

## ***Interactive comment on “Groundwater fauna in an urban area: natural or affected?” by Fabien Koch et al.***

### **Anonymous Referee #2**

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#### General comments

This study on the distribution of groundwater fauna in the shallow subsurface of urban (city of Karlsruhe) and rural (nearby forest) areas, as well as the use of groundwater fauna for the assessment of the ecological status in groundwater has considerable scientific novelty. To my knowledge, this is the first study that investigates groundwater ecological aspects in a city’s subsurface. This strength by novelty, however, is kind of counteracted by serious weaknesses. While I like the study very much on one hand, it is a pity that the authors did not spend enough time to distill the best out of it. Besides obvious shortcomings in the study design (the selection of chemical parameters measured, the restriction to only well water), the authors did not dig at all into the data available in a ‘statistical’ sense. I do see more categories of land-use types. I

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think measures such as well depth and origin of groundwater (what if groundwater impacted in the urban area travels underneath the forest where it is sampled) would be interesting aspects to evaluate. Moreover, fauna data set comes along with further information that has not been used, i.e. the Shannon-Wiener biodiversity and the ratio of stygobites/stygophiles vs. stygoxenes. Not to talk about the determination of individual 'species' of Crustaceans and other groups of animals that could resolve the picture much more. Although, the basic water chemistry in the urban groundwater exhibits some differences to the groundwater sampled in the rural area, there is obviously no clear indication for a 'contamination' of the urban groundwater. An exception is only some temperature deviations. Thus, why it is expected that the groundwater fauna in the urban area is different. I would have loved to see a few hypotheses that are tested. When reading the preprint I also got the impression that most groups of groundwater fauna are described as quite temperature tolerant, however, other publications of the same authors claim the strong sensitivity of groundwater fauna upon groundwater warming. I really missed individual statistical testing of such questions. To be very honest, the paper addresses a really interesting topic that has hardly been studied to date but has not been properly prepared before submission. My feeling is also that some of the co-authors have not spent much time with the paper, otherwise it would not contain so many flaws. In the following, I will try to provide detailed comments that may help to improve the manuscript. Overall, I am not sure if the paper, even when reworked properly, will satisfy the high standard of HESS.

## Specific comments

P1 L19-20: How have the anthropogenic impacts be measured. I agree that elevated temperature may be seen as Impact. What else? The groundwater chemical analyses do not focus on any contaminants, with exception of nitrate; and nitrate concentrations are not elevated.

P1 L21: it is mentioned here that more comprehensive assessment methods are required to fully capture the different effects on groundwater fauna. I agree. However,

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you should mention, at least in the discussion section, what you think of.

P2 L44-50: This paragraph does not seem to be linked to the what is introduced before and after.

P2 L51: There is a pile of studies dealing exactly with that. You should name some as examples. What is really new with your study is that there is hardly anything investigated in urban areas.

P2 L53: Are you sure that the European Union (FP5) PASCALIS project focused on 7 North-American regions. Please check that again.

P3 L57: If you state here that regional features have a stronger influence on groundwater fauna than local habitat features, you should test that with your data set. If this is true, maybe the anthropogenic impacts are not strong enough to overrule the regional selective forces. This point should also be discussed.

P3 L83: you could also have used a different approach to look at your results. What if you treat the forest samples as your local natural reference? Just an idea. Starting from there, you could evaluate which well downtown Karlsruhe match natural conditions and which not. Currently, you obviously use a German-wide reference conditions and thresholds (Crustaceans >50%, worms <20%) that may not 'absolutely' reflect the situation in the natural surroundings of Karlsruhe. In P3 L86: you say that the authors of the UBA study come to the conclusion that aquifer typology is more important than local features. Is this what you say? Why this is not properly discussed in your paper?

P4 L113: If 56% of the city's area is covered by vegetation, doesn't it make sense to group the wells in the urban area according to their 'land type' on top and do some statistical analyses?

P5 L127: It is mentioned here that the sampling took place between 2011 and 2014 and 39 wells have been sampled. But how often each well were sampled is not mentioned. Did I miss it. 3 times, as said in line 134? Or more often? You cannot have followed

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the recommendations of Hahn & Gutjahr published in 2014 when sampling took place between 2011 and 2014.

P5 L134: what you mean with 'integrative sampling'? Explain!

P5 L136: replace 'groundwater ecology' by 'groundwater ecological status' ; we 'sampled' the fauna . . .

P6 L145: If this table shall stay in the paper then the information provided with the individual groups of organisms asks for a balancing. The provided information is very heterogeneous. Some of the terms used have not been explained before, e.g. 'stygophile'.

P7 L156: No, I do not agree at all. There is many natural groundwaters in good ecological shape that do not contain any dissolved oxygen, they may also produce ochre where they come in contact with oxygen. I guess we agree that these sites are not 'good' habitats for groundwater fauna. However, the absence of fauna does not necessarily mean a disturbed ecosystem status.

P7 L170: Doesn't it make sense to further categorize the land use types, also within the city limits?

P9 L177: did you also consider well depth in your data analysis. It si a big difference between 8.5 and 39m below land surface which may affect occurrence of fauna and the availability of dissolved oxygen.

P10 Figure3: why are there two lines (red and blue) indicading the percentage of wells with good and affected ecological status? Automaticly one looks if the box is above or below. However, the values of the individual physicaö-chemical parameters are not in line with the ecological status. I recommend to delete the lines.

P10 L192: To my understanding, a concentration of 1 mg/L dissolved oxygen in wells water strongly indicates that there are anoxic conditions in groundwater. As is mentioned I the preprint well water is not representative for groundwater. To my opinion,

since well water is open to the atmosphere, DO concentrations are likely to be overestimated. Gw fauna may, at times of elevated DO in groundwater migrate through the local subsurface and enter wells. There, they may outlast times of no oxygen in the surrounding aquifer. Frankly speaking, I am not sure if the threshold of 1mg/L of DO mentioned before should refer to the surrounding groundwater.

P10 L198: The study does not show high nitrate concentration! When stating that  $\leq 10$  mg/L is natural, then in consequence nitrate concentrations between 1.3 and 14mg/l are not high!

P10 L199: In general, their relationship between DO and nitrate is not inversely correlated. Only when the oxygen is gone nitrate is reduced. As such, low or no oxygen goes along with low or no nitrate. I do not get the 'link' between oxygen and pollution claimed here (P10 L200).

P11 L220: does this mean that Parastonocaris and Bathynellacea are 'type'-species (groups) for urban situations? Such a possibility is not discussed in the paper. There are groundwater ecology experts in the list of authors. I miss an in depth interpretation of the ecological data.

P13 L231: Is it that stygobiont amphipods live predominantly within wells? This is to my opinion not a correct interpretation of what is published in Hahn & Matzke (Hahn is co-author of this preprint) and Korbelt et al.

P13 L264: When the authors write about 'groundwater quality' it is not straightforward what is meant. Only very basic water chemistry (e.g. selected nutrients, pH, DO) and temp was measured. There is no indication for a 'bad' or 'impacted' groundwater quality (with the exception in temperature), so why should the groundwater fauna show associated distribution patterns.

P13 L235: Does the study of Brielmann et al. 2011 really state that amphipods react sensitive to a gw temperature of  $11 \pm 5^\circ\text{C}$  (which is natural gw temp in central Europe)

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or do they refer to a change of ambient gw temp by 11°C? Check that carefully.

P14 L266: It would help the reader if you indicate the general groundwater direction in one of your maps (Fig. 2). If the groundwater flow direction in the area is north-west, then it is very likely that groundwater originating from the urban area is travelling below the forest. This point should be discussed as well.

P14 L285: Why only the two criteria (>70% Crustaceans and <20% of oligochaetes were used for the evaluation of the ecological status. There are more criteria mentioned in the UBA report and in the international literature, some of which have been used or even developed by the co-authors, i.e. the Groundwater Fauna Index, the ratio of stygobites/stygophiles vs. stygoxenes, etc. Making use of these additional measures could provide a much clearer picture.

P15 L300-301: 'as expected, this indicates anthropogenically influenced groundwater ecosystems ...'. Again, the physical-chemical data provided do not hint at a seriously 'impacted' groundwater quality. The only exception is the temperature. It would have been worth to expand the list of chemical parameters analyzed and include 'contaminants' besides nitrate which is more of an issue in agricultural land. I ask the authors to make clear in the paper 'what exactly the urban impact' is.

P15 L304-306: This sentence needs an explanation. Why do the results you obtained lead to the 'offer' of using groundwater for heating and cooling? This sentence is not in line with what has been discussed right before.

Discussion section in general: I miss proposals for improvement, i.e. the use of additional parameters, more sampling, more wells, other sampling techniques (here I could find 1 sentence), ...

Technical comments

P1 L12: 'scarce' not 'scare'

P1 L15: If I am correct, then the classification is from German Federal Environment

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Agency (UBA) but the result from a UBA funded research project. This makes an important difference. The funding agency not necessarily identifies itself with the outcome of funded projects. The 'invention' and 'responsibility' is with the authors from the study. As such, I would not call the scheme used, and UBA classification scheme. Same applies to P2 L31.

P1 L16: wrong wording: 'fine' ecological conditions. Replace by 'good', 'natural' or something similar. Best you use the terminology used with the assessment scheme you used.

P2 L26: HESS is an international journal. I would cite 'German' and 'grey' literature only if there is not similar publication in international journals. This is my very personal opinion.

P2 L28: 'retention' is the wrong term here! What you mean is 'degradation' or 'mineralization'.

P2 L30: delete 'valuable'. What do you mean with 'tied'? Reword.

P2 L34: change 'relatively' to 'typically' or 'naturally'. Typo: Brielmann et al. 2011 not 20011.

P2 L35: change 'stygobiote' to 'stygobite' or 'stygobiont'.

P2 L38: ... groundwater ... is not yet recognized as a protected habitat ... reword this part of the sentence. What you probably mean is that gw is not yet recognized as an ecosystem that deserves protection.

P2 L39: change 'assessing groundwater ecology' into 'assessing groundwater ecological status'.

P3 L59: delete 'Unfortunately'. Not needed.

P3 L65: do the temp fluctuations range between 4°C and 20°C or is there a temp fluctuation with a temp range between 4°C and 20°C. Try to be more precise with your

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wording.

P3 L73: change 'clearly increasing' to 'increased and 'usually decreases' to 'decreased'.

P3 L75: Brielmann et al. 2011 not 20011!

P3 L79: The UBA did not develop anything! The UBA funded a research project in which these tools you refer to were developed. Rephrase this sentence.

P4 L96: change 'waterside filtration' to 'river bank filtration'.

P4 L98: 'beneath' an urban area

P4 L99: you can not sample thermal properties. You collected or sampled gw fauna and 'analyzed' gw chemistry and measured gw temp.

P4 L100: Again, it is not the classification scheme of the UBA.

P4 L101: 'state of ecosystem quality' sounds weird.

P4 L116-117: annual mean LST! Is this what you mean?

P4 L120: Didn't you specifically 'analyze' statistically if wells in the area of known contaminations show different features than others?

P7 L149 ... classification scheme in the framework of a research project funded by the ...

P7 L152: O.K. is an improper term in this connection

P11 L207: chemical characteristics do not distribute! There is distribution patterns.

P13 L242: 'Larger'!

P13 L252: 8.3 mg/l is 'not' a rather high nitrate content! Same applies to P13 L257.

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