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Nitrate in shallow groundwater at CFOs in south and central Alberta

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Summary

A field research project was conducted from 2009 to 2015 to better understand the effects of manure management activities on groundwater quality in Alberta. As a part of this project, five confined feeding operations (CFOs) were selected to assess the controlling processes on the fate and transport of manure constituents in shallow groundwater: three in central Alberta and two in southern Alberta. Nitrate-nitrogen (NO_3-N) and chloride (not discussed here) were used as primary indicators groundwater contamination by manure. Effects of manure storage (e.g., earthen manure storages, temporary manure stockpiles) on groundwater quality appeared to be localized (i.e., within 100 m of the source) and relatively shallow (i.e., less than 15 m below the ground surface).

Method

One-hundred and three groundwater monitoring wells were installed at five confined feeding operations (CFOs) (Figure 1), and more than 1,500 groundwater samples were collected from 2009 to 2015. The primary objective was to assess potential effects of manure storage facilities, e.g., earthen manure storages (EMSs), catch basins, and pens, on groundwater quality (Lorenz et al. 2014, Bourke et al. 2019). Two CFO sites were in southern Alberta: one a combined dairy and beef feedlot, with an EMS, catch basin, and pens (CFO-1) and one a beef feedlot, with catch basins and pens (CFO-2). Three CFO sites were in central Alberta, all of which were dairy operations and each with an EMS. Sites were selected to represent typical hydrogeological conditions in Alberta; one characterized by permeable (sandy) soil (CFO-1), two characterized by thin till over shallow permeable bedrock (CFO-3 and -4), and one characterized by thick clay till (CFO-5). Monitoring wells, which included water-table wells and piezometers, were installed up and down gradient of the CFOs and up and down gradient of manure storage facilities (e.g., the EMSs). Well depths ranged from 6 to 34 m below ground surface. Water samples were collected and analyzed for NO_3-N concentrations, as well as other water quality parameters (not discussed here), and water levels were measured. Generally, NO_3-N concentrations greater than 3 mg L^{-1} are commonly associated with anthropogenic sources, such as livestock (Madison and Burnett 1985, Rodvang et al. 2002, Forrest et al. 2006).

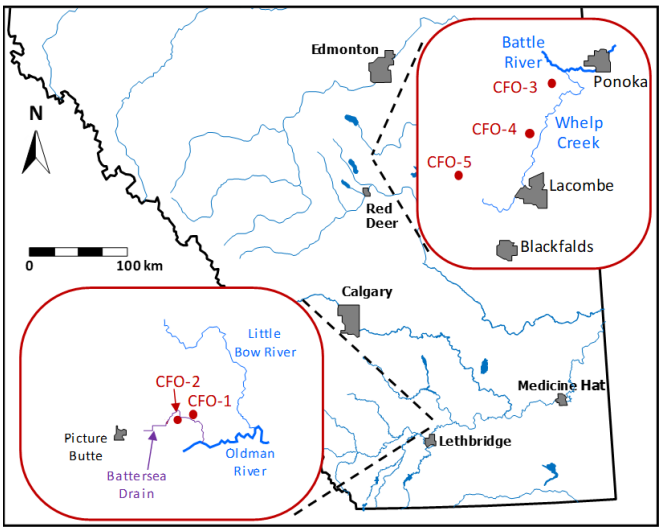

Figure 1 Location of the confined feeding operations in southern and central Alberta.

Results

Concentrations of NO_3-N ranged from 0.05 mg L^{-1} at all sites to a maximum of 31 mg L^{-1} at CFO-1, 156 mg L^{-1} at CFO-2, 152 mg L^{-1} at CFO-3, 80 mg L^{-1} at CFO-4, and 26 mg L^{-1} at CFO-5. Elevated concentrations of nitrogen species (primarily NO_3-N) were observed in wells surrounding EMSs, indicating a negative effect from liquid manure storages on shallow groundwater quality. While manure seals can form under feedlot pens, as well as EMSs, and can result in relatively low hydraulic conductivity in soil beneath pens, this does not act as an effective liner. Evidence of elevated NO_3-N concentrations in the groundwater as a result of solid manure storage (e.g., feedlot pens and temporary manure piles) was also observed at comparable or higher values.

Results from the CFO sites showed that NO_3-N contamination from the EMSs may be restricted laterally from within a few metres, at sites characterized by thick clay till, and up to 150 m from the facilities at the sites characterized by more permeable material (i.e., sandy soils and thin till overlying shallow bedrock). The lack of elevated NO_3-N concentration below depths of 10 to 15 m in the groundwater suggested limited downward movement of manure constituents.

Conclusions

Observations suggested that manure storage can contaminate shallow groundwater at CFOs, particularly for NO_3-N, but that many factors must be considered for specific sites (e.g., hydrogeologic conditions) and that other activities (e.g., spreading, temporary storage) and sources may be present and likely are contributing. By improving the scientific and practical understanding of the fate and transport of manure constituents in groundwater at typical Alberta CFO settings, more suitable management, policy and protection of the groundwater and environment can be achieved. The results from the greater overall study also provide insights

and understanding into the effects of other point and non-point sources of manure-associated contamination on Alberta groundwater.

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