

Comments to HESS-2018-31:

The paper by Bourke et al. was trying to use nitrogen isotope tracer to investigate the denitrification process in shallow aquifer at two feeding fields in Alberta, Canada. I recommend major revision on the present format. Hope these comments would be of use to you.

Abstract:

The abstract should provide a clear and concise summary of the aims of the paper together with the key results.

Page 1, Line 13: "Elevated NO<sub>3</sub>- concentrations in groundwater" please give specific data on this in the abstract.

*This sentence is a general introductory statement about potential mechanisms for nitrate attenuation in groundwater and does not summarise the results of this study. It would not be appropriate to report measured data here.*

**NO CHANGE MADE**

Lines 16-17: it should be expanded to describe "the NO<sub>3</sub>- source and denitrification enrichment factors".

*It isn't entirely clear how this sentence could be expanded. This sentence describes aspects of the modelling approach and is a complete statement as written. Further detail is provided in the main body of the paper.*

**NO CHANGE MADE**

Lines 20-21: the range of NO<sub>3</sub>- concentrations can be shown here.

*Readers can refer to the full open-access manuscript for details of the range of measured values (e.g. Table 2).*

*CHANGE MADE: sentence changed and maximum measured concentration now reported in the abstract.*

Could the authors keep consistent with using the NO<sub>3</sub>-N concentration or the NO<sub>3</sub>- concentration in the whole paper? According to the description in the section RESULTS, you used "NO<sub>3</sub>-N concentration in groundwater".

*When referring to concentrations in measured data and values used in the data analysis we use NO<sub>3</sub>-N, which refers to the nitrogen in the form of nitrate that was actually measured. When referring to concentrations this must be specified in full for accuracy.*

*When discussing processes in general we use the simpler NO<sub>3</sub> for the benefit of brevity and readability. Any statement made about processes controlling NO<sub>3</sub> will also clearly apply to the N in this NO<sub>3</sub> (which is NO<sub>3</sub>-N).*

*We feel that this approach balances the needs for accuracy and readability.*

*NO CHANGE MADE*

## Introduction

The introduction provides good background to the study and places it in an international context. The specific aims of the study are reasonably clear.

Page 2: Lines 16-17: "Groundwater containing significant agriculturally derived NO<sub>3</sub><sup>-</sup> also typically has elevated chloride (Cl<sup>-</sup>) concentrations" could use a few more details. Specifically, it is not clear what is meant by "elevated chloride concentrations" and "the characteristic enrichment of ... (Line 34)" etc. Without a detailed knowledge of the area it is difficult to assess exactly the extent of the problem or what has been done to address it. If you provide a few more details, the context will be clearer.

*This is a general statement that acts as an introduction as to why NO<sub>3</sub>/Cl ratios can be used to investigate NO<sub>3</sub> contamination. The Cl<sup>-</sup> is not a problem in and of itself. Site specific details on agricultural activity are already presented in 2.1 Experimental sites.*

*NO CHANGE MADE*

Page 3: "the extent of agriculturally derived NO<sub>3</sub><sup>-</sup> in groundwater" compared with "On-site denitrification reduced agriculturally derived NO<sub>3</sub><sup>-</sup> concentrations by at least half" (in Abstract) did not show the variational concentrations.

*It is not clear what the reviewer is suggesting here, it makes no sense to report concentrations measured in this study in the Introduction.*

*NO CHANGE MADE*

"sources and initial concentrations of NO<sub>3</sub><sup>-</sup>" (Line 25, Page 3) was not clear in the text and abstract.

*It's not entirely clear what the reviewer is asking for here. If the issue is a lack of information on site-specific agricultural practices in the introduction, this is already presented in 2.1 Experimental sites.*

*NO CHANGE MADE*

## Materials and methods:

Page 4, Line 28: "slug or bail tests" could you expand them and give brief introduction to make the experiment clearer for readers.

*These are standard hydrogeological tests, and the purpose is simply to determine hydraulic conductivities (as already stated) by measuring water level changes in response to addition or removal of water from the well.*

*CHANGE MADE: description of "slug test" and "bail test" added for clarity along with a reference for the analysis approach.*

Page 5, 2.3 section: where did you complete the measurements of groundwater and pore-water hydrochemical components? *Pore water from core was analysed at USask. Groundwater wells were analysed in Lethbridge and manure filtrate was analysed by ALS in Saskatoon.*

*CHANGE MADE: Laboratory now specified in the text.*

Results:

Page 8, Lines 4-19: how to obtain some specific data (e.g. mean K, vertical gradient) in this part?

*Site-specific ranges of values are reported here in the main text so as to give an indication of the variability in this heterogeneous groundwater system. Geometric mean K's are already presented in the text of 3.1 where the average velocity is calculated. The complete dataset of measured K and hydraulic gradients are presented in supplementary information. Readers are free to calculate means from the raw data if they wish.*

*NO CHANGE MADE*

Lines 25-30: "The enrichment factor of  $\delta^{15}\text{NO}_3$ " can be replaced by " $\epsilon^{15}\text{N}$ ".

*Presumably the reviewer is referring to page 9.*

*CHANGE MADE as suggested*

Page 10, Lines 17-18: "The  $\text{NO}_3\text{-N}$  in this core sample was most likely introduced into the groundwater system by vertical infiltration or diffusion from above." What's your evidence for this description?

*The well directly up-gradient or this core has low  $\text{NO}_3$ , but the soil above the watertable in this core has very high nitrate, therefore this high nitrate concentration at the top of the core is most likely to be top-down input, not lateral flow within the subsurface.*

*CHANGE MADE: The text has been updated and expanded to clarify this.*

Line 18: "much higher  $\text{Cl}^-$  concentrations" please give a range of concentration levels with mean value.

*It seems the reviewer means page 11.  $\text{Cl}^-$  concentrations for BMW2 are already reported within this sentence as a mean and standard deviation.*

*CHANGE MADE: Concentrations for BMW3 and BMW4 now also reported.*

Discussion:

This section needs in-depth analysis and focus on interpreting data combined with hydrogeological conditions, such as characteristics of glacial sediments, and agricultural operations.

*In-depth analysis of the data at each site is already presented within results.*

*NO CHANGE MADE*

The thrust of this paper should be distinguished into two or three aspects, explaining the main factors controlling the denitrification processes in the groundwater systems. You should try to keep this as the main focus of the paper.

*The focus of the paper was not on explaining factors controlling denitrification because we did not have the data to do this. Denitrification will depend on redox conditions, and because the wells were sampled using bailers with long recovery times the measured values of DO and ORP recorded are unlikely reflect conditions within the groundwater system. This was previously discussed in response to comments by Sebastian Lamontagne during the open discussion phase (AC1).*

*NO CHANGE MADE*

Additionally, how does the paper inform our understanding of nitrate fate in groundwater caused by agricultural activity in general? It is mainly a case study and while these are important, you need to revisit those topics and explain in the conclusions the relevance to research elsewhere.

*Paragraphs 1-3 of the discussion already address how the results from these sites can be used to inform our understanding of agricultural practices overlying glacial sediments in general.*

*CHANGE MADE: Subheadings within the discussion have been added to clarify the sub-topics for the reader.*

Conclusions:

There are very study specific. Please use the conclusions to look at the broader implications for regions outside this specific area. There must be a few things in here that will inform studies in other regions that will give the paper more impact.

*A number of the concluding statements were intended to apply broadly, not just at these sites.*

*CHANGE MADE: The conclusion has been modified and re-structured into two paragraphs to clarify the broad general findings.*

*A number of minor modifications have also been made throughout the manuscript to improve clarity and readability.*