

Interactive comment on “Real-time monitoring of nitrate transport in deep vadose zone under a crop field – implications for groundwater protection” by T. Turkeltaub et al.

Anonymous Referee #1

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Thank you for the opportunity to review “Real-time monitoring of nitrate transport in deep vadose zone under a crop field - implications for groundwater protection.” I enjoyed reading the paper. The text is clear and well written. The structure of the paper is concise and generally easy to follow. A notable strength of the paper is the dataset of 6 years of NO₃⁻ concentrations in the vadose zone, which is an unusually long and complete record. There is room for improvement in the data interpretation and discussion. Some of the interpretations of the data seem a bit oversimplified. I suggest revising sections dealing with data interpretation and discussion in order to provide readers with a more in-depth understanding of the data, and to highlight the most novel contributions of this study. Specific suggestions are given below.

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Specific comments:

Line 30 – “and these isotopes were barely affected by natural soil or industrial nitrogen components.” It is not clear how this conclusion is reached. I suggest revisiting the interpretation of the d15N results.

For Figure 4, please provide a reference for the arrows showing ranges of 15N ratios for different sources. They seem to be from Figure 16.9 in Kendall, 1998, (Tracing Nitrogen Sources and Cycling in Catchments, in Isotope Tracers in Catchment Hydrology (1998), C. Kendall and J. J. McDonnell (Eds.). Elsevier Science B.V., Amsterdam. pp. 519-576). Because there are no d18O measurements in this study, a better source of information about typical ranges of d15N in sources might be figure 16.4 in that same chapter, which shows manure separate from septic: <http://wwwrcamnl.wr.usgs.gov/isoig/isopubs/itchfig16-4.html> or Fogg et al., 1998, Figure 1 <https://info.ngwa.org/GWOL/pdf/981563606.PDF> In either case, it seems that many of the measurements shown in this figure could be from soil organic N, and that all the measurements could be mixtures of soil N and manure. I suggest revising the discussion accordingly.

Also, there is an interesting trend in the d15N values with depth (from 0 to 12.6 m), and the sample at 12.6 m has relatively low d15N. Did the source of N vary over time? Given the estimated vertical velocity of 0.9 m/yr and the date that these samples were collected, it should be possible to estimate the time at which the NO₃⁻ in the 12.6 m sample entered the soil. What was going on at this site at that time?

33 – “excluded the possibility of lateral nitrate input”. It’s not clear how the model results lead to this statement. How does a 1-D model, fitted to breakthrough at a single depth, “exclude” the possibility of lateral nitrate input?

88-91 – In terms of the novelty of the current study, this seems to be an important point that there are few 5+ year monitoring studies of NO₃⁻ in the deep vadose zone. Consider moving this to a more prominent location and/or adding a similar statement

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in the abstract.

98 – 106 – I suggest adding a sentence to clarify how the existing studies relate to the current study. How does this study build on, or differ from, the previous VMS studies of long-term monitoring of NO₃⁻ in the unsat zone, especially those at the same site (Turkeltaub et al., 2014)? This will help to clarify the novelty of the current study.

122 – Please add brief info about samples taken for N and for d15N. How were the samples collected? When were the d15N samples collected?

126 – Please give the start and stop dates of the study in this sentence or in the first sentence of the paragraph below (line 136).

136 – Please explain - what was the land use of the study site before 2009?

320 – Meaning is unclear for “none of these assumptions could be found in the field”. Presumably this means that the assumptions were not violated, but that seems inconsistent with figures showing NO₃⁻ breakthrough that is not consistent with a uniform homogeneous medium, e.g. in 2013 there is breakthrough at depths of 9.5m and 15.6m but not at the intervening port at 12.6m. I suspect that the 1-D analysis approach would not do a good job of fitting all the depths simultaneously, and that different sample depths/locations have different effective transport properties. Consider discussing this issue in more detail, relating to other unsat zone studies, and possibly proposing measures to address the related uncertainty.

326-327 – Please clarify - The model was calibrated against data from the depth of 6.3m, so for consistency it would seem to make sense to use the water content at that depth (rather than at 3.1m) to calculate the annual water flux.

329 – Section 3.5 – I suggest revising to emphasize the most novel results of this study. Some additional analysis may be necessary in previous sections to identify the most novel contributions. The first paragraph of this section is very generic, more like introductory material than discussion. The second paragraph mentions the current study,

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but does not explain how the results of this study add to our knowledge of vadose zone monitoring as a tool to understand NO₃⁻ delivery to groundwater. Readers already know that applying manure slurry contaminates groundwater. They will be more interested to read about what this study (maybe in combination with previous studies) tells us about time-scales of transport, interactions of 15N with soil N, magnitude of dispersivity, or other open questions about vadose zone N.

Technical issues:

55 – “the land surface”

56-64 – Consider combining this single-sentence paragraph with another paragraph, or expand to clarify how these various methods relate to the current study. E.g. Is there a lack of studies that characterize long-term NO₃⁻ concentration profiles in the vadose zone?

77 – I suggest “concentrations” or “levels” instead of “level”. Is the point of this sentence that it can advantageous to study NO₃⁻ transport in the unsaturated zone, closer to the source, before mixing occurs in groundwater?

80 – Consider substituting “common practice” in place of “easy”.

108 – “patterns”

176 – should be “were analyzed”

186 – Throughout the paper consider using “vadose sampling port”, “sampling port” or just “port”, which will have more meaning to readers than the abbreviation “VSP”.

219 – “From September 2009 to the end of the study in January 2015”?

236 – Consider giving an approximate interval between sampling (e.g. “approximately 4 times per year”) in place of “frequent”

256 – “as compared to”

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277 – missing “e” at end of author’s name

Fig 1 – Is there any significance to the color distinction for blue versus red arrows?

Fig 3 – The different vertical scales on the panels makes it difficult to interpret the data. Consider plotting a few different depths on a single panel.

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