Anonymous Referee #2:

General Comments

This is potentially an interesting and valuable dataset; however, the paper as written does not do it justice. Most of the sections of the paper are too long and lack focus. The Introduction and Study Area sections are generally clearly written but it is not always clear how the information here relates to the groundwater chemistry (which is the main topic). They should be shorter and better focussed on the specifics of the work carried out.

Response: We will make substantial changes in response to this comment, and related subsequent comments (below), including a re-origanization of the paper to be shorten and highlight the key points. We will condense the Introduction and Study Area to fucus on background issues relevant to the topic.

Unfortunately, the Results and Discussion sections which are critical to the study are very hard to follow. Material is repeated, the writing is difficult to understand in places, and it is not clear what is important. The interpretation of the data (in particular the ^{14}C) is superficial and uncritical. These sections really need rewriting.

Response: We will thoroughly revise the Results and Discussion to reduce repetition and give it a good readability. We will re-examine the interpretation of ^{14}C data, and further revise the text according the related subsequent comments.

The Conclusions and Abstract also need to convey something of the general importance of this study and how it relates to work occurring elsewhere. Case studies are publishable in international journals such as HESS. However, unless they have relevance to researchers working elsewhere, they may be better in a regional journal.

Response: The Conclusions and Abstract will be re-organized and highlighting the relationship between researching elsewhere and the contribution made in this case. The relationship between this study and other research is as follows:

Variable groundwater types, including fresh, brackish, saline or brine, have been found in global coast areas (Larson et al., 2017), such as Nile delta (van Engelen et al., 2019), Mediterranean (Antonellini et al., 2008; Sola et al., 2014) and Bohai Sea coast (Liu et al., 2017; Li et al., 2017). Marine transgression deposits are often put forward to explain observed saline groundwater, while fresh and brackish are related to flushing during the river deposits development (Post, 2004; Santucci et al., 2016; Han et al., 2020). Many researchers believe the hypersaline (or brine) groundwater are associated with fine sediments of barrier-lagoon environments during Middle Holocene (Giambastiani et al., 2013; Vallejos et al., 2018). Few previous studies examined cases involving multiple salinized processes and groundwater evolution throughout sedimentary deposition. Luanher River Delta (LRD) is a typical fan-shape delta developed from wave domination, which is similar to Nile delta. This study provided a novel case study, using a series of hydrochemical, isotopic and sedimentary indicators to identify the evolutionary pattern of saline groundwater and its link to LRD sedimentary setting. The insights of this study are also applicable to salinized aquifers throughout the world that have a similar sedimentary history, like Po River Delta in Italy (Colombani et al., 2017), Laizhou Bay in China (Han et al., 2014) and Western Port Bay in Australia (Lee et al., 2016).

Reference:

Antonellini, M., Mollema, P., Giambastiani B., et al. 2008. Salt water intrusion in the coastal aquifer of the southern Po Plain, Italy. Hydrogeology Journal, (2008) 16:1541-1556.

Caschetto, M., Colombani, N., Mastrocicco, M., et al.,2016. Estimating groundwater residence time and recharge patterns in a saline coastal aquifer. Hydrological Processes, 2016.

Colombani, N., Cuoco, E., Mastrocicco, M., 2017. Origin and pattern of salinization in the Holocene aquifer of the southern Po Delta (NE Italy). Journal of Geochemical Exploration, 175: 130-137.

Giambastiani, B., Colombani, N., Mastrocicco, M., et al., 2013. Characterization of the lowland coastal aquifer of Comacchio (Ferrara, Italy): Hydrology, hydrochemistry and evolution of the system. Journal of Hydrology, 501: 35-44.

Han, D. M., Song, X. F., Currell, M. J., et al., 2014. Chemical and isotopic constraints on the evolution of groundwater salinization in the coastal plain aquifer o fLaizhou Bay,China, Journal of Hydrology, 508, 12-27.

Larsen, F., Tran, L. V., Van Hoang, H., et. al., 2017. Groundwater salinity influenced by Holocene seawater trapped in incised valleys in the Red River delta. Nature Geoscience, 10, 376-381.

Lee, S., Currell, M., and Cendon, D. I., 2016. Marine water from mid-Holocene sea level highstand trapped in a coastal aquifer: Evidence from groundwater isotopes, and environmental significance. Science of the Total Environment, 544, 995-1007.

Li, J., liang, X., Jin, M. G., et al., 2017. Origin and Evolution of Aquitard Porewater in the Western Coastal Plain of Bohai Bay, China. Groundwater, 55(6):917-925.

Liu, S., Tang, Z., Gao, M. et. al., 2017. Evolutionary process of saline-water intrusion in Holocene and Late Pleistocene groundwater in southern Laizhou Bay. Science of The Total Environment, 607-608, 586-599.

Post V. E. A., 2004. Groundwater salinization processes in the coastal area of the Netherlands due to transgressions during the Holocene. Thesis, Vrije Universiteit, Amsterdam.

Vallejos, A., Sola, F., Yechieli, Y., Pulido-Bosch, A., 2018. Influence of the paleogeographic

evolution on the groundwater salinity in a coastal aquifer. Cabo de Gata aquifer, SE Spain. Journal of Hydrology, 557 (2018) 55-66.
van Engelen, J., Verkaik, J., King, J., et al., 2019. A three-dimensional palaeohydrogeological reconstruction of the groundwater salinity distribution in the Nile Delta Aquifer. Hydrology and Earth System Sciences, 23, 5175-5198.
Sola, F., Vallejos, A., Daniele, L., Pulido-Bosch, A., 2014. Identification of a Holocene aquifer–lagoon system using hydrogeochemical data. Quaternary Research, 82 (2014) 121-131.

Specific Comments

Abstract

The abstract is not clearly written and not that informative. For example, "The results of hydro-geochemical modeling (PHREEQC) suggest that the salty sources of salinization are seawater and concentrated saline water (formed after evaporation of seawater)" is not clear.

Response: We will recheck this section, and rephrased the sentences which are not clear.

There is also a lot of repetition: Page 2 lines 10-20 give the same information three times and some of the same information also appears on Page 3 lines 1 to 6.

Response: We will remove the repetition texts.

Try to put a bit more detail into the abstract (report the important results and highlight the important general points) rather than just the repeated brief summaries. Abstracts are important as they are what the reader uses to see if the paper might be worth reading, so they need to convey enough detail and a sense of importance.

Response: We will integrate more detail information about the important results and key points into the Abstract.

Introduction

The introduction covers a lot of topics, but it is not clear how the paper will address these topics. It has a general literature review feel to it rather than setting up the study. The final sentence seems to be indicating how prior research on sediment cores helps, which is not what the paper is about. Try to focus on aspects that relate more directly to the study and add an objectives section at the end so the reader has an idea of what you are trying to achieve.

Response: We will improve the Introduction to focus on background issue relevant to the topic, and add a paragraph to clearly introduce the objectives of this study.

Study area

This is comprehensive, but like much of the paper it is long. What details are important here and focus on those. Some of the geological history is a bit superfluous.

Response: We will remove the superfluous texts.

Results

The sections on major ion geochemistry (4.1) and stable isotopes (4.2) present the data but could be more succinct. There is a tendency to repeat information (especially in the major ion section).

Response: We will recheck the section 4.1 and 4.2, and remove the repeated information.

More importantly, there are some data that you interpret in Section 5 that would have been better presented here, for example you introduce Fig. 6 in section 5. If you are going to split the discussion from the results, make sure that you are not describing data in the discussion section.

Response: We will make change to ensure description of data is confined to Section 4.

Radiocarbon (Section 4.3)

This section deals with the data in a superficial way. Conventional radiocarbon ages assume simple one-dimensional, non-dispersive flow (piston flow) such that all the groundwater collected at the well was recharged at the same time. This is obviously an oversimplification as groundwater flows along paths of varying lengths and undergoes hydrodynamic dispersion and diffusion. Thus, groundwater has a range of residence times and, while a mean residence time may be defined, this does not equate to a specific age (Maloszewski and Zuber, 1982; Cook and Bohlke, 2000; Suckow, 2014). The use of a uniform input value for ^{14}C of 100 pMC rather than accounting for the long term variation in atmospheric a^{14}C also yields "ages" in radiocarbon years (not ages BP as is in Table 2).
The combination of a variable atmospheric A^{14}C and more realistic flow models makes a non-trivial difference to calculated residence times of up to several thousand years in some cases (i.e. it is not just a matter of terminology: e.g., Cartwright et al., 2020).
Additionally, many regional aquifers show macroscopic mixing between younger and older groundwater such that there are large volumes of groundwater that contain tritium but which also have "old" ^{14}C (Jasechko, 2016; Jasechko et al., 2016). While you may

not have the data to assess some of these issues, you should at least acknowledge them and recognise the limitations. The correction for addition of ^{14}C-free carbon from the aquifer matrix is not always correct. A simple way to check on the reasonableness of this calculation is to estimate what the initial $A^{14}C$ of the Modern waters are. Those waters were recharged over the last few decades (post nuclear tests) so there has been negligible decay of ^{14}C and the initial $A^{14}C$ = measured ^{14}C / q. The estimated initial $A^{14}C$ values for the data in table 2 are: G01 = 125 pMC, G06 = 169 pMC, G07 = 104 pMC, G08 = 150 pMC, G09 = 139 pMC

The ^{14}C activities in the atmosphere were as high as this following the nuclear tests but soil zone CO_2 (from where groundwater derives its DIC) are generally below 120 pMC (Jenkinson et al., 1992; Tipping et al., 2010) and I am not aware of modern groundwater with ^{14}C activities any higher than that. Anomalously high estimates of initial $A^{14}C$ (above 120 pMC) indicate that the correction cannot be correct. That is not necessarily surprising as the ^{13}C of the end-members are not always well known and can be locally variable, and there are other unaccounted for processes (such as methanogenesis, open system calcite dissolution, recharge from river systems) that may be locally important. However, this needs to be recognised rather than just presenting the results uncritically.

Response: We are aware of that interpretation of ^{14}C data define a mean residence time of groundwater, instead of specific age. We are sorry for the unprecise expression in this section. According the above comments, we recognized that some factors including possible factors that may influence the ^{14}C value and, limitations of the correction should be taken into considerations. To interpret the ^{14}C data properly, the improvements of this section would be done.

The distribution of ^{14}C activities with depth implies that the general interpretation here is correct; however, the details of the interpretation are oversimplified; at the very least some error propagation is needed.

Response: We will conduct more uncertainty analysis about groundwater residence time in this part.

Discussion

This is not very well written and it loses focus. I generally agree with the results but the explanations tend to be overly long and very confused.

Response: A full-reorganisation of this section will be conducted to ensure most of the introductory material is significantly condensed and consolidated.

Section 5.1

The relative residence times here are fine; however, this section needs to deemphasise the discussion of absolute ages (see above).

Response: We will make change to avoid the discussion of absolute ageds.

Some of the terminology is poor ("has a slightly higher stable isotope content than deeper groundwater, which is typical of the recharge source as the atmosphere has changed since the last deglaciation") – I can guess what this means but it is verging on being unintelligible.

Response: The sentences will be rephrased.

Some of the material here is repeated later – for example you discuss mixing at the bottom of page 20, but that is repeated in Section 5.3

Response: We will merge the repeated part into Section 5.3.

Section 5.2.

I am not sure what the Scholler plot adds. It is a common observation that saline groundwater has a similar geochemistry to ocean water (not because it is always necessarily derived from ocean water as mineral precipitation and ion exchange can modify its geochemistry during evaporation). You have reported the salinities and water types, which is enough.

Response: We will remove the interpretation of Scholler plot to avoid superfluous discussion.

Here again, the explanation of the results is not always clear (e.g., "the salinity of salinization groundwater mainly originates from seawater or, the CSW which is subject to evaporated seawater" and "Due to reach saturation, there were loss of ions follow mineral precipitation such as…" and "Calcite and gypsum will be dissolved along with surface water during lateral recharge, resulting in brackish groundwater samples plotted above the mixing line, highlighting surface water flushing processes in the study region"). Having to guess the meaning of these sentences detracts from the study.

Response: We will rephrase the sentences to make sure that the meaning is clear.

It is not always clear what the important points are here, so while you are probably interpreting the processes correctly, why are they important? Somewhere in this section, you need to explain how this information relates to your overall objectives and why these pieces of information are important.

Response: This section will be further improved to clearly explain the implication of salty sources and hydrochemical evolution for salinization processes.

Section 5.3.

The general model of mixing (Fig. 9) is also probably correct and it is clearer from the objectives why you are doing this. However, again this section could be shorter; the general introduction on the first few lines is probably not needed and the explanations on Pag 25 are repetitious. As with the rest of the discussion section, there are no attempts to justify the results (the end-members for example are just assigned without comment).

Response: According the comments, we will remove the superfluous part, and further discuss the reasonability of end-members in different mixing processes.

Section 6

This is far better written than most of the paper. It is still long and some of the narrative could be shorter. This material is not generally well linked to the geochemistry and it is not always clear how much it is a synthesis of previous studies rather than a discussion of this study.

Response: The texts will be shortened, and revised to clearly delineates the roles of hydrochemistry in evolutionary pattern of groundwater.

Conclusions

Most of these repeat details from the main part of the study. It would be better with a much briefer summary of these and some consideration of how what you have done here has improved understanding of processes in these environments more generally. Also, how do your results fit into the broader research going on elsewhere. Explaining that will give the paper more impact.

The last paragraph does not relate well the to study as there is no discussion of groundwater levels, monitoring, or policy. While those things may be important, it is not clear how your research informs them. Perhaps that could be the focus of this section?

Response: According to comments, we will re-organize the Conclusions, and rewrite the last paragraph to highlight how the insights of this study improve understanding of groundwater salinization elsewhere, to increase the global relevance of the paper.