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Comment on hess-2021-364

Anonymous Referee #1

Referee comment on "Contrasting lacustrine groundwater discharge and associated nutrient loads in different geological conditions" by Xiaoliang Sun et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-364-RC1>, 2021

The manuscript "Contrasting lacustrine groundwater discharge and associated nutrient loads in different geological conditions" by Xiaoliang Sun and co-workers focuses on an important and understudied topic: Lacustrine groundwater discharge (LGD) and associated nutrient loads are often quite relevant for lakes but there has been little research on these exchange processes. As the authors state, the impact of different geologic settings has not been studied yet and it is commendable that the authors promise in the title that they will address this issue. Thus, the paper promises to address relevant scientific questions within the scope of HESS? However, I don't think that the present manuscript focuses on different geologic conditions. First of all, the authors study only two different sites, i.e. geologic settings. Unfortunately, the authors don't describe in detail in which parameters the sites differ exactly and in which not. What about anthropogenic impact? The flow through EEDL and WEDL is obviously quite different and this will probably also have impacts on the results and not only the geologic situation.

In general the study is well written in good English and mostly easy to understand. The data used in the study are novel. However, the number of studied samples is quite small and thus, the study is of limited value. There is no or insufficient information about repetitions, methodological uncertainties, weather impacts on radon concentrations, shore distance of sampling points, depth of groundwater sampling etc. Additional severe weaknesses are listed below in more detail. A rough estimation suggests that the calculated LGD rates are impossible. I don't think that it is possible to overcome the shortcomings of the present study with a few additional investigations and more detailed discussions. Instead, I recommend considering the current results as a pre-investigation and basis for a future more in depth study. Based on additional sampling points and additional methods to quantify LGD rates I am sure that substantial conclusions can be reached. Currently the results are insufficient to support the interpretations and conclusions.

General comments:

Please report water retention times in WEDL and EEDL.

L141ff: I disagree. You state that there is flow parallel to the shore line. This is only possible if there is a completely sealed lakebed with no hydraulic conductivity at all. In a lake there is typically no gradient of the surface water level, i. e. the water level is spatially constant. For groundwater flow parallel to the shore line you need some kind of water level gradient in the aquifer. That gradient and the constant lake level will result in a gradient between lake and groundwater at most locations along the flow path. Thus, flow parallel to the lake won't occur.

L152ff: As far as I understand there were only two field campaigns in January 2019 and January 2020 with a total of 32 samples, thereof 12 groundwater samples and 17 lake water samples. It is not mentioned which samples were collected in 2019 and which were collected in 2020 or if some locations were sampled in both years. The numbers are quite small for reliable results considering the spatial heterogeneity of the aquifer, of the sediment, of the lake and the size of the investigated system. Furthermore, it is mentioned that samples were collected from local wells with depths of 5-30 m and by push points from 1 m depth. The sampling depth might impact on the results. Unfortunately, it is not mentioned which samples were collected from which aquifer depth and if both depths were used at both sites.

Even though radon in surface water originates from groundwater it will depend very much on the distance of the sampling location to the shore and on the water depth which radon concentrations occur. However, shore distances aren't reported in the manuscript. Furthermore, weather conditions (especially wind) will affect the loss of radon to the atmosphere. Weather conditions aren't reported in the manuscript in sufficient detail. The dependency on weather conditions results in a severe need of replicates which weren't taken in the present study. Repetitions are required for reliable results. L174ff: I am also missing information about the detection limit of the radon measurements (Rad7, Rad H2O).

L167ff: The manuscript is according to the paper title about nutrients but I could not find any information about phosphate measurements in the method section.

L291f: I don't see any similarity in ^{222}Rn concentration between lake water and groundwater. Can you explain this a little bit more?

L305ff & Fig. 5: I don't see any use in flow profiles in WEDL and EEDL. As mentioned before, the water retention times in the lake basins aren't reported in the present study. However, due to the short half live of radon and the intense atmospheric loss a focus on radon along flow paths in the lake would only be useful if the water retention times in lakes are in the range of less than a week. Even though that information is missing I doubt that there is such a fast water exchange. I think the radon profile is more impacted by the distance to the shore, the current wind direction and the weather conditions. Furthermore, in Fig. 5 error bars are missing for radon measurements. Radon measurements should have been repeated at several time points in the course of a year. The conclusion that ^{222}Rn originates from groundwater discharge is unclear. Actually, this is a prerequisite of the method and not a conclusion.

L310ff & Fig. 5: In Fig. 5 error bars are also missing for stable isotope measurements. The measurements of stable water isotopes should have been repeated at least 5 times under different weather conditions. As you state the $\delta^{18}\text{O}$ value increases due to evaporation from the lake surface. It would have been good to get at least a rough estimation of the water retention time along the flow path and the amount of evaporation to be able to understand if any gradient of stable water isotopes along the flow path is possible. I doubt that your explanation is useful. Usually, in most lakes lateral mixing processes are so

important that the stable water isotope composition is more or less identical in the entire lake. This is usually also true for stable water isotopes originating from groundwater discharge. The difference in the stable water isotope composition of exfiltrating groundwater and lake water is so small that it is hardly detectable since the proportion of groundwater is relatively small. The major difference between stable water isotopes and radon and why radon is a suitable groundwater discharge tracer whereas stable water isotopes aren't is that the radon concentrations in groundwater are several orders of magnitude larger than in lake water whereas stable water isotopes deviate only slightly between lake water and groundwater. Looking at the groundwater concentrations reported in Fig. 5 reveals this problem clearly.

L326ff and Fig. 6: I have not seen a distribution of EC in groundwater in the catchment of EDL. However, without such data this interpretation is quite vague. Also, the correlation presented in Fig. 6a is mainly based on one single data point.

L339f: Is this about surface inflows or groundwater inflow or both? On which data is this statement based. According to the method description you conducted only investigations in Jan. 2019 and Jan. 2020.

L351f: Are two sediment samples sufficient for a lake of this size. Is anything known about sediment heterogeneity?

L347ff: I doubt that the numbers calculated by you for groundwater discharge are possible. WEDL has an area of 173 km², i.e. is a quite large lake. According to your calculation the average groundwater discharge is 93 L/m²/d which is a quite large number compared to other lakes especially when considering the size of the lake. Usually, average LGD rates decrease drastically with increasing lake area. Furthermore, most lakes exhibit an exponential decrease of LGD rates with increasing shore distance, i.e. LGD rates close to the shore would be several orders of magnitude higher and more or less zero in the lake center. This is especially true in shallow lakes because a thick mud layer in the lake center will intensify the focusing to the lake shore. I doubt that 93 L/m²/d as average rate is possible. In addition: Do you know the size of the catchment and the groundwater recharge rate in the catchment? Assuming an extremely high groundwater recharge rate of 500 mm/yr and the complete absence of any groundwater-fed streams or surface water bodies in the catchment would require a catchment size of 66 times the lake area to deliver a sufficient amount of groundwater to feed the lake with 93 L/m²/d. Unfortunately, the size of the catchment and the groundwater recharge rate in the region aren't reported in the manuscript. Probably, the number of radon samples is too small and not representative for the entire lake.

L398ff: Since the calculations of nutrient loads are based on the erroneous calculation of LGD rates these calculations are not useful at all. The same problem applies to the contrasting spatial patterns of LGD and associated nutrient loads and the conclusion.

Technical corrections (Please note that I am no native speaker and my suggestions might be wrong):

L11: has not been

L12: loads at two sites

L34: groundwater can be an important component of lake water budgets

L37: delete "globally"

L38: impacts on lake water

L44: geomorphology

L54: has not been

L64: and it also has

L72: has not yet been studied.

L117, L119: originating

L184: Schmidt et al.

L238-240: Are you referring here to lake water levels of EDL. A variation of 1.2 meters is quite a lot. Is this a temporal variation or a spatial variation? An if this is a temporal variation are these data from the two measurement campaigns in January 2019 and January 2020 or from different dates?

L246: How does the range of groundwater levels and lake levels reported as 15.6 to 20.4 m fit to the groundwater levels around EDG ranging from 23.2 to 41.9 m (reported in line 239).

L246-257: I do not really understand the purpose of the lake water quality parameters such as dissolved oxygen, pH, redox, temperature etc. in the context of the present paper and reported here in much detail.