

## Author's response to editor's and referee's comments on hess-2020-151

“Groundwater fauna in an urban area: natural or affected?”

5 **Dear Editor,**

We would like to thank you for the opportunity to once more revise our manuscript, for your time and for the constructive comments. We are convinced that we have fully addressed now all comments and substantially improved the manuscript.

10

In general, our replies to the comments are highlighted in blue.

Best regards,

Fabien Koch, on behalf of all authors

15

**Editor:**

Comments to the Author:

20

The reviewer acknowledged the improvement of the manuscript. Still, there are parts needing further revisions; mainly for more precise language and more critical evaluation of used methods and found results.

The manuscript can only be accepted for publication if those are corrected accordingly. Therefore, please carefully go through the general recommendation as well as the very detailed suggestions given in the attachment to further improve the manuscript.

25

Response: We agree that the referee gave very detailed and helpful comments for improving the manuscript. Hence, we specified the manuscript's language and as suggested critically evaluated the used methods and results for improving the manuscript.

**Dear Referee #2,**

30 we would like to thank you for your time and the constructive comments, which helped to improve the quality of the manuscript. Please find our detailed replies on the comments below. We hope that we answer all your remarks.

In general, our replies to the referee's comments are highlighted in blue. To highlight the nature of our replies we use a traffic light system indicating agreement with the referee marked in green, partial agreement in yellow, and objections in red.

Best regards,

Fabien Koch, on behalf of all authors

40

**Referee #2:**

The MS has been improved considerably in the second round of revision. Well done. However, there is a few issues left that needs to be considered when submitting the final version ready for publication. First, the abstract needs to be polished. I provided some suggestions in the attached pdf version of the MS. Second, I really ask the authors to replace some of the 'non-scientific' phrasing by clear expressions. Here is one example: To my opinion, it is not an appropriate expression to write "the ecological status of groundwater is O.K." but "the ecological status of groundwater was found very good or good applying tier-one of the groundwater ecosystem status index (GESI)". I suggest to replace all 'gw status is O.K.' statements with mor scientific expressions. Third, the authors say that they only applied tier-one of the GESI in their work because their intention was a first evaluattion of gw fauna in Karlsruhe. I am fine with that. However, i the M&M section it is mentioned that, whenever the tier-one assessment leads to a status that is not very godd or good, tier two shuld follow which involved the deliniation of a regional or even local natural reference status. Groundwater ecosystems in Germany are very heterogeneous. As such, it is very likely that the reference values provided by Griebler et al. (2014) are not perfect/ideal for the situation in Karlsruhe. In such as case, considering local or regional peculiarities and the definition of

55

60 site-specific reference values would lead to much more reliable results of the assessment. This point needs to be discussed and best also mentioned in the abstract (see my suggestions in the pdf). The important point here is that the authors cannot be sure that applying tier-two would lead to a much better separation of forested sites and residential/commercial/industrial sites. Or in other words, failing of tier-one of the GESI approach may be caused by lack of a local reference data set. Forth, all sites investigated are in urban area (city of Karlsruhe). I suggest to distinguish the urban area into the two categories 1. residential/commercial/industrial areas and 2. forested areas. A forest in a city is maybe not a 'natural' area. A few more minor points are highlighted in the pdf file.

65 Response: Thank you for the critical assessment of our study. We address your specific comments in detail below. We fully agree to reformulate parts of the abstract, replace the 'non-scientific' phrasing by clear expressions in the whole manuscript and discuss the issue of local reference values (see 'specific comments').

### Specific comments

70 Comment #1. First, the abstract needs to be polished. I provided some suggestions in the attached pdf version of the MS.

Response: We agree to reformulate parts of the abstract. Our changes are listed in the following:

Line 12: We agree to delete the word 'tier'. Done.

75 Lines 13-14: We agree to replace the word 'assess' by 'examine', because in this context 'explored' sounds too dramatically in our opinion. Moreover, we agree to replace 'condition' by 'status' as well as to delete the words 'the groundwater'. Furthermore, we agree to add 'in the city of' and to delete the last part of the sentence ('and a nearby forest').

80 Lines 14-16: We do not agree to add 'a' in front of classification, but we agree to add the other suggestions. Thus, we have reformulated the sentence as follows:

“For classification, we apply the groundwater ecosystem status index (GESI), in which a threshold of more than 70 % of Crustaceans and of less than 20 % of Oligochaetes serves as an indication for very good and good ecological conditions.”

85 Lines 16-17: We partially agree to distinguish the urban area into the two categories. We agree that a forest outside a city area might not classify as a 'natural' area. Moreover, parts of the forest containing the measurement wells belong to the districts 'Neureut' and 'Waldstadt' and therefore to the city area of Karlsruhe. Thus, we agree to reformulate the phrasing in the sentence:

“Our study reveals that only 35 % of the wells in the residential, commercial and industrial areas and 50 % of wells in the forested area fulfil these criteria.”

90 Lines 17-18: We agree to delete the beginning of the sentence and 'and nitrate concentrations'.

Lines 19-21: We agree to reformulate the sentence and thus accepted the suggestions:

95 “Nevertheless, there are noticeable differences in the spatial distribution of species in combination with abiotic groundwater characteristics in groundwater of the different areas of the city, which indicate that a more comprehensive assessment is required to evaluate the groundwater ecological status in more detail.”

Lines 21-23: We agree and added the suggested, final sentence together with further information:

“In particular, more indicators, such as groundwater temperature, indicator species, delineation of site-specific characteristics and natural reference conditions should be considered.”

100 Comment #2: Lines 26 & 31: This is not an appropriate journal to be cited if there is alternative publications to be cited.

105 Response: We agree that there are alternative publications to be cited. Thus, we replaced the study of Avramov et al. (2010) by (German Environment Agency, 2018) in the first sentence of the paragraph and by Griebler and Avramov (2015) and Boulton et al. (2008) in the last sentence (see manuscript).

Comment #3: Line 78-79: Is this true. I would rather say, there is already some threshold or target values published but none of these have been implemented in official regulations and water law.

Response: We agree and thus added this information as follows:

110 “Until now, there are scientifically derived threshold values for groundwater temperature in the case of thermal (heat) pollution published, but none of these have been implemented in official regulations or water law (Hähnlein et al., 2010, 2013; Blum et al., 2021).”

Comment #4: Line 91ff: The GESI of Griebler et al. (2014) builds on the assessment scheme of Korbel & Hose 2011. Better to mention this one in front of the GESI approach.

115 Response: We agree. Therefore, we placed the approaches in chronological order.

Comment #5: Lines 112-113: I suggest to distinguish between 1. residential, commercial, and industrial areas, and 2. forested areas within the 'urban' area of the city of Karlsruhe.

Response: As already mentioned in Comment #1, we agree and added the suggestions.

120 “The objective of this study is to investigate specifically the groundwater fauna beneath residential, commercial and industrial, i.e. urban areas in comparison to a forested area outside the built-up area of Karlsruhe to determine whether land use has an impact on groundwater faunal communities.”

125 Moreover, we apply this change in the whole manuscript, like for example at the beginning of chapter 2.2 and 3.1.

Comment #6: Line 189-190: This is a weird sentence. too many repetitions. rephrase!

Response: We agree. Hence, we rephrased the sentence as follows:

130 “If an ecological assessment of groundwater ecosystems, which is based on groundwater fauna analysis, takes place, some faunistic criteria must be considered.”

Comment #7: Line 197: In theory, when tier-one does not deliver a clear result or 'negative' results one need to go to tier-two (Korbel & Hose 2011, Griebler et al. 2014). Here you stop at tier-one, although  
135 many wells are classified affected. It is very likely that goig on with tier-two and definig a location-specific reference data set for 'natural conditions' will lead to a new outcome. As such, one can only judge about the two-tiered approach after using both tiers.

Response: As it is mentioned in the manuscript, our aim was a first screening of an urban area, whereas we only applied Level 1 in our study. We agree, that one can only judge about the Level  
140 2 approach after using it. Therefore, we mentioned in the abstract and conclusion that the delineation of site-specific natural reference conditions and the use of Level 2 will be a next logical step. Moreover, we added information to the discussion of chapter 3.3 as follows:

“Because of heterogeneous groundwater ecosystems in Germany it is likely that reference values provided by Griebler et al. (2014) do not reflect the situation in Karlsruhe correctly. Considering  
145 site-specific characteristics and reference values would lead to a more robust assessment.”

Comment #8: Line 244: If this is the average nitrate concentration of all wells then it cannot be a range from xx-xy, but one value with a standard deviation, isn't it?

Response: We agree that this sentence can be misunderstood. In this case we mean that the average  
150 nitrate contents of all wells varies between 1.3 and 14.7 mg/l. To clarify this, we rephrased the sentence as follows:

“In our study area, the average nitrate contents of all wells vary between 1.3 and 14.7 mg/l.”

Comment #9: Line 247: ‘most likely caused’ instead of ‘caused’

Response: We agree and added ‘most likely’.  
155

Comment #10: Line 249: ‘promotes’ instead of ‘is characterized by’

Response: We agree and replaced ‘is characterized by’ by ‘promotes’.  
160

Comment #11: Line 269: mention the percentage of colonized wells

Response: **We agree.** We added the percentage of colonized wells as follows:

“In the pool of samples, 3,666 individuals were detected in 37 of 39 wells, which means that 95 % of the wells are colonised (Table S3).

165

## References

- Avramov, M., Schmidt, S. I., München, C. G., Jürgen, H. and Berkhoff, S.: Dienstleistungen der Grundwasserökosysteme, KW - Korrespondenz Wasserwirtschaft, 3(2), 74–81, doi:10.3243/kwe2010.02.001, 2010.
- 170 Blum, P., Menberg, K., Koch, F., Benz, S. A., Tissen, C., Hemmerle, H. and Bayer, P.: Is thermal use of groundwater a pollution?, J. Contam. Hydrol., 103791, doi:10.1016/j.jconhyd.2021.103791, 2021.
- Boulton, A. J., Fenwick, G. D., Hancock, P. J. and Harvey, M. S.: Biodiversity, functional roles and ecosystem services of groundwater invertebrates, Invertebr. Syst., 22(2), 103–116, doi:10.1071/IS07024, 2008.
- 175 German Environment Agency: Bericht des Bundesministeriums für Gesundheit und des Umweltbundesamtes an die Verbraucherinnen und Verbraucher über die Qualität von Wasser für den menschlichen Gebrauch\* (Trinkwasser) in Deutschland 2014 – 2016, Dessau-Roßlau., 2018.
- Griebler, C. and Avramov, M.: Groundwater ecosystem services: A review, Freshw. Sci., 34(1), 355–367, doi:10.1086/679903, 2015.
- 180 Griebler, C., Stein, H., Hahn, H. J., Steube, C., Kellemmann, C., Fuchs, A., Berkhoff, S. and Brielmann, H.: Entwicklung biologischer Bewertungsmethoden und -kriterien für Grundwasserökosysteme, Umweltbundesamt., 2014.
- Hähnlein, S., Bayer, P. and Blum, P.: International legal status of the use of shallow geothermal energy, Renew. Sustain. Energy Rev., 14(9), 2611–2625, doi:10.1016/j.rser.2010.07.069, 2010.
- 185 Hähnlein, S., Bayer, P., Ferguson, G. and Blum, P.: Sustainability and policy for the thermal use of shallow geothermal energy, Energy Policy, 59, 914–925, doi:10.1016/j.enpol.2013.04.040, 2013.