

The authors thank the reviewers Eduard Hoehn and Rudolf Liedl for their helpful comments. In the following all comments are discussed in detail and the changes in the revised manuscript are marked.

Answer to reviewer Eduard Hoehn:

p. 4209: Given the many abbreviations and parameters, work requires utmost precision in the formulations of the text, which is somewhat lacking. Work lacks conciseness.

The authors think that the presented manuscript allows the reader to follow the IPT field application and the related evaluation. The removal of manuscript sections to shorten the paper will hamper the understanding of the study. However, some formulations were stated more precisely as you can see in the following.

p. 4211, l. 1: Losing conditions, rather than alternating conditions is here the crucial issue.

The focus of the manuscript is the influence of losing streams on the groundwater quality. This can be seen also from the title. However, the investigated stream *Bauerngraben* is characterized by alternating conditions. We therefore also introduced references that deal with alternating streams.

p. 4212, l. 3: Infiltration of surface water to ground water, rather than exfiltration of river water to ground water. It depends on the definition. Define!

According to Freeze and Cherry (1979) infiltration of surface water to groundwater and exfiltration of stream water to groundwater are possible definitions of the investigated process. We prefer to use the term exfiltration of stream water to underline that the stream may also lose possible contaminants. One sentence was included to define the term exfiltration with more precision.

p. 4211, l. 11: "In this context the water flow from the stream to the groundwater is defined as exfiltration from the stream."

p. 4212, l. 15: Biogeochemical redox reactions seem to me to play a big role in the concentration distributions of your system. This would be worth being discussed in a separate paragraph. What is organic carbon content of the sediment, and the DOC of the aqueous phases?

The reviewer is partly right. Biogeochemical redox reactions may play a role in the investigated system, but a discussion of specific reactions will go beyond the scope of the manuscript. The presented approach provides mass flow rates M_{CP} through control planes up- and downstream of a losing stream to estimate exfiltration mass flow rates M_{ex} . An identification of biogeochemical redox reactions was not the main focus of the study. The transport behavior of the target compounds was characterized by retardation and degradation. These are common expressions in groundwater hydrology and can be specified by existing references (e.g. Wiedemeier et al., 1999).

p. 4212, l. 16: If Bauerngraben acts as a pool-and-riffle stream, you must introduce this feature here, and not only in the discussion of the results.

The channel walls and the bottom of the *Bauerngraben* are characterized by an artificial surface structure of cobbled pavement. Therefore pronounced hyporheic flow (pool-riffle system) will not occur in the *Bauerngraben*.

p. 4213, l. 24: Define expression "control plane"

The term "control plane" is a common expression in groundwater hydrology. Detailed explanations about the control plane definition for IPT evaluations are given in Bayer-Raich et al. (2004) and others. It is therefore not necessary to give more detailed explanations about the term "control plane" in the manuscript.

p. 4214, l. 4: Give one sentence about what this code does.

We changed the following section.

p. 4214, l. 4: "The code CSTREAM (Bayer-Raich, 2004) can be used to estimate c_{av} and M_{CP} by performing a weighted average with the values from the obtained concentration-time series. The weights base on spatial distances between isochrones that were calculated by a particle tracking tool (Modpath) in combination with a one-layer Modflow model."

p. 4215, l. 5: What evidence makes you assume that the Bauerngraben is not connected hydraulically to the ground water? Say something about drawdowns

Before pumping groundwater levels were measured to be 20 cm below the streambed (see p. 4215, l. 3). A hydraulic connection due to capillary rise is possible, but of minor interest because an increased gradient between stream and groundwater due to pumping (drawdown less than 0.6 m in this study) will lead to a weaker hydraulic connection and therefore to reduced exfiltration rates. We deleted the term disconnection to clarify this.

p. 4215, l. 4: "For that reason it was assumed that pumping-induced drawdown would not increase the leakage from the *Bauerngraben*."

p. 4215, l. 8: The units [L/m'-d] refer to a specific flux rather than a discharge rate. Be precise!

The authors prefer to use discharge rate per stream length unit. A specific flux refers to a constant area, but the width of a stream may vary. Also the second reviewer of the manuscript supports the definition as discharge rate per stream length unit.

p. 4215, l. 6: "Therefore, the leakage was implemented as a constant discharge rate per stream length unit Q_{ex} ."

p. 4215, l. 14: How do you define streamtubes? They seem to me to be pretty large for a Poiseuille definition.

The streamtubes are not based on the Poiseuille definition. They base on the streamlines from the groundwater model and the control plane extent.

p. 4215, l. 14: "Streamtubes 1 and 2 are defined by streamlines from the groundwater model before pumping and by the CP extents of wells 13 and 14 that determine the width b ."

p. 4216, l. 1: I think that the concentration difference is the issue rather than the concentration increase.

This sentence was intended to refer to mass flow rates and not to concentrations. We replaced concentrations by mass flow rates.

p. 4216, l. 1: “The estimation of M_{ex} was only possible for substances that show a downstream mass flow rate increase (positive ΔM_{CP}).”

p. 4216, l. 4: What is an inorganic sample ? Be precise!

We improved this sentence.

p. 4216, l. 4: “samples for inorganic analyses every 4 h and samples for organic analyses every 8 h”

p. 4218, l. 10: You mean "non-constant" inflow rather than heterogeneous inflow.

The term “heterogeneous inflow” refers to variable inflow at different locations. The authors state that more inflow of wastewater constituents occurs in the groundwater upstream of streamtube 2 because the concentrations are mostly higher than in streamtube 1. The term “non-constant” would lead to an interpretation that was not intended.

p. 4218, l. 10: “This is caused by heterogeneous inflow of wastewater constituents to the groundwater upstream of the test site where parts of the urban area of Leipzig are located.”

p. 4218, l. 20: Do you mean "variable"?

Heterogeneous concentration patterns describe that areas with different (low and high) concentrations in the capture zone of the IPT wells exist. Therefore we prefer “heterogeneous” instead of “variable”.

p. 4220, l. 6: Do you mean streamtubes? Be precise!

The authors mean streamlines. However, we changed the sentence to make this clear.

p. 4220, l. 6: “The Streamlines that define streamtubes 1 and 2 (Fig. 1) were only marginally deflected by the stream.”

p. 4220, l. 25: What do you mean by "bank storage"? Define!

We introduced the definition from the given reference (Li et al., 2008).

p. 4220, l. 25: “In this context Li et al. (2008) defined bank storage as the storage of water in stream banks during the rise of stream level due to a flood.”

p. 4221, l. 18: Address the fact that you could use for your estimations the conservative behavior of Cl for mixing assessments, assuming the presence of end-members.

The use of the conservative ion Cl^- for mixing calculations is in principle possible. Due to exceptionally high Cl^- concentrations at well 12, which cannot be explained completely with the obtained data (see p. 4222 l. 5), another ion (SO_4^{2-}) was chosen for mixing calculations (see p. 4219 l. 18).

p. 4222, l. 8: Reducing conditions in the aquifer would have deserved treatment in the theoretical sections, since both NO_3 and SO_4 are redox-dependent compounds. What is the water quality of Bauerngraben, and what bacterial community would you expect in the river bed? fOC of the sediment? DOC of waters?

A low oxygen content of 0 to 1 mg L⁻¹ in the groundwater (see p. 4217 l. 26) points to reducing conditions in the aquifer. Figure 3 also shows the concentrations of the relevant wastewater constituents in the *Bauerngraben*. A detailed description of the bacterial community in the streambed, of the fOC of the sediment and of the DOC goes far beyond the scope of the presented manuscript.

p. 4223, l. 4: This assumption must be discussed in the theoretical section. Negative concentrations could point to reducing conditions, in a double-porosity nature aquifer.

An additional theoretical section about redox reactions is not necessary because these facts are common knowledge. More detailed explanations are given already in Wiedemeier et al. (1999).

p. 4225, l. 5: Spatial heterogeneity was not discussed in the paper.

The sentence refers to concentration heterogeneities that were certainly investigated in the study. We changed the sentence.

p. 4225, l. 5: "... points to high concentration heterogeneity in groundwater."

p. 4225, l. 16: DO YOU SEE, HOW MANY TIMES YOU USE THE WORD "DEGRADATION" IN THE "CONCLUSIONS" SECTION !?? Biogeochemical redox processes must be addressed in the work.

As already stated above a detailed description of biogeochemical redox processes at the field site is not the focus of the manuscript and is also not possible with the obtained data set.

p. 4225, l. 29: A list of the (very many) abbreviations and parameters used would be very helpful.

The used abbreviations are self-explanatory (e.g. CAF for caffeine or CSO for combined sewer overflow) and described when they are introduced for the first time. The parameters are defined by scientific standards: *c* for concentration, *M* for mass flow rate and *Q* for the discharge. Therefore an additional list of abbreviations and parameters is not necessary.

Answer to reviewer Rudolf Liedl:

1) p. 4218, l. 5: The authors mention "higher concentrations of K⁺ ... at the downstream wells 11 and 12 (Fig. 2)". Fig. 2 clearly indicates that K⁺ concentrations at the downstream well 12 are higher than at the upstream counterpart, i.e. well 14. In addition, most of the time K⁺ concentrations decrease along the streamtube from well 13 to 11.

The reviewer is right. Well 12 reveals K⁺ concentrations that are always higher than the upstream well 14 whereas well 11 and 13 reveal concentrations in the same range. In this context it must be stated that a comparison of concentration values from up- and downstream wells for the same time (e.g. 12 h) is not useful because these concentrations do not represent control planes that are completely overlapped. It is only possible to compare average concentrations of the different wells. The corresponding manuscript section was adapted and we included some more explanation about the described issue.

*4218, l. 5: "The influence of the *Bauerngraben* can be identified by higher concentrations of Cl⁻ and lower concentrations of SO₄²⁻ at the downstream wells 11 and 12 (Fig. 2). The*

concentration comparison between up- and downstream wells has to focus mainly on average concentrations that include all observed concentration values at one well. The comparison of single concentration values between two wells for a specific time (e.g. after 8 h) is not useful because shortly after start of pumping the control plane extents of up- and downstream wells (see isochrones in Fig.1) do not or only in small parts overlap. Hence for K^+ higher concentrations can be identified at downstream well 12 whereas wells 11 and 13 show K^+ concentrations in a similar range.”

2) p. 4218, l. 7: *Referring to the statement cited above it is said that “NO₃⁻ shows a similar concentration gradient between upstream and downstream wells”. Fig. 2, however, does not appear to provide clear evidence for a gradient between wells 14 and 12. Between wells 13 and 11, NO₃⁻ concentrations decrease for the first 10 days or so. Later on, the gradient becomes comparatively small and changes its sign three times.*

The comparison of NO₃⁻ concentrations bases on average concentrations as already stated above. This means that even if several downstream concentrations are lower than upstream concentrations the average concentrations of NO₃⁻ are still higher at the downstream wells. This was clarified in the section.

p. 4218, l. 7: “NO₃⁻ shows a similar concentration pattern between upstream and downstream wells with mostly increased concentrations downstream of the *Bauerngraben* in both streamtubes...”

3) p. 4219, l. 12: *Based on data given in Tab. 1 the authors claim that “micropollutant MCP’s are mostly lower at the downstream wells with the exception of CAF in streamtube 2”. I think that the decrease in MCP for CAF along streamtube 1 is only minor and should not be over-interpreted. The data definitely indicate an MCP decrease for NON but corresponding values for CAF basically remain unaltered.*

This section was adapted to the comment.

p. 4219, l. 12: “Micropollutant M_{CP} are lower at the downstream wells for NON whereas M_{CP} of CAF increase (streamtube 2) or remain unaltered (streamtube 1) at the downstream wells.”

4) p. 4221, l. 10 and p. 4224, l. 4: *If there is exfiltration from the Bauerngraben, there will be an increase in MCP even if concentrations C_{ex} are low. Of course, MCP will be proportional to C_{ex} but “temporally high concentrations in the stream” are certainly not required to explain positive MCP values.*

The authors agree with the reviewer. Temporally high concentrations are not necessary to explain positive M_{CP} . The corresponding sentences were improved.

p. 4221, l. 10: “Positive M_{CP} may partly derive from process (a) temporally high concentrations in the stream.”

p. 4224, l. 4: “Process (e) mixing of groundwater with exfiltration water may lead to positive ΔM_{CP} , but observed negative ΔM_{CP} in both streamtubes reveal...”

5) p. 4210, l. 7: *Please indicate that M_{ex} denotes mass flow rate per unit length of stream.*

We adapted the following sentences.

p. 4210, l. 6: “This paper presents a method to quantify exfiltration mass flow rates per stream length unit M_{ex} of wastewater constituents from losing streams...”

p. 4211, l. 10: "...a method to estimate exfiltration mass flow rates per stream length unit M_{ex} of wastewater constituents..."

p. 4224, l. 22: "Exfiltration mass flow rates per stream length unit M_{ex} from the investigated stream..."

6) p. 4210, l. 10: *Check hyphenation.*

The hyphenation was included during the uploading process of the manuscript. We will check this in the proof version of the manuscript.

7) p. 4215, l. 7/8: *Exponent -1 is missing twice in the unit of Q_{ex} . Please also indicate that this quantity is a discharge per unit length of stream.*

These technical issues were corrected.

p. 4215, l. 6: "Therefore, the leakage was implemented as a constant discharge rate per stream length unit Q_{ex} . Best fitting of observed to simulated water levels at the observation wells was obtained for a Q_{ex} of $85 \text{ L m}_{\text{stream}}^{-1} \text{ d}^{-1}$."

8) p. 4215, l. 13: *I think that "13" should be replaced by "11".*

The sentence in its present form is right. The last samples of wells 12 and 13 were neglected for the IPT evaluation. This can be proven by the comparison of the final capture zone. Well 11 reveals the largest capture zone because no samples were neglected.

9) p. 4215, l. 23: *How can JCP values be "given"?*

This sentence was changed.

p. 4215, l. 22: "For the comparison of the two streamtubes the mass fluxes J_{CP} at each CP were included."

10) p. 4216, l. 25: *Please explain SPE for the non-specialists.*

The term SPE was introduced in the same section, but the explanation was missing the short form SPE. This was improved.

p. 4216, l. 21: "The sample preparation for micropollutant analysis was derived by solid phase extraction (SPE) to enrich the target compounds from the water samples."

Beside the reviewer comments some additional technical corrections were included in the revised manuscript. We changed

CSO's to CSOs

IPT's to IPTs

CP's to CPs

Δc 's to Δc

M_{CP} 's to M_{CP}

J_{CP} 's to J_{CP}

ΔM_{CP} 's to ΔM_{CP}

Q_{ex} 's to Q_{ex}

References:

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