# Nebraska News

## Solving Nitrate Problems at the Plant Level

**by Ben Day/Olsson Associates and Bruce Dvorak/UNL**

In our previous article ("The trouble with nitrates," Spring 2011 *Wise Water Words*), we described the sources of nitrate contamination in drinking water sources. These generally include runoff from agricultural and household sources, wastewater (especially from septic systems), and natural sources like leaching from legumes and lightning. Unfortunately, nitrate mitigation at the source isn't always possible, and some community water systems must react in order to protect public health. When a community is faced with nitrate issues, a few options are available:

- Drilling new wells or finding new sources of water
- Implementing wellhead protection programs
- Blending water from wells with lower nitrate levels
- Connecting with another public water system
- Building or modifying a treatment plant specifically to address nitrates

When feasible, finding new sources is usually the most economical long-term option. Unfortunately, nearby water sources are often contaminated with nitrates as well. In some cases, blending water from high-nitrate sources with water from lower-nitrate sources can result in a satisfactory dilution of nitrates. This may require connecting with another public water system — and in some cases, such connections are the only economical solution. Neighboring communities and rural water systems may be used to provide either a partial supply (for blending) or a complete replacement for a community that finds itself with no other options.

When other nearby sources are similarly high in nitrates, or when the cost of pumping from other public water systems is too high, several treatment options for nitrate removal are available, including ion exchange, reverse osmosis, and electrodialysis reversal.

**An ion exchange (IX) process** exchanges nitrate ions with anions (atoms or molecules with a net negative charge) from an ion-exchange resin. Sodium chloride can be used for this purpose, in which case the nitrates are replaced with chlorides. This ion-exchange process also softens the water by replacing calcium with sodium. The anion exchange process for nitrate removal is similar to the cation exchange routinely used in household water softeners to remove hardness.

**In reverse osmosis (RO),** pressure is applied to the water on one side of a permeable membrane, causing it to overcome osmotic pressure. The water crossing the membrane (called permeate) is nitrate-free and can be used as potable water, but typically requires pH adjustment, blending, disinfection, and other treatment prior to entering the distribution system. Nitrates and other contaminants remain on the other side of the membrane in a brine solution and are disposed of as waste.

**In the process of electrodialysis reversal (EDR),** water goes through a vertical stack of membranes with electrodes on the top and bottom of the stack. The membranes are coated with ion-exchange resins, and a direct current is applied across the stack. This causes cations to pass through the cation membranes into concentrate spacers, while anions pass through anion membranes into different concentrate spacers. The desalinated water stays in the feed spacer, and the salted water in the concentrate spacers is disposed of. To offset the potential for scaling on the membranes, the polarity is reversed several times per hour, causing the feed spacers to become concentrate spacers and vice versa.

Because each of these processes is costly, water that has been treated for nitrates is often blended with non-treated water to lower the overall concentration of nitrates to acceptable levels at a reasonable cost. A major add-on cost, though, is that any water treated for nitrates must also then be disinfected. This can not only raise the expense of water treatment, but also change the scent and taste of a community's water.

The main technical challenge accompanying these treatment options is the disposal of the waste streams. Waste may be discharged to nearby stream, but that requires a NPDES permit. Discharging to the sanitary sewer may have less of a direct environmental impact, but it may cause problems for the wastewater treatment facility receiving the sewage. Evaporation basins may also be used, but those may require a lot of land.

Other issues may arise in connection with treatment, as well. Treatment for nitrates may not be optimal for other contaminants that may also be present, like arsenic and uranium. And any kind of treatment change could have unintended consequences, like changing the basic chemistry of the treated water—creating the need, for instance, to add corrosion inhibitors such as phosphates.

Dealing with nitrates in drinking water can be a complex issue, involving engineering, environmental and economic factors that may be in competition with one another. The appropriate treatment option must be evaluated and selected by not only considering the up-front capital costs, but also the long-term costs. Operation and maintenance costs such as labor, power and chemical usage, equipment replacement and waste-disposal expenses must be considered in addition to the capital expense and the financing costs of borrowed money.

An effective nitrate-mitigation solution for a public water system should consider all of the available alternatives (including both alternative sources and direct treatment), each compared against the others on at least a 20-year life cycle. These costs, adjusted for their net present worth, offer a reasonable picture of what the community will really have to pay over the life of the system in order to get a consistent and safe supply of usable drinking water.