Reliable Monitoring of Adenosine Triphosphate (ATP) in Water Reuse and Reverse Osmosis Treatment

Hach® EZ7300 Adenosine Triphosphate (ATP) Analyzer Successfully Used as a Measurement Surrogate for Log Removal Value to Monitor Reverse Osmosis Performance and Integrity

Problem

The water district wanted to demonstrate a higher log removal value (LRV) across the reverse osmosis (RO) system to address state requirements for potable reuse. The goal was to identify and test improved surrogates for monitoring RO performance for water reuse that can demonstrate greater LRV, including monitoring online extra cellular (free) Adenosine Triphosphate (ATP).

Solution

To evaluate the use of free ATP as a potential surrogate for monitoring RO integrity and to achieve higher LRV for the RO process, free ATP using the Hach EZ7300 ATP analyzer was measured in the RO feedwater and RO permeate.

Benefits

The results of the study and the performance of the EZ7300 ATP analyzer provides a new approach for the water district to demonstrate the continuous integrity of the RO process, which is a critical step in the water purification process. It also increases confidence in the multi-barrier treatment scheme and showed that continuous monitoring of free ATP is effective and helps ensure that target LRV is achieved.

Background

Orange County Water District's Groundwater Replenishment System (GWRS) is the largest indirect potable reuse facility in the world, producing 100 million gallons per day of highly purified water to replenish groundwater (which is the region's primary drinking water supply) and to maintain a local underground seawater intrusion barrier. The GWRS Advanced Water Purification Facility utilizes a multiple-barrier approach to recycle secondary-treated wastewater through treatment by microfiltration (MF), reverse osmosis (RO), and ultraviolet disinfection with hydrogen peroxide addition (UV/H_2O_2)

Orange County Water District Potable Water Reuse Facility (Fountain Valley, CA)

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To comply with local regulations and demonstrate effective treatment of wastewater, potable reuse facilities in California are required to demonstrate a high log removal value (LRV) for their overall treatment scheme. This LRV ensures that effective treatment removes bacteria, giardia, cryptosporidium, viruses, and other harmful contaminants.

RO is a widely accepted treatment technology in reuse scenarios, serving as a physical barrier to pathogens and most dissolved constituents. However, for potable reuse, pathogen removal credit for RO systems is dependent upon proving continuous integrity of the membranes, usually through online monitoring of a surrogate for virus rejection.

Traditional surrogates, such as total dissolved solids and total organic carbon (TOC), demonstrate only 1-2 logs of removal credit. These values are much lower than the 6 logs of virus removal demonstrated by RO in past studies. In order to obtain greater log removal credits, new surrogates are necessary.

Currently, not all promising surrogates have an effective online monitor as an alternative to laboratory grab sample methods. In some cases, a same-day lab analysis may be a viable alternative, however the water district wanted to demonstrate that a higher LRV could be shown for their RO system through the use of an effective online monitoring strategy.

Therefore, a study was initiated to determine whether Adenosine Triphosphate (ATP) could serve as this new, effective surrogate for membrane integrity monitoring. Goals of this pilot study were to:

- Identify better, more representative surrogates for use in monitoring RO performance for potable reuse
- Understand the measurable permeate concentrations of the surrogates, including free ATP
- Identify a cost effective, reliable online monitor of RO membrane integrity
- Achieve higher log removal credits than conductivity and TOC

Solution

In this study, ATP was chosen as a potential surrogate due to its specificity and relatively large size (507 Daltons). Its high-molecular weight makes it easily removed by RO. The Hach EZ7300 ATP analyzer was installed to measure free ATP in the RO feed and RO permeate of the OCWD Advanced Water Purification Facility as follows:

- Free ATP was measured every 30 minutes
- Highly sensitive and stable reagents installed in analyzer and stabilized by internal cooling system
- Automatic acid/base cleaning and rinsing cycles to ensure that sample contamination is minimized

Free ATP was measured every 30 minutes for approximately 5 months. In contrast to cellular ATP bound inside bacterial cells, free ATP is dissolved in the extracellular portion of the water sample, and was chosen over cellular ATP as the primary analyte for use for LRV monitoring due to the need to demonstrate high removal of (large) molecules dissolved in water.

Figure 1 shows free ATP in the RO feed (yellow) and RO permeate (green) and calculated LRVs (blue). Over 5 months of continuous online free ATP analysis, the free ATP average was 3.03, with minimum value of 2.60 and maximum value of 3.30.

The pilot study successfully showed that free ATP was removed by the RO treatment process as evidenced by the difference between free ATP values between the RO feed and RO permeate.

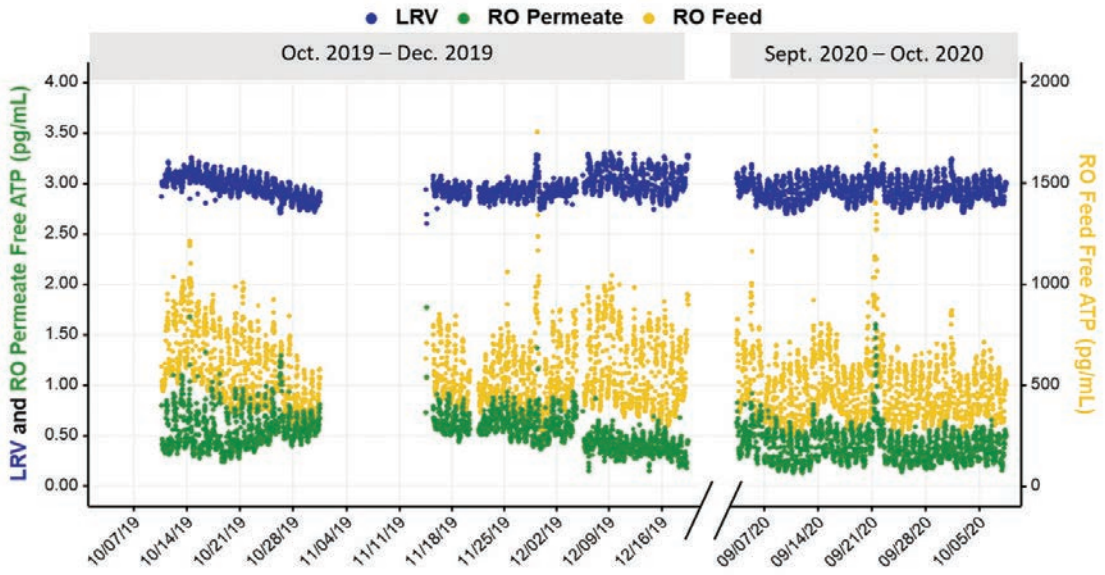


Figure 1. Continuous online free ATP measurements collected every 30 minutes. Average LRV = 3.03. Min LRV = 2.60; Max LRV = 3.30. Note: Data gap in November 2019 was due to pilot source water not being available. 2020 project data gap was result of Covid-19 pandemic.

Conclusion

The results of the pilot study and the performance of the EZ7300 ATP analyzer provide a new approach for the water district to demonstrate the continuous integrity of the RO process, which is a critical step in the water purification process. Continuous monitoring by the analyzer provided these additional benefits:

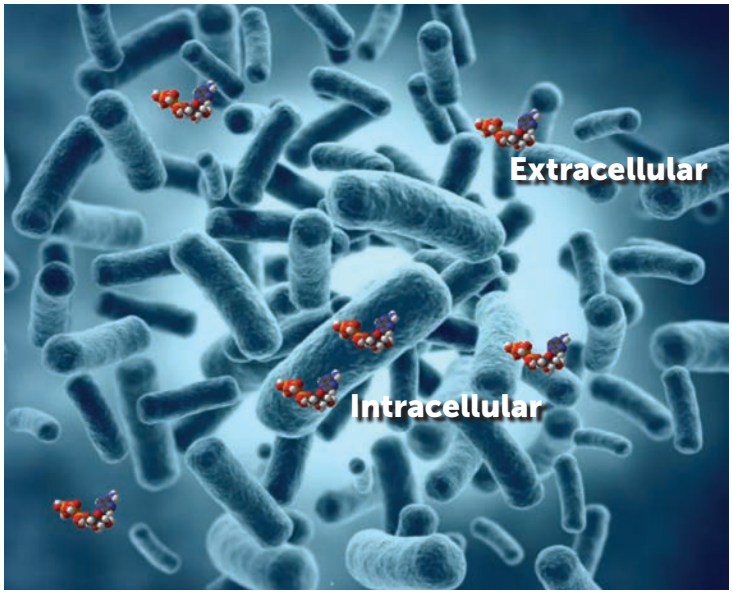
- Online monitoring of free ATP across the RO system yields a higher LRV than the traditional surrogates TOC and electrical conductivity.
- Improved monitoring of RO integrity may allow greater pathogen log reduction regulatory credits (LRV).
- Higher LRV increases confidence, from both the industry and public, in RO's ability to remove high levels of pathogens.
- The self-cleaning routine of the analyzer ensures that sample carryover and instrument contamination does not occur.

EZ7300 ATP Analyzer installed

This study demonstrated that Adenosine Triphosphate (ATP) is continuously present in treated wastewater, as a naturally occurring compound of biological origin. It is present in high concentration in the RO feed and in measurable concentrations in RO permeate; this combined with its high removal by RO makes free ATP an excellent candidate for LRV demonstration. Free ATP concentrations in the RO feed and permeate can be successfully and continuously monitored by the EZ7300 online analyzer.

The study demonstrates that ATP removal by RO exceeds typical LRVs achieved by monitoring of TOC or conductivity, making it a promising alternative surrogate for virus rejection. The Hach EZ7300 ATP Analyzer has proven to effectively monitor biological activity in biofiltration and disinfection applications and has now proven to be effective for continuous online monitoring of free ATP in RO feed and RO permeate streams. This monitoring provides data to calculate log removal values and demonstrates that ATP can be an effective surrogate to monitor RO membrane integrity in water reuse.

Why measure different forms of ATP?



The addition of oxidants or biocides during the disinfection process damages the cells, resulting in ATP being released. The proprietary sample pretreatment of the ATP analyzer makes a differentiation between living and dead organisms possible.

- Extracellular ATP (Free ATP) is the portion of ATP released by dead cells
- Total ATP is obtained after lysis of the biomass by sonication of the sample
- Intracellular ATP is the portion of ATP from the metabolically active (living) organisms

Intracellular ATP = Total ATP – Extracellular ATP

As demonstrated in this case study, Free ATP can be used in reverse osmosis (RO) applications to monitor contaminant removal.

DOC043.53.30659.Oct21

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