the path toward potable reuse through reliable organics monitoring

introduction

Water reuse has proven benefits for increased operational efficiencies and cost savings but until recently, was only implemented occasionally by industries and municipalities. Climate change, increased urbanization, and population growth have driven demand for water reuse technologies and better source water security. To meet these demands, regulators aim to quantify treatment reliability and develop adequate analytical indicators to ensure safe operations. Organics monitoring is a vital part of meeting high water quality requirements, protecting public health, and maintaining optimal treatment efficiencies for contaminant removal.

challenge

Water for indirect potable reuse (IPR) has gained momentum with projects scattered throughout the US and the globe but increased scarcity of water resources is driving researchers and regulators to develop a framework for direct potable reuse (DPR). Water reuse combines wastewater treatment and drinking water treatment efforts with multiple barriers to protect public health. These efforts include:

- Reducing Biological Oxygen Demand (BOD)
- Controlling nutrients
- Removing pathogens/viruses
- Ensuring proper disinfection
- Controlling taste/odor
- Eliminating trace organic contaminants

Proper disinfection requires a balance between the inactivation of pathogens/viruses and the formation of carcinogenic disinfection byproducts (DBPs), which are produced when disinfectants react with natural organic matter (NOM). To monitor and balance these efforts, utilities need to better understand the quality of influent, process, and effluent waters during stages of the reuse cycle. Total Organic Carbon (TOC) analysis is a reliable method for determining water quality that has several advantages over alternative surrogate parameters (**Table 1**). TOC includes NOM, taste and odor compounds, microbes and bacteria, trace organic contaminants, and organic industrial waste.

Table 1: TOC compared to alternative surrogate parameters

TOC	Turbidity
• Measures gross amount of organic matter • Includes suspended particulate, colloidal, and DOM • Does not include settleable solids, inorganic sediments, organic particulate	• Measures water clarity—how much the material suspended in water decreases the passage of light through the water • No health criteria • Does not distinguish between organic, inorganics, color, etc.
DOC	**SUVA (specific absorbance at UV 254 nm)**
• Measures soluble and/or colloidal organic matter, filtered through 0.45 µm	• Measures DOC aromatic content—calculated by DOC and UV absorbance at 254 nm as alternative EPA compliance • Several interferences at 254 nm • Requires DOC and UV254 components
BOD	**COD**
• Measures biologically active organic matter • Used to measure degree of pollution of water • Can gauge effectiveness of WWTP • Test typically takes 5-days; poor precision • Every organic compound has a different BOD	• Measures chemical oxidative action of organic matter • Measures effectiveness of industrial and municipal wastewaters, but with poor precision • Test typically takes 2 hours and requires strong, hazardous chemicals • Every organic compound has a different COD

solution

TOC monitoring can enhance treatment processes and achieve target contaminant removal efficiencies. The value of monitoring TOC is to:

- Control treatment processes
- Make data driven decisions

- Maintain overall health of the systems
- Meet effluent quality requirements

When designing a water reuse treatment system, it is important to identify critical control points (CCPs) and quality control points (QCPs) to monitor performance and ensure water quality through the process. In addition to monitoring changes in source water and final effluent quality, **Table 2** provides examples of treatment process applications that benefit from organics monitoring.

Table 2: Solutions provided by monitoring organics

Application	Solution
Security Monitoring	• Detect changes in water quality
Chemical Dosing	• Choose right chemical and dose
Granulated Activated Carbon	• Control regeneration frequency • Optimize for desired effluent quality
Ion Exchange	
Membranes (MF/UF)	• Avoid fouling with proper pre-treatment
Reverse Osmosis	• Increase lifetime • Manage backflush routines
Ozone Dosing	• Dose O_3 based on O_3/TOC ratio
Proper Disinfection	• Limit formation of DBPs but ensure deactivation of microorganisms

examples

Recycled water contribution (RWC) for groundwater recharge in California is determined by the amount of TOC, which is used as a surrogate for unregulated organic contaminants. Other states are also adopting TOC standards for recharge regulations as shown in **Table 3.**

Table 3: State TOC levels for recharge and reclaim

State	Recharge framework for TOC
CA	≤0.5 mg/L
WA	≤1 mg/L
FL	≤3 mg/L
MA	≤1-3 mg/L
NM	≤3 mg/L

http://www.reno.gov/home/showdocument?id=30769

Reuse facilities are adopting TOC monitoring as an analytical tool for improving process control, meeting recharge guidelines, and improving treatment practices as noted in **Table 4.**

Table 4: Reclaim treatments and TOC monitoring examples

Location and Reuse Treatment	Use of TOC
Orange County, CA MF + RO + UV AOP	• Test membrane integrity • Protect against RO fouling
Singapore NEWater MF/UF + RO + UV	• Test RO membrane integrity • Monitor source water contamination
San Diego, CA O_3 + BAC + MF + RO + UV/H_2O_2 AOP	• Monitor tertiary effluent • Measure TOC removal efficiencies across O_3/BAC • Measure TOC in MF/RO effluent
Fairfax, VA Lime + GMF + GAC or O_3/BAC + Cl_2	• Optimize O_3 dosing and monitor TOC removal across GAC
El Paso, TX MF/UF + NF/RO + UV/H_2O_2 AOP + GAC/O_3 + Cl_2	• Monitor treatment train from source water to drinking water quality effluent

BAC-biological activated carbon filtration, GAC-granulated activated carbon, GMF-granular media filtration, MF-microfiltration, O_3-ozone, RO-reverse osmosis, UF-ultrafiltration, UV AOP-ultraviolet disinfection advanced oxidation

Orange County Water District (OCWD) is a leader in the production of reliable, high quality reclaimed water for groundwater recharge and prevention of seawater intrusion into the groundwater basin. Its process from secondary wastewater through MF, RO, and UV advanced oxidation produces water that meets or exceeds reuse water standards and state and federal drinking water standards. OCWD uses TOC analysis to test for membrane integrity, monitor removal efficiencies, and prevent membrane fouling. Improper pre-treatment to MF, UF, and RO can lead to high energy costs, expensive cleaning, and potential membrane replacement. Knowledge of TOC concentrations before and after membrane filtration helps optimize organic removal efficiency and monitor changes in water quality coming to the plant.

summary

Monitoring TOC allows operators to make real-time, data driven decisions that optimize processes. It also allows facilities to monitor the overall health of treatments systems and meet goals for effluent water quality. Growing needs for water reuse and emerging treatment technologies are driving framework development for DPR. This framework will depend on reliable, real-time monitoring, such as TOC analysis, to protect public health and ensure efficient operations.