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A Pivotal New Method for Predicting Concentrations of Redox Sensitive Elements in Agricultural Aquifers

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Degradation of water quality from anthropogenic and geogenic contaminants is common in agricultural areas. The occurrence and groundwater mobility of some contaminants, including nitrate, uranium, arsenic, and manganese, are strongly impacted by oxidation-reduction (redox) processes. However, groundwater redox is difficult to determine from the surface and generally requires time-sensitive geochemical analyses. A previous study [1] demonstrated that elevated groundwater nitrate concentrations could be qualitatively estimated by looking at the presence or absence of rust on irrigation center pivots. The 'rust' is a coating of Fe-oxides formed by spraying Fe-rich groundwater on the surface of pivot. Thus, the pivot rust could be a qualitative indicator of reducing conditions where Fe is soluble in groundwater without directly sampling. To expand on this concept, redox sensitive elements (nitrate, arsenic, uranium, iron, and manganese) were measured in groundwater samples taken from irrigation wells associated with 25 pivots (15 rusted and 10 non-rusted) in Central Nebraska. Significantly higher ($p<0.05$) concentrations of iron and manganese and statistically lower concentrations of nitrate and uranium were associated with rusted vs non-rusted pivots, thus demonstrating the link between pivot rust and redox sensitive elements in groundwater. There was no statistically significant relationship between arsenic and pivot rust, indicating that another process must be controlling groundwater arsenic mobility in this area. There was a geologic influence on the distribution of rusted pivots in the study area with most (12/15) occurring along the eastern boundary of the Ogallala group. Overall, this research highlights the utility of pivot rust as a rapid, non-invasive indicator for redox sensitive elements in agricultural aquifers. Future work will focus on creating models that predict spatial groundwater redox trends based on the presence/absence of rust on irrigation center pivots. In addition, determining the geologic and geophysical signatures associated with pivot rust and groundwater redox state could allow this framework to be applied to flood irrigated or dryland systems.

[1] Cherry, Gilmore, Messer, Li, & Westrop (2022). *ACS ES&T Water*, 2(12), 2297-2304.