

DO vs. ORP: Choosing the Right Measurement for Your Application

In wastewater treatment, monitoring and controlling biochemical reactions is crucial for effectively achieving desired outcomes, particularly in biological nutrient removal (BNR) and odor control applications. This brief compares the advantages and limitations of Dissolved Oxygen (DO) and Oxidation Reduction Potential (ORP) in wastewater treatment, particularly in relation to BNR and odor control applications.

Background on Control in Wastewater Treatment

Wastewater treatment facilities are tasked with the removal of contaminants to protect public health and the environment. Traditionally, Dissolved Oxygen (DO) has been the primary parameter for monitoring and controlling aerobic and anoxic processes. However, Oxidation Reduction Potential (ORP) offers a broader scope of measurement, providing insights into the oxidation and reduction states within the treatment system. This paper investigates the nuances of using ORP versus DO, providing insights into their respective applications in wastewater treatment.

The Role of DO in Wastewater Treatment

DO is a measure of the amount of oxygen dissolved in water and is crucial for aerobic biological processes, such as cBOD removal and nitrification. DO levels are typically maintained between 1-2 mg/L for effective treatment. However, DO measurements provide limited information about anoxic and anaerobic conditions where oxygen is not present but other electron acceptors are in use.

The Role of ORP in Wastewater Treatment

ORP measures the overall electron activity in the solution and thus provides a composite picture of aerobic, anoxic, and anaerobic processes. For example, ORP can help detect conditions favoring sulfide formation or methane production, which are critical for odor control. ORP offers a more nuanced understanding of the biochemical environment, facilitating better control of the treatment process.



Handheld ORP Meter
Photo courtesy of Lovibond

ORP Overview

When used in wastewater treatment systems, oxidation-reduction potential is a measurement of the ability or potential of wastewater to permit the occurrence of specific biological (oxidation-reduction) reactions. Important oxidation-reduction reactions in wastewater treatment systems include the removal of cBOD (carbon- and hydrogen-containing compounds), nitrification, denitrification, biological phosphorus removal, and biological malodor production. These reactions involve carbon (C), phosphorus (P), sulfur (S), and nitrogen (N) and their change from oxidized states (containing oxygen) such as nitrate (NO_3^-) and sulfate (SO_4^{2-}) and reduced states (containing hydrogen) such as ammonia (NH_3) and sulfides (H_2S).

ORP is measured in millivolts (mV) and on the ORP scale, the presence of an oxidizing agent such as oxygen increases the ORP value, while the presence of a reducing agent such as substrate or cBOD decreases the ORP value. By monitoring the ORP of wastewater, an operator can determine what biological reaction is occurring and if operational conditions should be changed to promote or prevent that reaction.

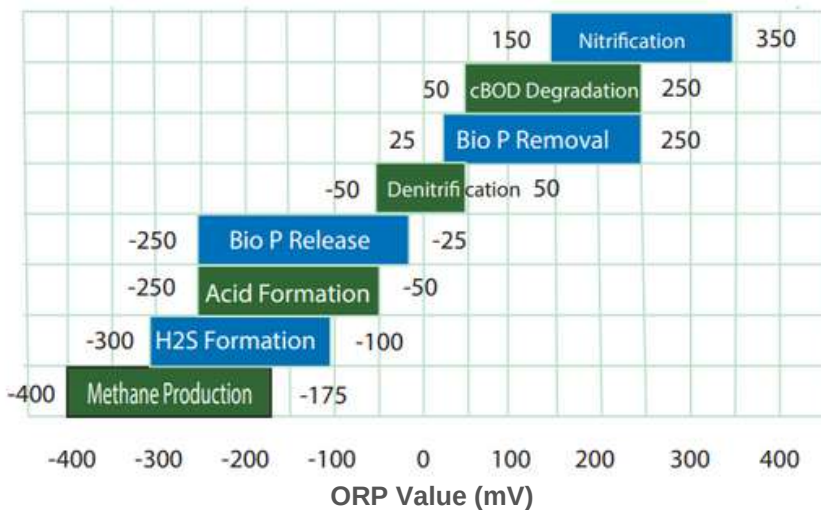
Biochemical Reactions and ORP Ranges

Understanding the biochemical reactions and their corresponding ORP values is essential for applying ORP measurements effectively.

The tables to the right and below outline key reactions and their typical ORP range.

Biochemical Reaction	ORP (mV) Range
cBOD Degradation with Free Molecular Oxygen	+50 to +250
Nitrification	+100 to +350
Denitrification	-50 to +50
Biological Phosphorus Removal	+25 to +250
Biological Phosphorus Release	-250 to -10
Sulfide (H_2S) Formation	-250 to -50
Acid Formation (Fermentation)	-300 to -100
Methane Production	-400 to -175

Typical ORP Ranges by Biochemical Reaction



Key Oxidation-Reduction Reactions

- **cBOD Degradation:** cBOD is a measure of the amount of oxygen required to biologically oxidize organic carbon compounds. Effective cBOD degradation occurs under aerobic conditions with ORP values ranging from +50 to +250 mV. The presence of free molecular oxygen accelerates the degradation process.
- **Nitrification:** Nitrification is the biological oxidation of ammonia (NH_3) to nitrate (NO_3^-) via nitrite (NO_2^-). The process is carried out by nitrifying bacteria in the presence of oxygen. For effective nitrification, ORP values need to be within the range of +100 to +350 mV. DO levels should be maintained above 1 mg/L to ensure enough dissolved oxygen is present.
- **Denitrification:** Denitrification is the reduction of nitrate (NO_3^-) to gaseous nitrogen (N_2) and occurs under anoxic conditions. An ORP range of -50 to +50 mV is indicative of an effective denitrification environment. For example, if an operator doesn't want denitrification or "clumping" to occur in a secondary clarifier; the operator must maintain an ORP value above +50 mV.
- **Biological Phosphorus Removal:** Biological phosphorus removal involves the uptake of phosphorus by bacteria, which is later removed in sludge. This process occurs under alternating anaerobic and aerobic conditions. ORP values between +25 to +250 mV support phosphorus uptake, while release occurs between -250 to -10 mV. Traditional DO measurements are less effective in monitoring this process.
- **Sulfide Formation:** Sulfide formation from sulfate (SO_4^{2-}) reduction happens under anaerobic conditions. ORP values between -250 to -50 mV indicate sulfide formation environments. For effective odor control and avoidance of malodor production in the sewer system, the operator must typically maintain an ORP value of more than -100 mV to prevent sulfide formation, in practice.

Comparison of DO and ORP in Various Applications

	Dissolved Oxygen (DO)	Oxidation Reduction Potential (ORP)
BOD Oxidation/ Degradation	Operators historically target DO levels of 2 mg/L where cBOD oxidation is desired; however, cBOD oxidation can occur without a measurable DO.	Utilizing ORP in combination with DO can provide greater insight to cBOD removal, allowing further reduction of energy costs by minimizing the residual (excess) DO provided to the process.
Nitrification and Denitrification	Effective nitrification requires DO levels above 1 mg/L. However, denitrification cannot be directly monitored using DO, as it occurs in anoxic conditions.	Effective nitrification and denitrification can be monitored using ORP ranges. Nitrification occurs at ORP values between +100 and +350 mV, while denitrification ranges from -50 to +50 mV.
Biological Phosphorus Removal	Effective phosphorus removal typically requires DO levels above 1 mg/L. Limited use in directly monitoring phosphorus release, as it often occurs under anaerobic conditions.	Provides better oversight, with phosphorus uptake occurring between +25 and +250 mV and release between -250 to -10 mV.
Sulfide and Methane Formation	Cannot detect anaerobic conditions directly associated with greenhouse gas emissions (methane) and odor production (sulfide).	Can help in maintaining conditions to prevent sulfide (-250 to -50 mV) and methane production (-400 to -175 mV), addressing odor issues more effectively. Tight control of ORP at approximately -225 mV in anaerobic digesters has been shown to produce a much cleaner biofuel.

While DO measurements have been a cornerstone in traditional wastewater treatment, ORP provides a broader, more comprehensive metric that encompasses aerobic, anoxic, and anaerobic conditions. Using ORP alongside DO can enhance the control and efficiency of wastewater treatment processes, particularly in BNR and odor control applications. Facilities adopting ORP measurement can achieve better oversight, ultimately leading to improved process control and environmental compliance.

Contact Fuel Tech to learn more about using ORP to optimize your wastewater treatment process.




Fuel Tech develops and commercializes state-of-the-art proprietary technologies for air pollution control, process optimization, water treatment, and advanced engineering services. These technologies enable customers to operate in a cost-effective and environmentally sustainable manner.

info@ftek.com 

+630.845.4500 

 www.ftek.com

 27601 Bella Vista Parkway
Warrenville, IL 60555