OPERATOR **ESSENTIALS**

What every operator should know about nitrification

Woodie Mark Muirhead

Knowledge	Principle	A practical consideration
Definition	**Nitrification is the oxidation of ammonia to nitrate by two separate groups of organisms.** **Ammonia-oxidizing bacteria (AOB) oxidize ammonia to nitrite.** $NH_4^+ + 1.5\ O_2 \rightarrow 2H^+ + H_2O + NO_2^-$ **Nitrite-oxidizing bacteria (NOB) oxidize nitrite to nitrate.** $NO_2^- + 0.5\ O_2 \rightarrow NO_3^-$	**Nitrosomonas and Nitrobacter historically have been associated (including certification exams) with the oxidation of ammonia to nitrite and the oxidation of nitrite to nitrate, respectively. Now, it is known that more genera of nitrifying organisms are involved and the terms used are ammonia-oxidizing bacteria and nitrite-oxidizing bacteria.**
Environmental need	**Ammonia can be toxic and also create oxygen deficiency in receiving waters.** **Nitrite and nitrate in drinking water can affect health.** **All forms of inorganic nitrogen can serve as nutrients for undesirable biological growth, such as algal blooms.**	**It is important to understand the basis for effluent ammonia (and other nitrogen) limits, because other parameters in effluent and receiving water (e.g., pH for ammonia toxicity) can be critical for compliance.**
Respiration	**Nitrifying organisms are obligate aerobes that require oxygen for metabolism. Approximately 4.6 mg/L of oxygen is required to oxidize 1.0 mg/L of ammonia–nitrogen to nitrate–nitrogen.**	**The oxygen demand of 22 mg/L ammonia–nitrogen is equal to approximately 100 mg/L of carbonaceous biochemical oxygen demand (cBOD).** **Nitrification requires significant energy commitments associated with aeration (e.g., blowers) for suspended growth systems.**
Energy source	**Nitrifying organisms are autotrophic. They use inorganic compounds as an energy source. AOB use ammonia (NH4+), and NOB use nitrite (NO2–).**	**Nitrifying organisms do not need or use organic carbon — cBOD substances — for metabolism.** **Post-secondary nitrification processes (which follow cBOD removal) can be used to accomplish nitrification.**
Alkalinity	**The oxidation of 1 mg/L ammonia–nitrogen to nitrite–nitrogen consumes 7.12 mg/L of alkalinity.** **The alkalinity is consumed during nitrification almost exclusively by the AOB.**	**If wastewater alkalinity is not sufficient to support full nitrification and other alkalinity-consuming processes, pH depression can occur and result in a permit violation and even inhibition of NOB, which results in an accumulation of nitrite.**

Growth rate	**Nitrifying organisms are slow-growing, and their growth rate increases and decreases with wastewater temperature.**	**The solids retention time (SRT) needed for nitrification is higher than needed for cBOD removal and is critical to ensure that a sufficient population of nitrifying organisms can be established.** **Though environmental conditions influence the required SRT, an approximate SRT of 7 days is needed at 15°C. An SRT of 2 days is needed at 26°C.**
Suspended and fixed-film systems	**Nitrifying organisms are not floc formers. They consequently depend on being "trapped" in heterotrophic floc to prevent being washed out of suspended growth systems. However, they are able to attach to fixed media effectively.**	**Experience has shown that nitrifying organisms can attach and grow in effluent sample lines. Then the organisms slough off and seed the effluent samples. This contamination can accelerate nitrification in the biochemical oxygen demand (BOD) test and result in higher than normal BOD results. Routine sample line cleaning or replacement can prevent this.**
Inhibition	**Nitrifying organisms are more sensitive to changes in environmental conditions (e.g., temperature, pH, dissolved oxygen) than heterotrophic organisms.** **NOB are more sensitive to these conditions than AOB.** **NOB grow faster than AOB under environmental conditions typically found in domestic wastewater and oxidize nitrite as soon as it is produced by AOB.**	**When NOB are inhibited, increased concentrations of nitrite can occur in secondary effluent.** **Nitrite–nitrogen reacts with chlorine in a 5:1 ratio. So, elevated nitrite can suddenly increase chlorine demand to a level that hinders proper disinfection.**

Woodie Mark Muirhead is a vice president and operations specialist in the Honolulu office of Brown and Caldwell (Walnut Creek, Calif.).

©2012 Water Environment Federation. All rights reserved.