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Discussions

Interactive comment on "How effective is river restoration in re-establishing groundwater – surface water interactions? – A case study" *by* A.-M. Kurth et al.

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The manuscript describes a case study to investigate the effectiveness of river restoration. Three sites with different restoration statuses are chosen to carry out active and passive distributed temperature sensing together with Radon-222 measurements. It is hypothesized that the measurements indicate success of the restoration measures (ie. installation of gravel islands).

The manuscript is structured in a logical way and written in a clear and understandable way. Figures, and one table support the text appropriately. The authors provide a good

background on the topic of river restoration and motivate the importance of the evaluation of the hydrogeological conditions. Appropriate citations underline the relevance of the topic. Materials and methods, as well as results are - generally - explained and described in an adequate way. Some details should be added to the description of the selected sites and the on-site experimental setup. Unfortunately, the discussion and conclusion sections, fail to to properly evaluate the data, especially, to correllate the temperature measurements with the exchange processes between ground- and surface water.

In the following, I would like to give some general comments before raising more specific questions for the individual sections.

I feel, that the manuscript has large potential and would be happy, if the authors would address the raised issues. If the authors decide to submit a revised manuscript, I would be available for a second review.

General questions

I recommend to check the usage of commas (maybe, this could be done by a native speaker?); in some cases, you use a comma before an adverb like thus (P1096, L13), therefore (P1105, L20), ie. if the word is in the beginning of a sentence (the comma is also sometimes missing, eg. P1103, L24, "Presumably groundwater upwelling occurred uniformly..."). But you never set commas for occurrences within a sentence ("...and thus created conditions" vs ...and, thus, created conditions).

I think, you should be careful with using the term "temperature profile" - a "profile" is often expressing a change of a variable (eg. temperature) over depth, eg. temperature profiles for soil or the atmosphere. At P1100, L17, for example, this might sound misleading. Maybe, you can clarify the term at the first occurance, ie. that you talk about the temperature "along a stream"?

1 Introduction

Page 1094, Line 1: "In this study we investigated whether river restoration was successful in reestablishing vertical connectivity and, thereby, groundwater-surface water interactions, in a degraded urban stream." - I suggest adding a verb to the second part of the sentence, as it might confuse a little to what the second part refers to, ie. do you study the groundwater-surface water interactions, or was the groundwater-surface water interactions successfull (the latter missing the plural form, though): "In this study, we investigated whether river restoration was successful in reestablishing vertical connectivity and, thereby, *evaluated/assessed* groundwater-surface water interactions, in a degraded urban stream."

P1094, L7: "(near-) natural" - I would write "(near-)natural"; if you want to refer to near-natural, ie. omit the brackets, then, with the current style, one would end up with "near-natural"; maybe, a native speaker could give advice here.

P1095, L29: "We define hydrogeological success as an increase in vertical connectivity along the restored site of the stream, indicated by increased groundwater-surface water interactions." - with this definition, you implement that every stream was (before having been antropogenically influenced) connected to the groundwater; is this actually always the case? Couldn't it be possible, that, due to the sedimentation of fine material (eg of glacious origin, or in the lower regions of the catchment), colmation leads practically to a decoupling of river and groundwater?

2 Material and methods

P1096, L23: I suggest adding a line break before more detailed descriptions of the rivers for readability.

P1096, L25: You state, that a hydropower production plant is part of the upstream reach of the Urbach - do you have any information, whether this plant regulates the stream flow, and if yes, to what degree? Is the assumption of a "natural river morphology" valid if the stream is strongly influenced by water flow regulations? Can you please elaborate on these questions?

P1097, L3: "Although being lowered and straightened led to a rather uniform stream width, the Röthenbach still has a naturally varying water depth and flow velocities." - the first part of the sentence is grammatically incorrect. Please revise to something like "Although, the Röthenbach has been lowered and straightend to acquire/feature/present a rather uniform stream width, it still shows a naturally varying water depth and flow velocity."

P1097, L7; "Nevertheless, the stream bed was still considered to be near-natural and thus used as reference for near-natural hydrogeological conditions." - Maybe this is a little too philosophically, but it is unclear to me, how you relate the "hydrogeological conditions" with the "stream bed", ie. until which depth below the river do you define the stream bed, do you neglect a hyporheic zone and/or colmation? In terms of "hydrogeology", I would refer to the aquifer, but not necessarily to the river bed (which mostly shows different characteristics than the aquifer).

P1097, L9: Do you possibly have access to a map comparing the status of the Chriesbach before and after the restoration? Or was the river morphology only internally changed (ie. by adding sand banks, gravel islands etc.) and a map would not show this?

P1097, section 2.2: - Can you elaborate on the accuracy of the DTS measurements? - Do these instruments show a drift over time? - What is the reason to use a such small temperature range (15.9-16.1°C)? Is the temperature of the surface and groundwater only within these limits? - What method did you use (passive/active)? - Ok, you talk about that in 2.4; it is a little confusing, that information on the DTS method is given in two sections, maybe you can combine these, or make clear why you seperate them?

P1098, section 2.3: - What method(s) did you use to detect Radon-222? Can you please very shortly describe the method?

P1099, section 2.4: - Would you consider the possibility to add the locations of the measurement in figure 1? - After reading 2.4, it feels to me that the information given

there might be more appropriate in sections 2.2 or 2.3; but it is just an intention. It is ok, if you want to distinguish between a general description of the methods and the implementation in the field. - How did you ensure, that nothing blocks the cables, ie sediment settles on top, so that temperature measurements are influenced over time? - Ok, you state later, that you noticed some debris collecting at a cable. Do you have an idea if you can identify this error source in your measurements without noticing it in the field?

P1099, L24: If it is important to state, please give the heating as an energy in Watt - I do not know, what current you used in your setup (12, 24, 110, 220V?).

P1099/1100: You assume the drainage ditch was solely fed by groundwater. Do you have data that supports this hypothesis/assumption? Can you determine or estimate a proportion of influence from air temperature on the (ground-)water temperature? Considering the temperatures plotted for the ditch in figure 4, and that reported groundwater temperatures were around 11.4°C, the influence from air temperature should be relatively strong. What is the water depth and flow velocity in the ditch?

3 Results

P1101, Ls 7ff: You often write, that the temperature measurement was disturbed due to exposure of the cable to the air or direct sunlight - how did you notice that and how can you make sure, that this wasn't the case for the rest of the measurements? Are the measurements in the Urbach still usable? Maybe, you can add information on the exposition to sunlight in your figures, too, if you know which sections were exposed?

P1101, Ls 26ff: There seems another anomaly at around 140m - can you please elaborate on that?

P1102, Ls 10ff: "Maximum streambed temperatures occurred around cable sections 205 and 240 m. Elevated and minimum streambed temperatures appeared around cable sections 45, 135 and 143 m, but also, less pronounced, around cable sections

60, 70, 79 and 180 m." - Does this give a hint on decoupling from the groundwater or exposition to sunlight?

P1102, L15: "The heating of the fibre-optic cable caused a rise in cable temperatures of between 1.3 and 1.6°C,depending on the initial temperature of the cable." - why would the increase in temperature depend on the initial temperature if you provide a uniform heat? I would argue, that the heat capacity does not show a significant temperature dependence within the range of 2K. Actually, I would assume that the lower temperature increase is due to higher flow velocities around the cable, ie. where the heated water is advectively transporting the heat away from the cable, while this is the opposite for higher temperature increases. Can you confirm that? Furthermore, please consider using Kelvin to signify changes in temperature, also in figure 7 (you use Kelvin in P1104, L12).

4 Discussion

P1103, L5: "...and thus created conditions in which the ecosystem can, under given conditions, unfold its full potential." - This part of the sentence feels a little too diffusely formulated; how do you define the "potential of the ecosystem" and what changes, if it is at full potential? Do you want to say, that the compartments are more stongly coupled, or that flora and fauna can approach a near natural state?

P1103, L7ff & Figure 3: I can see a slight temperature decrease around cable section 346-360 - do you have an explanation for this? - ok, you explain that on P1104, L21.

P1104, L2 & Figure 5: "...groundwater upwelling occurred in discrete zones, in which surface water temperatures were constant or elevated throughout the experiment." - are you referring to the increased temperatures around cable sections 199, 213,227,241, 270m etc? If yes, can you please be more specific in the text? Can you explain, why there is a decrease in T at 143m (and maybe also around 295)? Do you have data on groundwater levels, that you can proof influent or effluent conditions for the streams?

P1104, L29: You say, that the Chriesbach was effluent at the time of your investigation within your river section. As the temperature looks homogeneous in time and space, this implies, that the river has influent sections upstream of your investigation site. Can you confirm that? I am wondering, what the flow velocities and water depths are in all the rivers, so that one can get an idea about the time of exposure to the air while flowing through your investigated section.

P1105, L4 ff: Both, the Radon and the active DTS measurements should be discussed in more detail. In particular: - P1105, L4 (Radon): I can not completely follow your interpretation of the Radon measurements. What makes you conclude on losing conditions, and that no groundwater upwelling occurred? In particular, I do not understand the following: Radon activity is generally higher in groundwater; at the investigated restored section (2) and the restored upstream section (4.1), the activities are nearly the same; but why did you find a siginficantly higher activity further upstream in the unrestored section (5.1)? Why does the activity decrease? Is there another stream with lower activity merging in between? - (Radon): Also, why don't your sample replicates, 4.2 & 5.2, show any Radon activity and why are they so very different from your first samples? - P1105, L8 (DTS): You conclude that at 195m, surface water downwelling occurred - how do you come to this conclusion? What is the origin of the increased temperatures at 195m (fig. 6)? I do not understand how the increase in temperature and the location of the DTS cable on the tip of the gravel island correlate; could you please elaborate a littel more on this?

Section 4: It is a little hard to follow your explanations, as you switch back and forth between the three streams. For example, in paragraph P1104, L24, you do not state what river you talk about - I assume, it is the Chriesbach. Can you please consider if the structure and readability improves, when you discuss each river on its own? Or maybe, you can add subheadings for different aspects that you discuss (eg. measurement errors, hints on connectivity,...)?

5 Conclusions

P1105, L17: "Even though success evaluations in river restoration are increasingly being employed to test whether restoration measures were successful in improving conditions for the ecosystem, hydrogeological success, which influences ecological success as well, is not routinely investigated." - This sentence is hard to understand, please consider to simplify and/or rearrange it for better readability. Suggestion: "Evaluations of river restoration (projects) are increasingly being employed to test the success of restoration measures with respect to improving conditions for the ecosystem. However, hydrogeological success, which influences ecological success as well, is not routinely investigated."

P1105, L24: As a major conclusion, you state that the river restoration was successful due to the installation of gravel islands. Except for P1105, L10, I cannot find a discussion on the influence of the gravel islands, eg. how they change the coupling of ground- and surface water. You should express more clearly, 1) what you expect from the installation of gravel islands (eg. a specific process is assumed to change), 2) how you investigated the change (explain the correllation of a measurement, eg. temperature, to that process/the coupling), and finally 3) explain your data to provide (hopefully) confirmation for your hypothesis. To be more specific, you state (P1105, L23): "Results indicated that in the Chriesbach, groundwater-surface water interactions after restoration significantly increased due to the installation of gravel islands." I assume, you refer to the results in P1105, L8: "The active DTS data with the fibre-optic cable buried at about 0.4 m depth indicated that most surface water downwelling occurred at cable section 195 m, the tip of a gravel island newly created during restoration of the Chriesbach." Here, I think, you evaluate the finding from your data in P1102, L21: "...the highest cooling rate was seen at cable section 195 m at the tip of a gravel island." - Over this line of interpretation, however, you did not explain the link between the cooling rate (or increased temperature at 195m) and the exchange between ground- and surface water. It would be good, if you could clarify this and, thus, provide more information on the gravel islands' influence on the restoration, so that this conclusion becomes clearer.

P1106, L8ff: You suggest to utilize the PAB/DTS methods to optimize cost-effectiveness - could you please give a short estimation on the costs of the measuring system?

Table 1 - How far away is "further away from stream"? - Measurements 4.2 & 5.2: why is the negative uncertainty limit below 0? Or is this only the range for the positive limit?

Figure 1: - please add a reference for the maps, or acknowledge the authors - is the copyright by "BAFU 2014" secured? What is BAFU? - please add a length scale to the overview map - is it possible to increase the resolution of the small figures? - are all maps shown with North directed to the top of the figure?

Figure 2: - Why does the "cable section" start at 214 m (and not 0)? - The grey shading used on the right figure disturbes the interpretation, I do not know what the elevation that causes the shading should mean. Could you please consider removing the shading, as you already have information on the temperature given through the color scale. - Idea: if you would use the color scale of the right figure also for the left figure, one could much easier compare the two figures. - "each coloured line on the x axis, from cable section 214 to 501 m, represents one measurement." - I cannot see any lines, what do you mean by that? - P1100, L22: "Apart from two cable sections with elevated surface water temperatures at 372 and 379 m" - 372 does not always show an elevated but also a decreased surface water temperature (around 15:00).

Figure 4: - You plot the "side channel", the "drainage ditch", and the "main channel" in a way, that one might think, that they are connected streams, ie. the side channel flows into the drainage ditch which flows into the main channel. Is that the case? If no, could you please clarify that? - Here, it would also help to identify location of the measurments, if you could add this information about the location of the measurements in figure 1. The same would be helpful for the information in table 1. - Are the data within the two black bars proper measurements or are they belonging to sections where the cable was not submersed in water? If the first, can you please say, where the data

belongs to; if the second, could you consider removing it (eg. add a "no data" value, or add a black area on top)?

Figure 6: - What is the meaning of the second line in the left side figure? The x-axis only states "T [°C]".

Figures 2-6: - I understand, that it might be not appropriate if the temperature range is too large and, thus, small variations might not be recognizable anymore, but can you please consider to use a uniform temperature color scale? - I like the way you plot the spatio-temporal data of temperature on the right side of the figures. For comparison with the air temperature, maybe it is a good idea to plot some selected places along the cable section additionally in the left figure (eg for figure 4 at cable section 160m, 220m, and 290m)? - Could you please add information to the caption, what measurement type was used (active/passive)? - Idea: in section 4, you are discussing the connection between river and groundwater by analyzing temperature anomalies in the surface water with respect to air temperature. You could plot the (relative) difference of both, ie (T_air - T_water) or (T_air - T_water)/T_water. Probably, you had to correct the time lag, but maybe, you could see termperature anomalies in a better way?

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