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Oxidation Reduction Potential: Understanding a Challenging Measurement

Melissa Voronin, Hach Company

Sand Creek Water Reuse Facility tests HQd digital meter and IntelliCAL™ ORP Probe.

Introduction

For more than 30 years, Aurora, Colorado's Sand Creek Water Reuse Facility (SCWRF) has treated a portion of the 30 MGD of wastewater the city produces every day. Using a Modified Johannesburg Process Biological Nutrient Removal (BNR) system to reduce ammonia and phosphorous, the award-winning plant currently treats 5 MGD, bringing ammonia from 30 mg/L down to less than 0.1 mg/L, and brings phosphorous from 6 mg/L down to 0.05 mg/L at the effluent.

In the spring and summer, reclaimed wastewater is moved through 16 miles of pipe to irrigate 12 sites and more than 800 acres of golf courses, parks, soccer fields and other greenbelt areas. In winter, or during unusually wet summers like 2009 brought to this semi-arid climate, any excess water is discharged into Sand Creek.

A long-term Hach customer, the city recently did a study using the Hach HQd digital meter and IntelliCAL ORP (Redox) probe. SCWRF Interim Chief Plant Operator Leah O'Connor undertook a test of the probe for Hach, while working to learn more about how oxidation reduction potential (ORP) measurement can help improve process efficiency.

What is ORP?

Oxidation Reduction Potential (ORP or Redox Potential) measures an aqueous system's capacity to either release or accept electrons from chemical reactions. When a system tends to accept electrons, it is an oxidizing system. When it tends to release electrons, it is a reducing system. A system's reduction potential may change upon introduction of a new species or when the concentration of an existing species changes.

ORP values are used much like pH values to determine water quality. Just as pH values indicate a system's relative state for receiving or donating hydrogen ions, ORP values characterize a system's relative state for gaining or losing electrons. ORP values are affected by all oxidizing and reducing agents, not just acids and bases that influence pH measurement.

From a water treatment perspective, ORP measurements are used often to control disinfection with chlorine or chlorine dioxide in cooling towers, swimming pools, potable water supplies, and other water analysis applications. For example, studies have shown that the life span of bacteria in water is strongly dependent on the ORP value. In wastewater, ORP measurement is used frequently to control treatment processes that employ biological treatment solutions for removing contaminants.

ORP sensor operation works similarly to that of a standard pH sensor. A two-electrode system makes a potentiometric measurement. The ORP electrode serves as an electron donor or electron acceptor, depending upon the test solution. A reference electrode supplies a constant stable output for comparison. Electrical contact is made with the solution using a saturated potassium chloride (KCl) solution. Platinum is normally used as an indicating sensor and the potential is measured against a reference electrode, usually Ag/AgCl.

ORP Summary

Once understood, Oxidation Reduction Potential can be quite beneficial in the operation of a BNR system. As with any control parameter, it is necessary to ensure the sample is representative of the larger system, that the method is reliable, and of course reproducible. Combined with other testing to confirm the site-specific conditions, ORP can be a simple and cost effective solution for process control and optimization.

While there are many different processes to accomplish removal of nutrients in wastewater, the same basics apply to BNR systems. All consist of an anaerobic zone, anoxic zone, and aerobic zone, typically accomplishing similar functions between systems. Knowing how these zones affect the bacteria and how ORP relates to the environment of each zone allows for the instrumentation professional to make application recommendations with ease.

SCWRF's ORP Experience

A prior brief study using a competitive ORP measurement product did not yield useful data. "The numbers were all over the place," said O'Connor, "so it did not prove to be a valuable tool for us."

After using it, she preferred the Hach IntelliCAL ORP probe. "It was more rugged, easier to calibrate, and I felt more confident in the results," she noted. She appreciated that the Hach probe tells you when the measurement is complete by locking in an ORP value, while the competitor's product did not.

O'Connor reports that the study gave them a better correlation of what they want to have at the plant when it comes to employing ORP measurement as part of their process control approach. Given how effective the SCWRF BNR system has proven to be, consistently meeting all discharge specifications without the use of any chemicals, process control is critical. O'Connor's entire plant relies on the careful balance of the system's biology, and using an ORP monitor can help operators understand what is going on in different treatment zones.

Without ORP data from the BNR, O'Connor and her team run the plant conservatively, returning more mixed liquor to the process, and sacrificing optimal plant efficiency in exchange for knowing the system is always in balance. Once ORP is incorporated into their plant management process to monitor the anoxic, anaerobic and aerobic zones, O'Connor expects to significantly improve efficiency.

"If we have more information on what's going on in the different zones, we have the capability to optimize our treatment process," said O'Connor. "Which, in turn, can optimize our reuse flow, thereby generating more revenue."

Award-winning Sand Creek Water Reuse Facility in Aurora, Colorado treats 5 MGD utilizing a Biological Nutrient Removal (BNR) system. Their effluent has ammonia less than 0.1 mg/L and phosphorous at 0.05 mg/L. (Photos courtesy of Sand Creek Water Reuse Facility.)

Hach ORP Probe Details

The Hach HQd digital meters and IntelliCAL ORP-Redox Probes (both standard and rugged models) provide a rugged design and easy-to-clean sensor, along with the unique calibration feature of two available factory standards plus a custom standard option, providing confidence in results since the user can calibrate the probe regularly against a known standard.

The polished platinum disk sensor is easy to clean and maintain, providing optimal performance. It can also be used as part of a multi-probe deployment with LDO (Luminescent Dissolved Oxygen) for nitrification/denitrification control, bringing portable process control to emerging treatment processes. Because ORP readings are temperature dependent, the probes also measure temperature, and these smart digital probes store calibration information and serial numbers.

About the Author: Melissa Voronin (MBA, Marketing, University of North Carolina at Charlotte; B.S., Industrial Engineering, Clemson University) specializes in Municipal Wastewater applications. She currently holds a position with Hach Company as a Vertical Market Manager with emphasis on process optimization through the use of instrumentation.

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Lit. No. 2075
J9 Printed in U.S.A.