

Nitrate changes in shallow groundwater in the Battersea Drain area

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Summary

Alberta Agriculture and Forestry, Natural Resources Conservation Board, and producers in the agricultural industry collaborated to conduct a 7-year project to assess changes in groundwater quality with time in the Battersea Drain area (near Picture Butte, Alberta) by comparing current conditions to historical data. A historical transect of monitoring wells installed in the area was partially re-activated in 2009 and monitored through 2015 to determine changes, if any, in groundwater quality as a result of manure management activities. The project focused on shallow groundwater (i.e., <20 m below ground surface) and nitrate-nitrogen (NO₃-N) as an indicator of changes to groundwater quality. Results showed that agricultural activities in this region have negatively affected shallow groundwater quality, and that steady-state conditions have developed, suggesting conditions have not worsened in recent years.

Method

The study was carried out in the Battersea Drain area, near Picture Butte, Alberta, Canada. This region had a high density of livestock and 82% of the land base was irrigated (Rodvang et al. 2004). This area was previously studied from 1995 to 2001 when a transect of groundwater wells was installed and monitored. In 2009, the transect was partially re-activated (Figure 1) and monitored until 2015 (Lorenz et al. 2014, Kohn et al. 2016). Current site locations and methods were selected to be consistent with historical work, in order to compare regional groundwater quality data between the two periods, and to assess current conditions. Water samples were collected two to four times annually depending on the well and year. Samples were analyzed for NO₃-N concentration, as well as other water quality parameters (not presented here). The hydrogeological properties of the study area have previously been described by Rodvang et al. (1998, 2002, and 2004). Groundwater flow direction was determined using hydraulic heads obtained from groundwater level measurements. Vertical gradients were also calculated for sites with nests of wells.

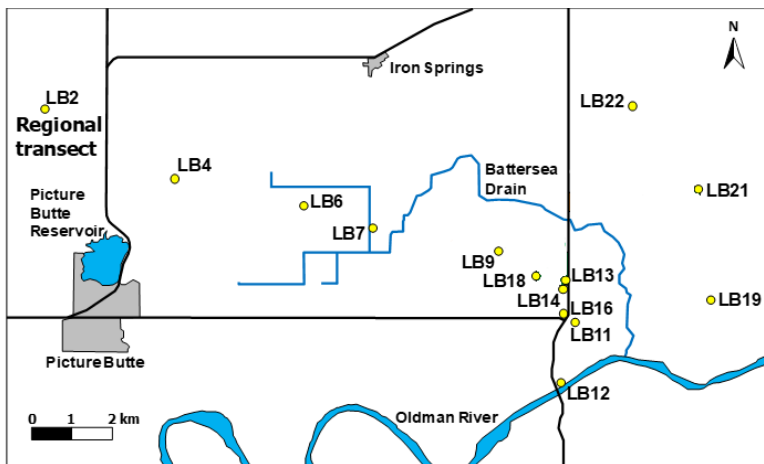


Figure 1 Location of the Battersea Drain regional transect. Each site consisted of either a single water-table well or a water-table well plus one to four piezometers. Wells ranged in depth from 1.77 to 20 m below ground surface.

Results

Twenty-four wells were used to compare historical and current data sets in the Battersea area. Groundwater $\text{NO}_3\text{-N}$ concentrations ranged from 0.05 to 130 mg L^{-1} in 2009 to 2015, and from 0.05 to 90 mg L^{-1} in 1995 to 2001. Elevated $\text{NO}_3\text{-N}$ concentrations were identified throughout much of the study area, particularly in areas characterized with coarse-textured soils, though elevated concentrations were also observed in areas with relatively fine-textured soils.

Of the 24 wells, eight wells had significantly higher median concentrations of $\text{NO}_3\text{-N}$ in the current period (2009–2015) compared to the historical period (1994–2001). Two wells had significantly lower $\text{NO}_3\text{-N}$ concentrations in the current period. Among the wells that displayed significant increases in concentrations from the historical period to the current period, the average median $\text{NO}_3\text{-N}$ concentration increased by about three times (from 10 to 29 mg L^{-1}). In contrast, for the wells that displayed a significant decrease in concentrations, the average median $\text{NO}_3\text{-N}$ concentration decreased by about 1.8 times (from 59 to 33 mg L^{-1}). However, the overall average $\text{NO}_3\text{-N}$ concentration for all 24 wells increased by 44% (from 10.7 to 15.4 mg L^{-1}) from the historical period to the current period.

However, $\text{NO}_3\text{-N}$ concentration generally remained stable during the current period, with only a few wells showing significant changes with time.

Conclusions

The overall average median $\text{NO}_3\text{-N}$ concentration in shallow groundwater at the Battersea Drain area increased significantly from the historical study period to the current study period, suggesting that agricultural activities continued to negatively affect shallow groundwater quality in the region between the two periods, recognizing some trend variation among individual sites. However, the relatively stable concentrations during the current period suggests the region may

have reached steady state conditions between the level of agriculture activity and the rate of groundwater contamination.

Evidence of contamination from agricultural activities was not apparent, or had been greatly attenuated, at depths greater than 15 m below ground surface.

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