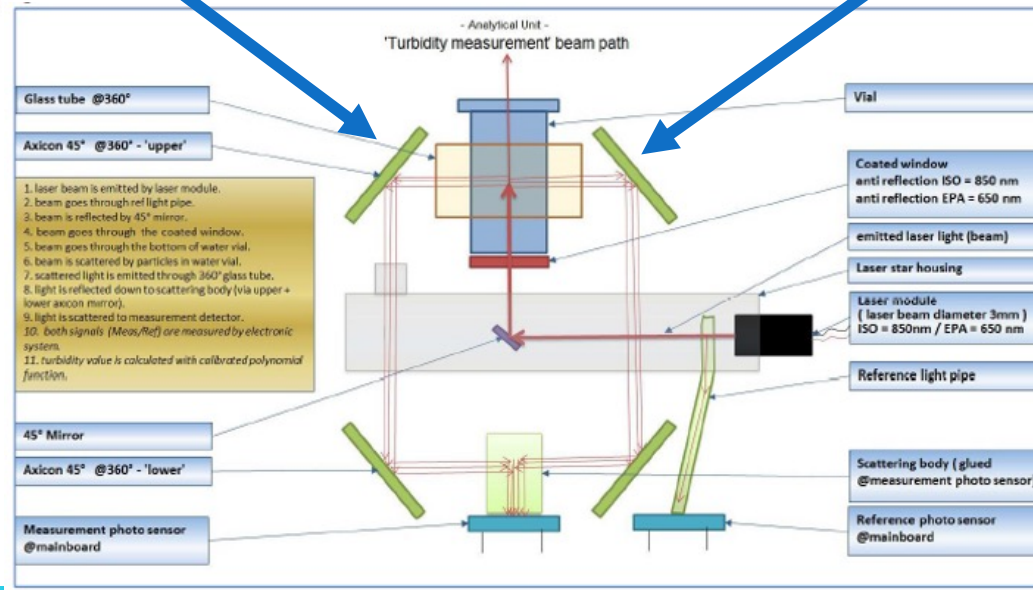
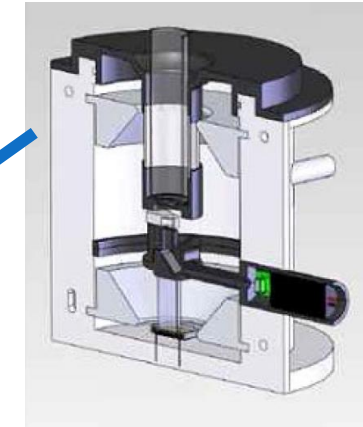
Process & Lab nephelometers TU54/TU52

- To protect against premature fouling or failures of reverse osmosis (RO) membranes, industrial plant operators have routinely monitored feed water using the **silt density index (SDI)**
- While this practice is valuable for assessing water quality, it may not be enough to **explain some operational anomalies**
- **In fact, many significant excursions in water quality—that could adversely impact membrane operation—go undetected with a routine SDI sampling protocol**

High Precision Laser Nephelometry (HPLN)



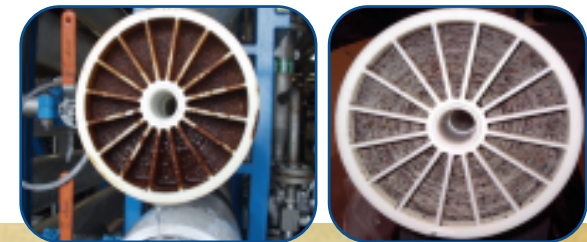
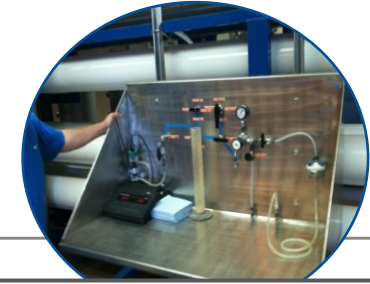
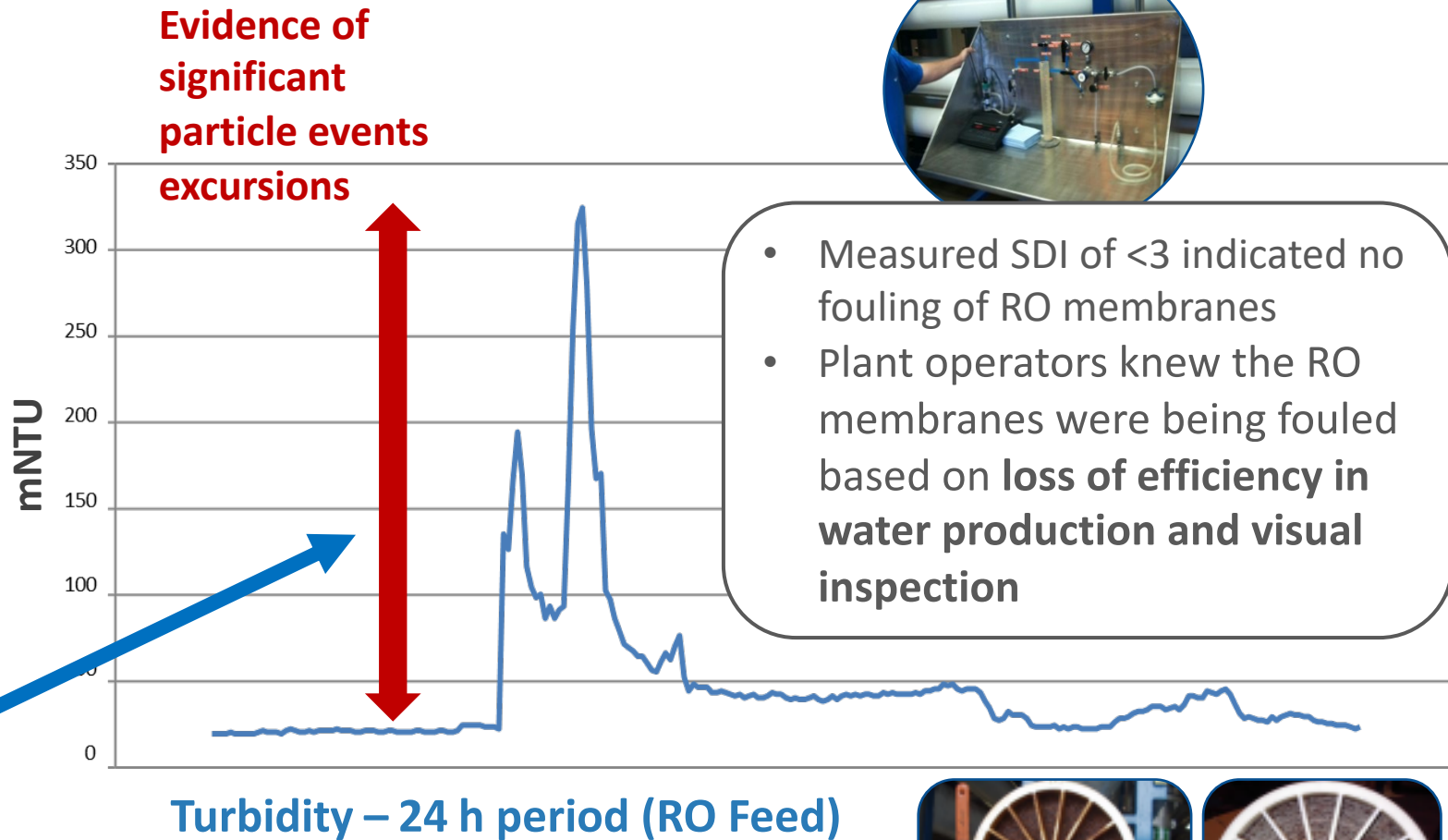
- By placing the incident light beam on the axis of the cuvette, we can use all the scattered light radiation on a perpendicular plane
- The signal received in the optical system is much higher than the conventional nephelometric system, minimizing dramatically errors at **very low turbidity**



- Potential solution for detection of pre-RO fouling
- 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

A case study. RO treatment unit in a Power Plant

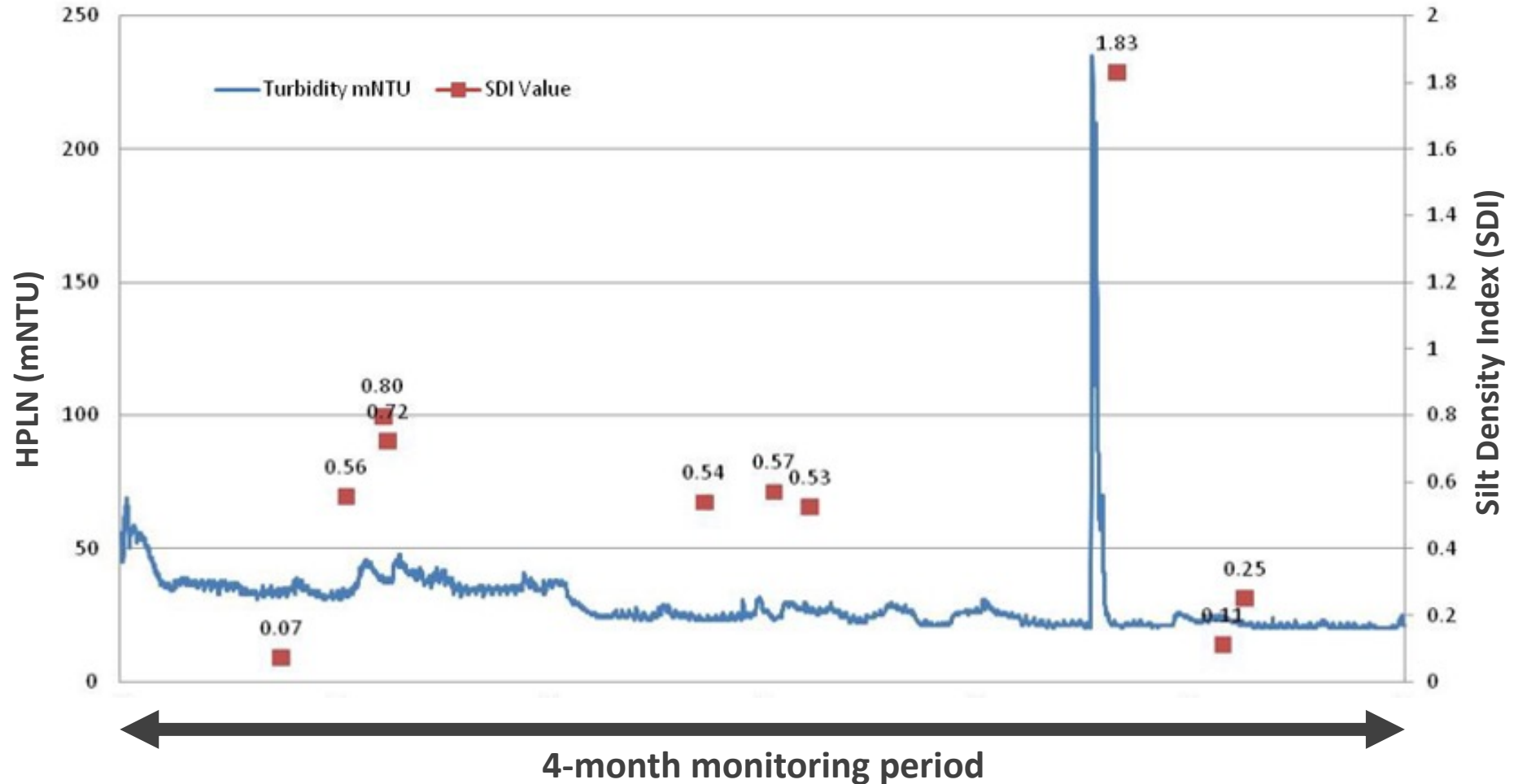
- Study conducted at the request of the power plant because of **fouling experienced of their RO membranes, although SDI values were well within expected limits**
- Nephelometer data indicated that the instrument easily and quickly responded to and detected particle events in the feed water sample



SDI VS LASER NEPHELOMETRY

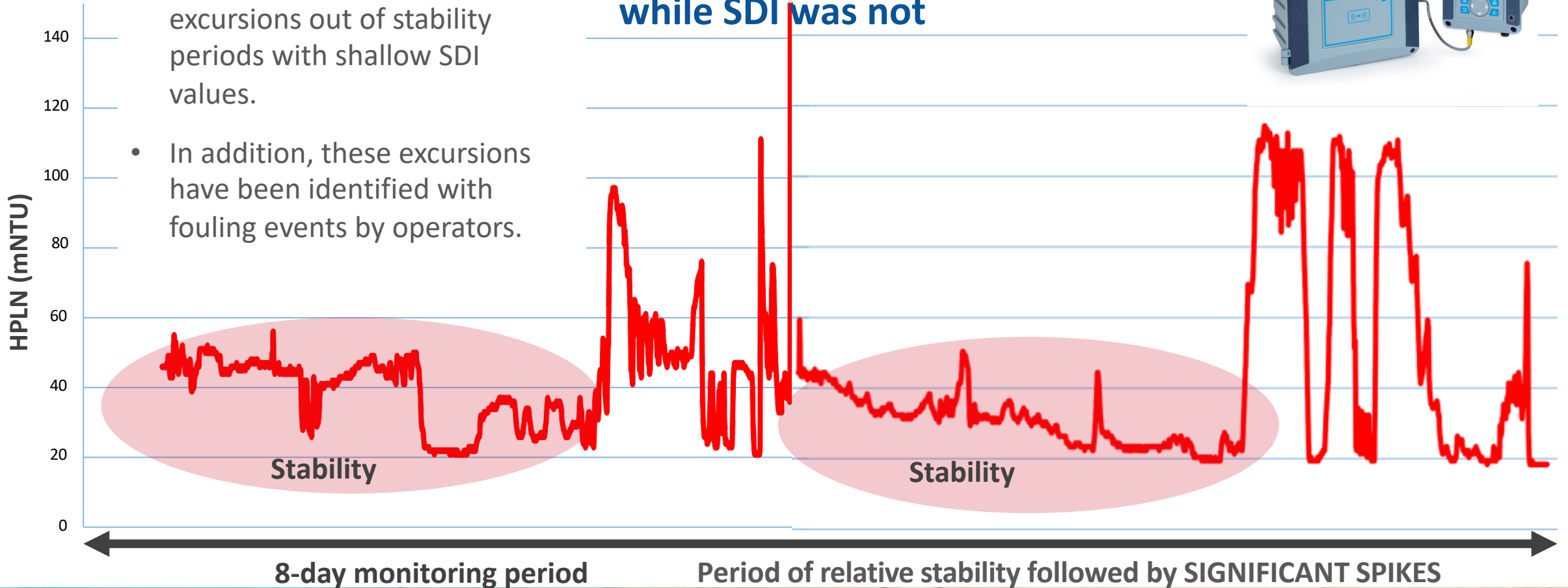
Laser nephelometry correlates well with SDI measurements and detecting peaks. Turbidity in the mNTU baseline window of 25 to 50 mNTU equals a window range of SDI from 0.07 to 0.8 (<1). A fast peak is identified (240 mNTU) by the laser nephelometer corresponding to an SDI excursion of 1.83

Measurement of Laser Turbidity on the Feedwater Supply to the RO System
(Steam Generation Power Utility)

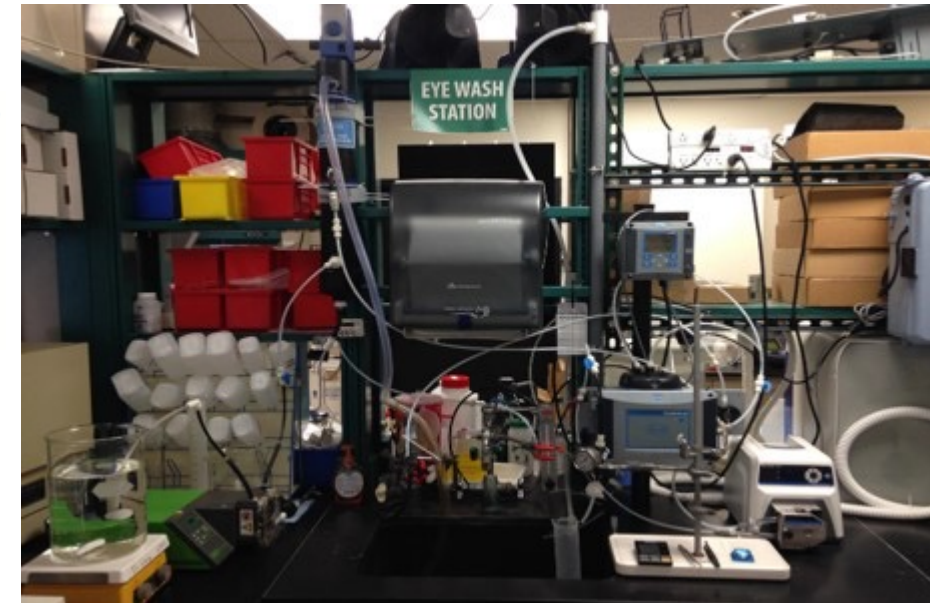
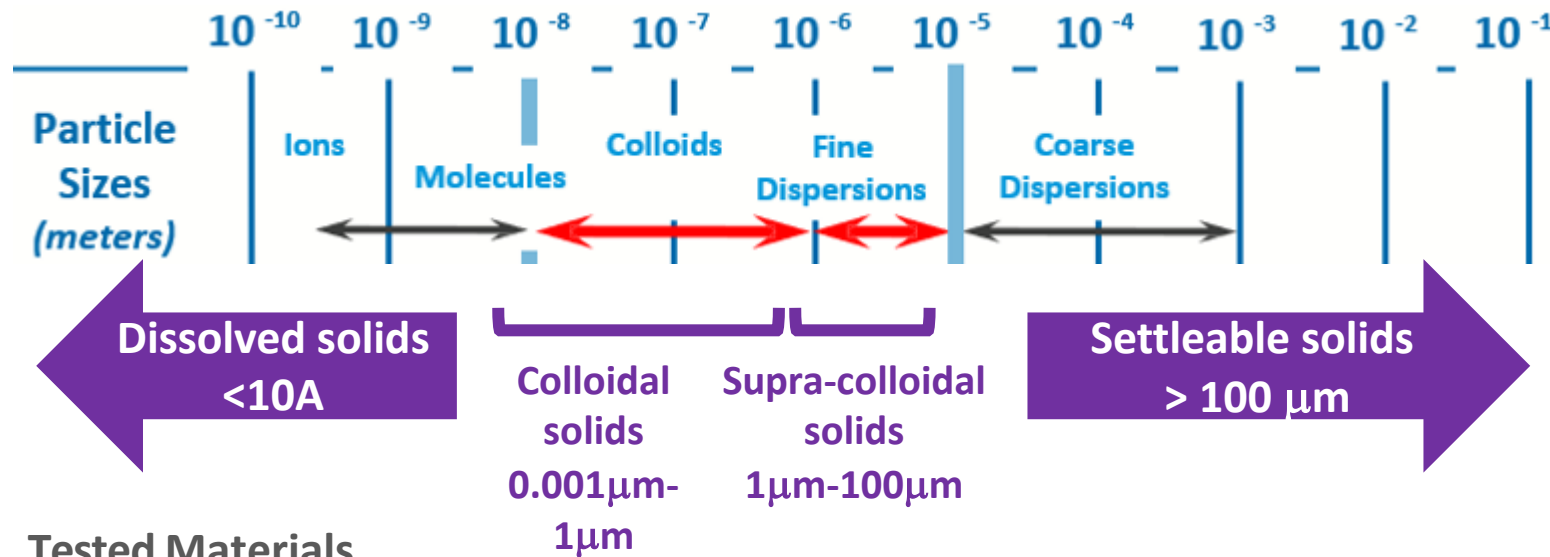


- A laser nephelometer TU5400 was used for the study
- It has demonstrated an accurate visualization of particulate (turbidity) excursions out of stability periods with shallow SDI values.
- In addition, these excursions have been identified with fouling events by operators.

This study clearly showed that Laser Nephelometry was able to continuously monitor and detect particle excursions while SDI was not



SDI and Laser Nephelometry correlation tests

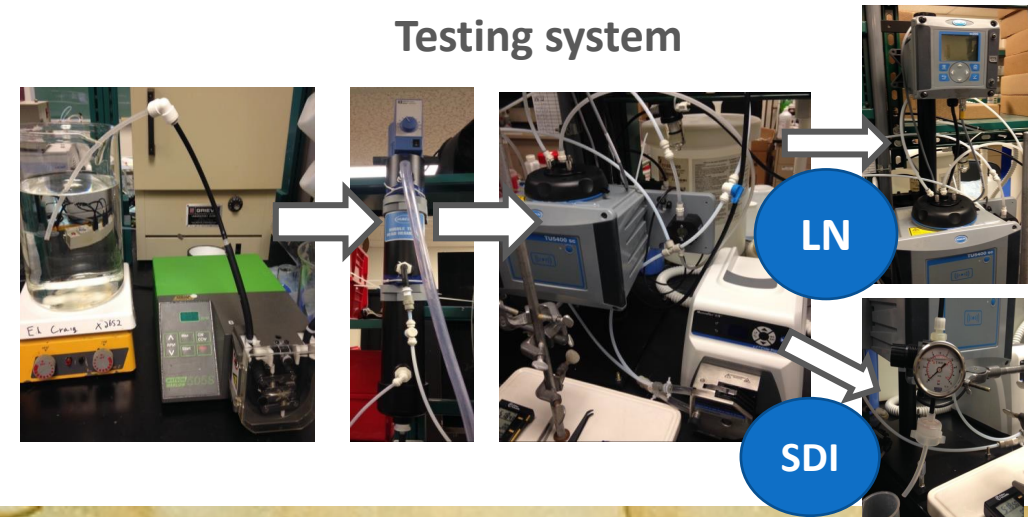


Tested Materials

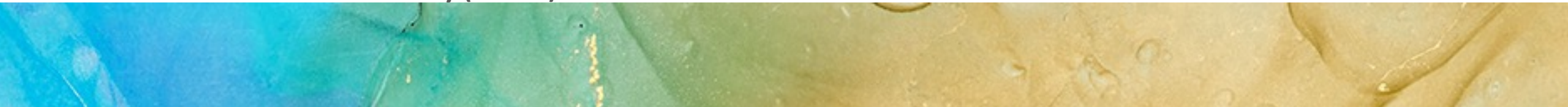
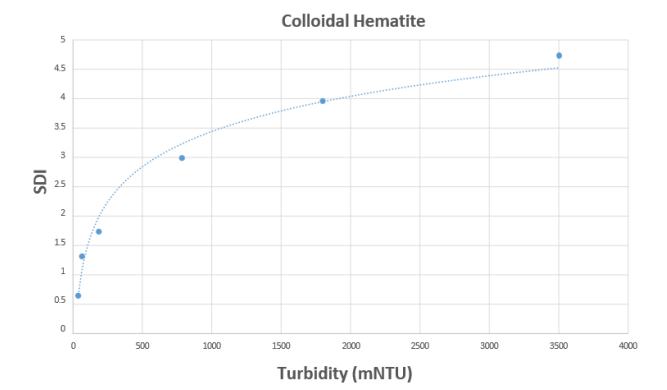
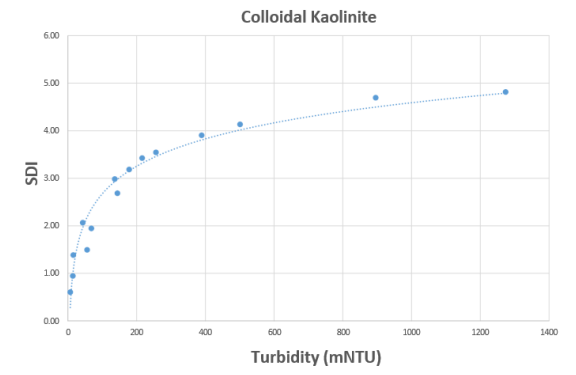
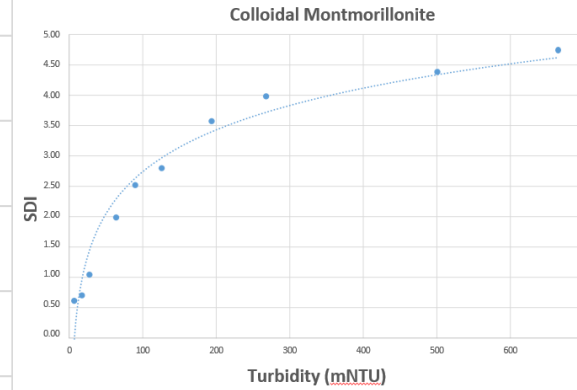
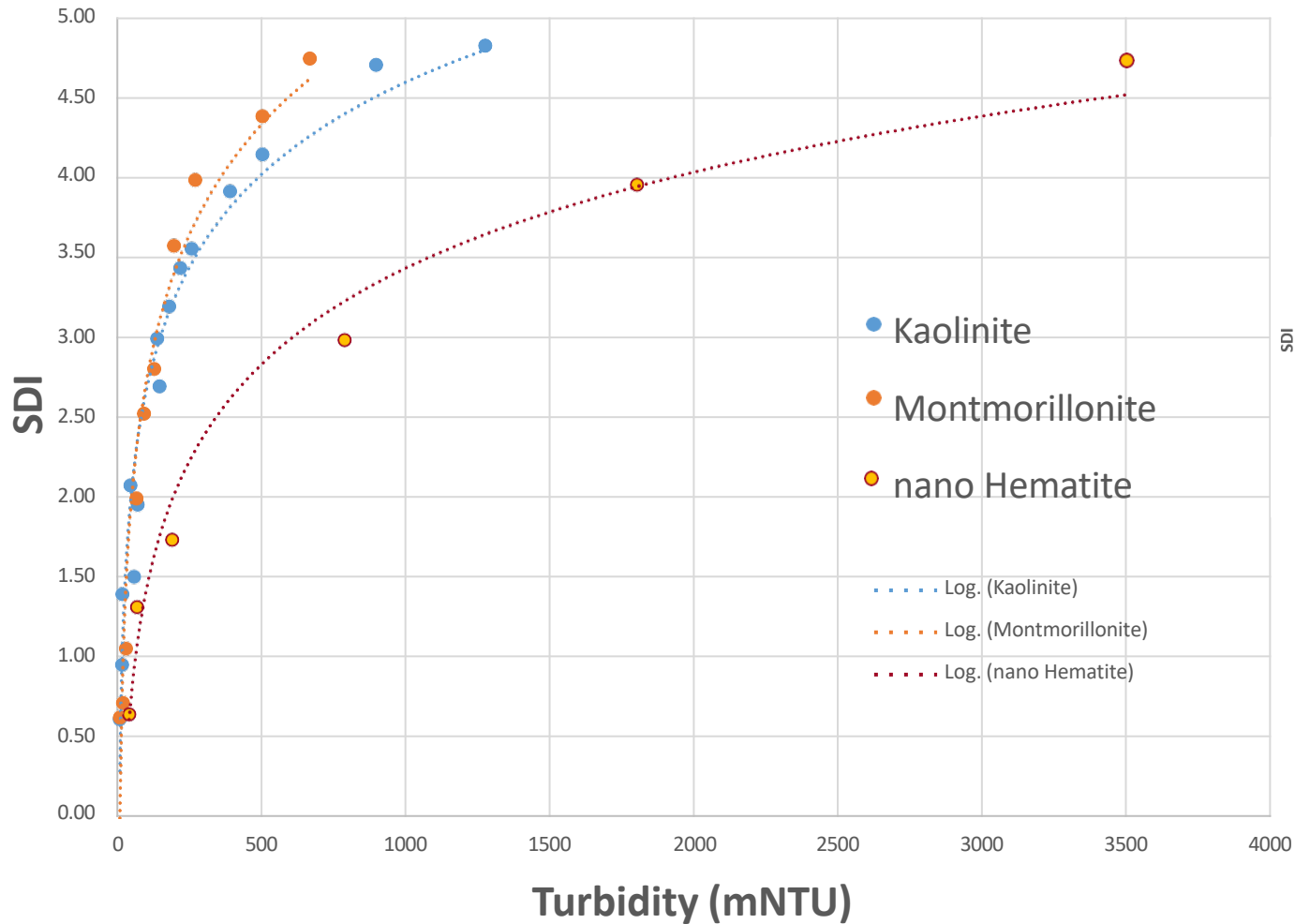
70% of deposits are aluminosilicates, iron oxides, and organics

- 1) Colloidal kaolinite $[Al_2Si_2O_5(OH)_4]$
- 2) Colloidal montmorillonite $[(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O]$
- 3) Supra-colloidal aluminum oxide
- 4) Colloidal hematite
- 5) Supra-colloidal hematite
- 6) Supra-colloidal calcium carbonate

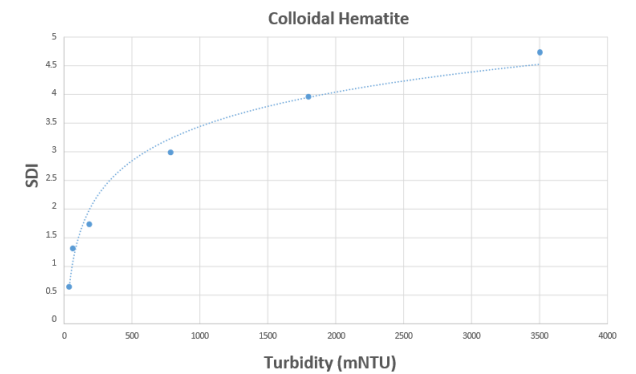
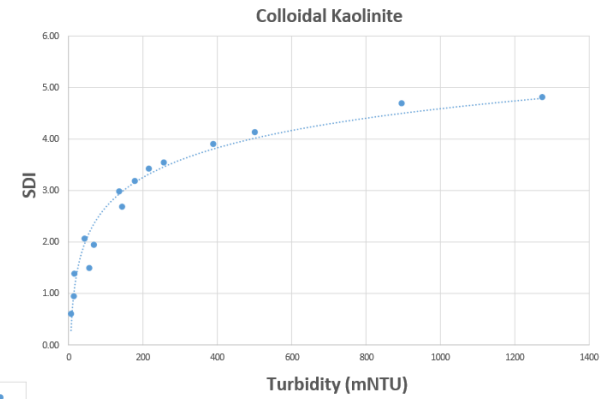
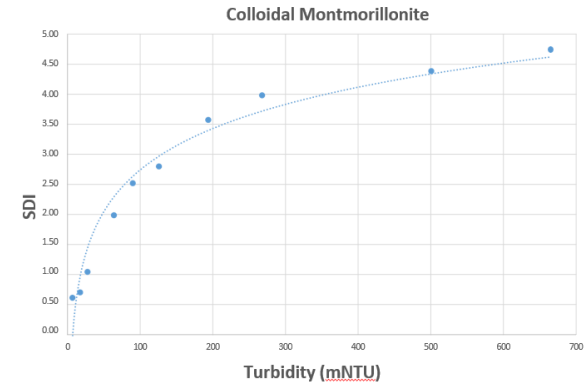
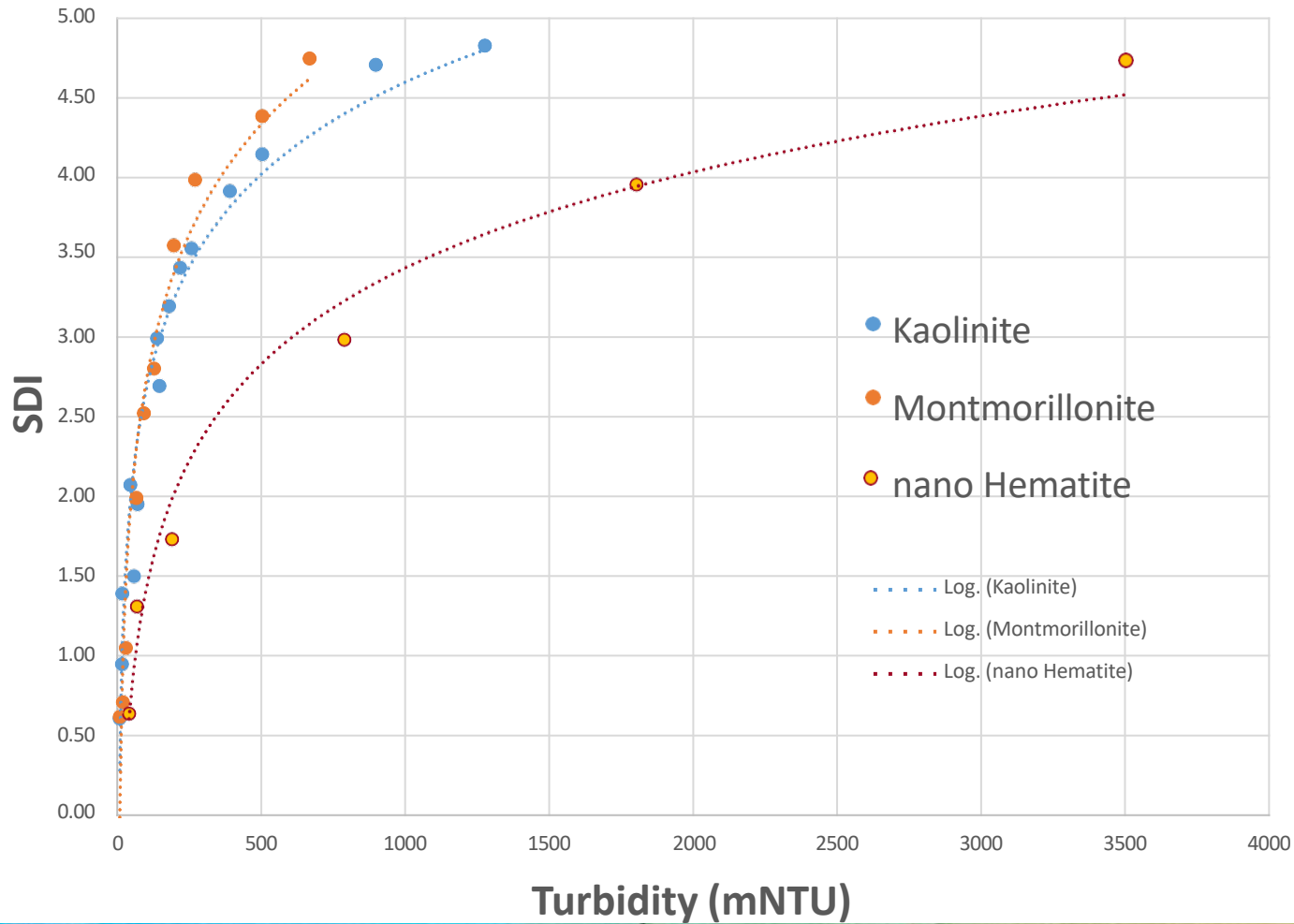
Testing system



SDI and Laser Nephelometry correlation Colloids

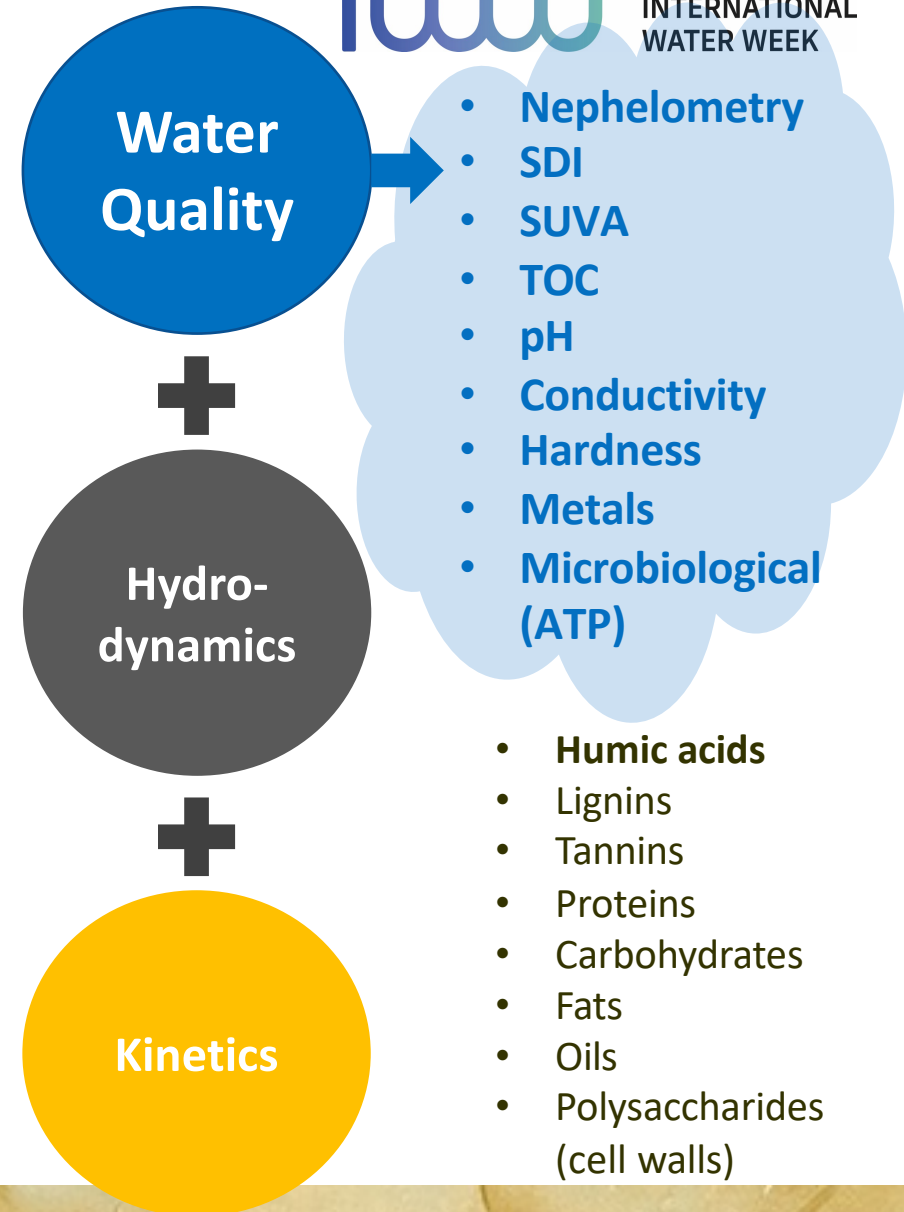


SDI and Laser Nephelometry correlation Colloids



Conclusions of the experiences

- An online nephelometer can **detect excursions in SDI** and may be able to predict fouling better (continuous vs. periodic data)
- Results indicate that the use of a laser nephelometer provides a qualitative **alternative to SDI**
- Nephelometry can be used to **monitor particulate fouling**, but a **universal correlation is not possible**. Something more sophisticated will be necessary.
- Particulate fouling is only a **part of the story**
- **SDI is a start**, but SDI plus HPLN is better, and SDI plus HPLN plus “TOC, SUVA, ATP, etc.” is probably even better
- **AI development** on ML and data prediction can evolve HPLN as a critical parameter for fouling potential prediction



THANK YOU!



**Please visit Hach at Aquatech
booth 07.516**

bart.verdonk@hach.com



GOLD SPONSORS



Deltares



SILVER SPONSORS



BRONZE SPONSORS



PARTNERS

