



Nebraska irrigation well survey: Nutrient supply and liming effects

By Matthew Ernst

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Sampling an irrigation well. Photo by Daryl Anderson, Lower Platte North Natural Resources District.

A comprehensive survey of Nebraska's irrigation wells in 2020 yielded extensive georeferenced water quality data, including essential nutrient supplies and liming effects. These data show irrigation well water properties may vary greatly, even between nearby wells, indicating that occasional sampling of individual irrigation wells can help producers optimize soil management and crop input decisions.

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Well-Specific Analysis

The database includes 642 irrigation wells in Nebraska and reports 24 water properties according to 11 aquifer-geology-depth categories. The results were published in a recent article in *Agrosystems, Geosciences & Environment*, which is available at <https://doi.org/10.1002/agg2.20137>.

The survey involved collaboration between the University of Nebraska-Lincoln (UNL), Nebraska's 23 Natural Resources Districts, and the Nebraska Department of Environment and Energy. Additional research results, detailed by the Natural

Resources Districts, are in the downloadable UNL Extension publication EC3052, *Irrigation Well Water in Nebraska* (<https://bit.ly/36OchR0>).

The database shows some substantial differences in water properties. “The variability we observed in water properties, even between wells at short distances from each other, implies each individual well or each group of similar wells should be sampled,” says study author Charles Wortmann, UNL professor of agronomy.

That variability underscores the importance of conducting an individual well water analysis, “maybe once every 10 to 20 years,” Wortmann says. “I’ve suggested you only have to sample wells once every 15 years, making it a very low-cost thing,” he says.

A water analysis with all the essential nutrients runs around \$55 in Nebraska. That results in an annual water analysis cost less than a nickel per acre (in today’s dollars) for a well supplying a 130-ac center pivot. The cost may actually be much less: A water analysis excluding some micronutrients may cost around half of the \$55 price.

Looking at Lime, Sulfur, Potassium

Although water properties can vary widely between wells, some of the statewide water property data point toward some general applications for irrigated agriculture. Three examples of these are lime, sulfur, and potassium.

More than 70% of the wells tested supplied 340 lb of agricultural lime equivalent in 10 acre-inches of water, the amount needed to neutralize acidification from 200 lb of



Water samples from Nebraska wells were analyzed by Ward Laboratories and showed that water properties vary widely between wells. Photos by Hannah Dorn of Ward Laboratories.

fertilizer N. The conclusion, says Wortmann, is that liming may not be required for land irrigated by those wells.

Well depth, location, and geology will impact the liming effect. "One producer I've heard from said he never sees liming impact from irrigation," Wortmann says. "It's possible that is true for a given well because there's variation between wells, as our results show. But generally speaking, far more liming effect is being put on by the wells surveyed than is needed to prevent acidification."

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Lime supply was relatively low from wells in Nebraska's Sandhills. Wells in the Sandhills and in eastern Nebraska also showed lower potassium levels. "It was a bit of a surprise that potassium levels were so low in eastern Nebraska compared with other areas," Wortmann says. He attributes that to older geological formations in eastern Nebraska.

That contrasts with the Ogallala, the state's dominant geological formation, formed from outwash when the Rocky Mountains were uplifted. "There's far more potential for higher nutrient concentrations in sandy loam or sandier soils for alluvial wells of less than 100 ft deep than for deeper wells in the Ogallala formation of the High Plains aquifer," Wortmann says. For example, potassium levels were higher in wells less than

100 ft deep than in deeper wells in the High Plains Ogallala aquifer.

The sulfur level in most of the surveyed wells exceeded removal by 200-bu corn yields. Wortmann says that's significant; the UNL recommendations for irrigated corn production advise producers to specifically consider irrigation well water sulfur content. "By being able to map it out, especially for sulfur, a producer can better see the places where fertilizer sulfur may be needed," he says. He adds that in Nebraska it is important for nutrients supplied in irrigation to be in synchrony with crop demand, resulting in better nutrient recovery than that from pre-plant fertilizer applications. "This is especially true for available nutrients that occur in the soil as easily leached anions such as for sulfur, chloride, and boron."

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Taking a closer look at potential contributions from irrigation water could save producers future fertilizer and lime costs. "We shouldn't assume we need to apply sulfur, calcium, magnesium, chloride, and lime—especially if those soil tests are not

changing over time on land irrigated from well water that may be delivering those nutrients to the soil," Wortmann says. "If you're finding that the soil test results aren't shifting, and you're wondering why, look at the water results and maybe that will explain things."

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Secondary and Micronutrients

The study also showed calcium, magnesium, and chloride applied in irrigation exceed 200-lb removal, for most wells. More than 15% of wells supplied potassium, boron, manganese, and molybdenum in excess of corn grain removal.

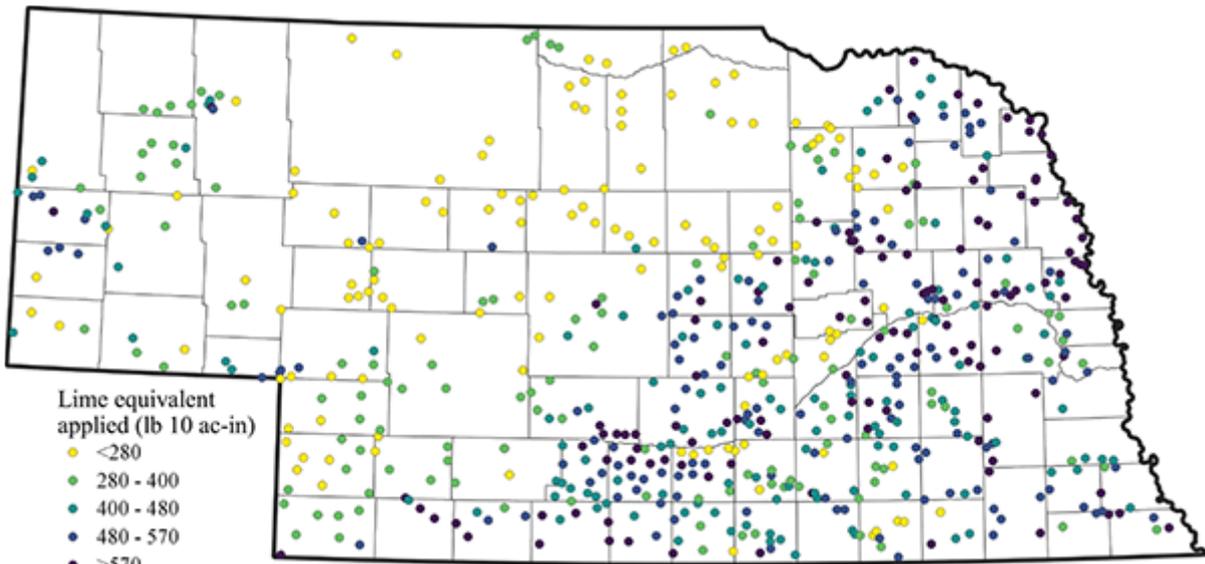
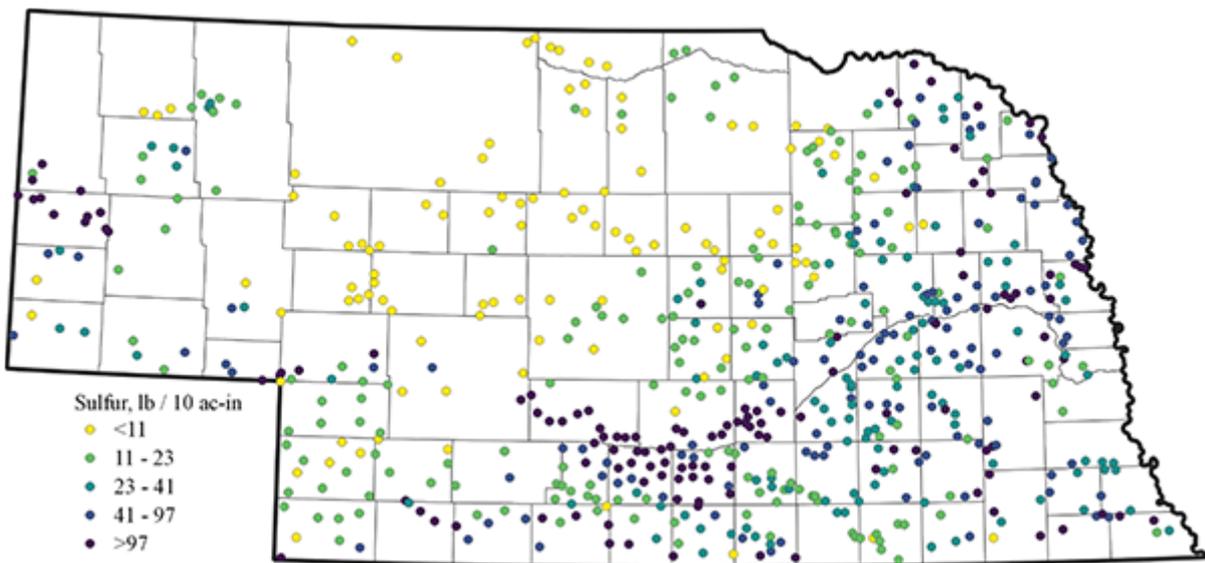


Illustration shows the agricultural lime equivalent applied in 10 acre-inches of irrigation well water in Nebraska. For comparison, it takes about 340 lb of agricultural lime to neutralize the acidification effect of 20 lb of fertilizer nitrogen.



Sulfur applied in well irrigation water (lb/10 acre-inches). For comparison, about 13.6 lb S are removed in the harvest of 200 bu of corn grain.

Chloride applied in 1 acre-inch exceeded 1 lb/ac in 63% of the wells. Chloride supply in 10 acre-inches exceeded removal in a 200-bu corn harvest for all wells.

But levels may vary from site to site. “Crops irrigated from deep wells in the Ogallala will actually get chloride applications in Kansas,” says Dorivar Ruiz Diaz, Kansas State University soil fertility specialist, who was not involved in the Nebraska study.

Chloride easily leaches, and low chloride availability is most likely to occur with rainfed cropland in sub-humid and humid areas where there is little or no recent history of potassium chloride or manure application. “Even if nutrients from the irrigation water do not exceed crop supply, the water is helping maintain nutrient availability. It may be reducing the need for fertilizer or putting off further into the future when nutrients may be needed,” Wortmann says.

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Nitrates

The survey data also showed variability in nitrate levels. “High nitrate levels in groundwater is a major human and livestock health concern in Nebraska while irrigation

supply reduces the required rates for fertilizer nitrogen,” Wortmann says.

Wortmann reports that wells less than 100 ft deep in the High Plains aquifer generally had a much higher concentration of nitrate than was found in deep wells in other aquifers. The median level of nitrate–nitrogen was 4.4 ppm; but 25% of surveyed wells had nitrate–nitrogen levels above 10 ppm, the safety limit for human consumption.

Nitrate levels in Nebraska irrigation wells can vary substantially, even between nearby wells. That is also the case in Kansas. “We just don’t see a widespread situation in Kansas where you are getting (significant) nitrate from irrigation water,” says Ruiz Diaz. “But this spring, I was looking at one situation in south–central Kansas where a producer was looking at water analysis from wells just a few miles apart. The nitrate levels were completely different, and we were helping him consider whether in some cases, he could cut back on nitrogen applications because of nitrates available in the irrigation water,” Ruiz Diaz says.

Higher nitrate levels, of course, are more common in shallower wells and aquifers. “Every well is going to be different, and these shallow aquifers vary a lot,” says Ruiz Diaz. “I couldn’t agree more that you have to consider every situation uniquely: Get the water analysis for each well, and see what that irrigation situation will require.”

Key takeaways from the study

- Nutrients supplied by applying 10 acre–inches or more exceeded those removed in 200 bu of corn grain harvest for: 100% of the wells for calcium, magnesium, and chloride; 72% of the wells for sulfur; more than 15% of the wells for boron, potassium, manganese, and molybdenum; and for no or very few wells for

phosphorus, zinc, copper, and iron.

- The liming effect of 10 acre-inches exceeded the soil acidification by 200 lb of fertilizer nitrogen for 70% of wells and greater than 90% of the wells outside the Sandhills.
- The median level of nitrate-nitrogen was 4.4 ppm, but 25% of the wells had >10 ppm (the safety limit for human consumption). This nitrogen supply often substitutes for significant fertilizer nitrogen need.
- Nutrient and lime supply is relatively low for wells in the Sandhills and often relatively high for wells in river valleys of <100 ft depth;
- Water properties vary widely between wells, and an infrequent sampling of the water is needed for full optimization of nutrient and soil management.
- Information on nutrients supplied through irrigation should be complemented by regular soil testing and the use of the recommended nutrient management guidelines.

Update Your Data

The Nebraska study underscores the need for producers and CCAs to have the highest quality data possible when making input decisions. With commodity price trends pointing to higher crop profits, producers may be more willing to invest in updated water analysis and consider those results in fertilizer and lime application decisions. Investment in updated irrigation well sampling during years of higher commodity prices could pay off in future years when profitability margins are tighter.

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