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Solid Earth Discussions

Interactive comment on "Mineral leaching chemicals transport with runoff and sediment from severely eroded rare earth tailings in southern China" *by* Huizhong Lu et al.

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Dear editor,
We are very grateful for you and the reviewers' comments and suggestions about this paper. Those comments are very valuable and helpful for revising and improving our manuscript, as well as the important guiding significance for our researches.
According to these revision suggestions, we have carefully addressed the comments and made revision in detail as following.
Sincerely yours,
Huizhong Lu

Response to reviewer's comments

Issues raised by Reviewer #2:
Question 1: The title, keywords and running title are all present and appropriate. Abstract, In general, the abstract is appropriately states the nature of the research but not its significance. Please list methods, main findings, etc.
Response: Thank you so much for your comments. We have revised the abstract in P1L13 to P1L35 as following:
[Background] Rare earth mining has led to severe soil erosion in southern China. Furthermore, the presence of the mineral leaching chemical ammonium sulfate in runoff and sediment poses a serious environmental threat to downstream water bodies.
[Methods] In this paper, the characteristics of mineral leaching chemicals in surface soil samples collected in the field were studied. In addition, NH_4^+ and SO_4^{2-} transport via soil erosion was monitored using runoff and sediment samples collected during natural rainfall processes.
[Main findings]The results demonstrated that the NH_4^+ contents in the surface sediment deposits increased from the top of the heap (6.56 mg/kg) to the gully (8.23 mg/kg) and outside the tailing heap (13.03 mg/kg). The contents of SO_4^{2-} in the different locations of the tailing heaps ranged from 27.71 to 40.33 mg/kg. During typical rainfall events, the absorbed NH_4^+ concentrations (2.05, 1.26 mg/L) in runoff were significantly higher than the dissolved concentrations (0.93, 1.04 mg/L), while the absorbed SO_4^{2-} concentrations (2.87, 1.92 mg/L) were significantly lower than the dissolved concentrations (6.55, 7.51 mg/L). The dissolved NH_4^+ and SO_4^{2-} concentrations in runoff displayed an exponentially decreasing tendency with increasing transport distance (Y=1.02*exp(-0.00312X), Y=3.34*exp(-0.0185X)). No clear trend with increasing distance was observed for the absorbed NH_4^+ and SO_4^{2-} contents in transported sediment. The NH_4^+ and SO_4^{2-} contents had positive correlations with the silt and clay ratio in transported sediment but negative correlations with the sand ratio.
[Conclusion] These results provide a better understanding of the transport processes and can be used to develop equations to predict the transport of mineral leaching chemicals in rare earth tailings. These can provide scientific foundation for erosion

control and soil management in rare earth tailings regions in southern China.

Question 2: Introduction The introduction given is relatively brief but does offer a good introduction to rare earth tailings. It would be useful to present some information about the rare earth elements, this should be stated as part of the rationale/objectives at the end of the introduction.
Response: Thank you so much for your suggestion. We have added some information about the rare earth elements and the REE mine in southern China. "Rare earth element (REE) refers to 17 elements containing lanthanide series along with scandium and yttrium (Khan et al, 2016)." The ion-adsorption deposits were formed by chemical weathering decomposition and dissolution of granite and granite porphyry (containing relative high abundance of REE) (Yang et al., 2013). The main ore body contains 0.05-0.2 wt% REE grades and strong cerium anomalies are found." Please refer to the P2L9, and P2L15.

Question 3: At the end of the introduction, it would be helpful to offer a brief, clear statement of the objective of this review. Such a statement would provide a transition to the main ideas being presented.
Response: Thank you very much for your suggestion. We have added some statements at the end of the introduction: The aim of a 2-year field study of runoff and sediment during natural rainfall events in a rare earth tailing area was to (1) get a knowledge of the two leaching chemicals spatial distributions at different locations around the tailing heaps and (2) determine the transport characteristics and influence factors of the two leaching chemicals in runoff, including both dissolved and adsorbed components. The results of this study may help the managers of mining to select effective and appropriate measures to reduce the contamination of REE mining areas in southern China. Please refer it in P3L22.

Question 4: In general, each figure is not presently referred to in the main text. In my view, this limits their usefulness to the reader. In my view this limits their usefulness to the reader. The figures should help the reader understand the main arguments of

the author and, as such, should be introduced in the main text. The titles to the figures could be more descriptive and should include definitions for terms of phases used in the figure itself.
Response: Thank you very much for your comments and suggestions.
Each figure has already been referred to in the main text. Please refer to figure 1 in P4L18, figure 2 in P7L24, figure 3 in P8L11, figure 4 and figure 5 in P9L3.
The titles to the figures have also been changed accordingly:
Figure 1.Study area and sampling design
Figure 2. Dissolved NH_4^+ and SO_4^{2-} concentrations variations with increasing transport distance in runoff
Figure 3. Absorbed $NH_4^+$and SO_4^{2-} concentrations variations with increasing transport distance in runoff
Figure 4. Absorbed NH_4^+ concentrations as a function of sand, silt and clay contents
Figure 5. Absorbed SO_4^{2-} concentrations as a function of sand, silt and clay contents

Question 5: Although no specific "Discussion" section is presented, I will include comments here on the main body of the text of the paper. * The main body of text is relatively concise given the wide range of topics covered. However, the text is somewhat disjointed and disorganized. The use of headings for sections and sub-sections is not clear and leads to confusion. The various sections of the main body of text do not seem to flow very smoothly. Please consider the overall structure of the paper to ensure that similar sections. Additionally, please consider defining any technical terms used in the section headings.
Response: Thank you very much for your comments and suggestions. We have already taken over the main body and then made adjustments. Now the heading of section 2.2 was changed from "Sample collection" to "Sampling procedure". We deleted the similar analytical methods part in this section 2.3. The heading of section 3.1 was changed from "NH_4^+ and SO_4^{2-} distributions in surface soils in different positions" to "NH_4^+ and SO_4^{2-} spatial distributions in surface soils". The heading of section 3.2

was changed from "NH_4^+ and SO_4^{2-} concentrations in runoff and sediment" to "Dissolved and absorbed NH_4^+ and SO_4^{2-} concentrations in runoff". The section 3.3 and 3.4 were merged into a new section 3.3 and the new heading is "Dissolved and absorbed NH_4^+ and SO_4^{2-} transport characteristics along flow route". The heading of new 3.4 section was changed from "Relationship between absorbed NH_4^+ and SO_4^{2-} and sediment particle size distributions in runoff" into " Variations in absorbed NH_4^+ and SO_4^{2-} contents with sand, silt and clay particles".

Question 6: Conclusions As it stands, the conclusion is quite brief. This section could be improved to better reflect the large amount of information reviewed in relation to the title/objective of the paper. In my view, the conclusions should be expanded to better summarize the overall "feel" of the main review section to give the reader a strong take home message.

Response: Thank you very much for your comments and suggestions. We expanded the conclusion and tried to give the reader a strong take home message. The new section was improved as follow: Large amount of mineral leaching chemicals (NH_4^+ and SO_4^{2-}), were still remaining in rare earth tailings in southern China. By collecting field runoff samples during typical rainfall events in a rare earth tailing area, this study assessed the contents of two mineral leaching chemicals in surface sediments at different positions and provided insights regarding runoff- and sediment-related transport characteristics along the flow route. During typical rainfall events, the absorbed NH_4^+ concentrations in runoff were significantly higher than the dissolved concentrations, while the absorbed SO_4^{2-} concentrations were significantly lower than the dissolved concentrations. The driving mechanism of the NH_4^+ and SO_4^{2-} resulted in their spatial distributions in different locations. NH_4^+ is mainly transported with sediment in an absorbed state, and NH_4^+ content in the surface sediment samples showed an increasing trend from the top of the tailing heap to the area beyond the tailing gullies. Whereas SO_4^{2-} is mainly dissolved and transported with runoff, and the SO_4^{2-} content did not show an observable trend. The dissolved NH_4^+ and SO_4^{2-} concentrations in runoff showed exponentially decreasing trends with transport distance from gully outlets to

the nearby water body as a result of diluting. The absorbed chemicals transport process may be more complex. The absorbed NH_4^+ and SO_4^{2-} concentrations in runoff showed no clear trends with transport distance. Linear regressions were conducted to establish the relationship between the NH_4^+ and SO_4^{2-} concentrations and the sand, silt and clay contents. The NH_4^+ and SO_4^{2-} concentrations tended to be enriched in the silt and clay particles of transported sediment. The above results will aid in better understanding the transport characteristics of mineral leaching chemicals during the erosion process and in developing predictive equations in rare earth tailing areas. Our results suggest that management practices for the soil erosion and soil remediation should be mandatory in rare earth tailings in southern China.Please refer it in P11L43.

Question 7: References. Some of the references are outdated; I suggest the following references should be cited in the manuscript.

1) Chemical speciation and bioavailability of rare earth elements in the ecosystem: a review (2016). Environmental Science and Pollution Research DOI: 10.1007/s11356-016-7427-1

2) Cumulative impacts of dissolved ionic metals on the chemical characteristics of river water affected by alkaline mine drainage from the Kuala Lipis gold mine, Pahang, Malaysia (2015) Chemistry and Ecology. 13 (1): 22-33.
DOI:10.1080/02757540.2014.950569

3) Historical variations of Bera Lake (Malaysia) sediments geochemistry using radioisotopes and sediment quality indices (2013)Journal of Radioanalytical and Nuclear Chemistry, 295(3): 1715-1730, DOI: 10.1007/s10967-012-2270-4

Response: Thank you for your suggestion. We have read the papers carefully and cited them in the manuscript. Please refer to reference 1) in P2L10, P3L16, P11L28, reference 2) in P10L31, reference 3) in P2L3.