Biogeosciences Discuss.,
doi:10.5194/bg-2016-521-AC1, 2017

Biogeosciences Discussions

Interactive comment on "Quantifying nutrient uptake as driver of rock weathering in forest ecosystems by magnesium stable isotopes" *by* David Uhlig et al.

David Uhlig et al.

david.uhlig@gfz-potsdam.de

Received and published: 21 April 2017

We thank the referee for the constructive comments that helped to improve the manuscript. Below we provide a point-by-point reply to these comments.

1. Comment: It would be nice that the authors could give a schematic figure showing Mg fluxes in the studied system with respective delta values, fractions, flow strength, etc.

1. Reply: In the revised manuscript, we will add a schematic figure that illustrates the most important fluxes used in the manuscript.

2. Comment: There are many notations and symbols. I found it difficult to remember all

of them while reading and had to go back to the text to look for them for the definition. So I recommend to make a list of the notations, providing necessary information, such as definition, link to the section, etc., similar in Bouchez et al., (2013).

2. Reply: In the revised manuscript, we will add a table that includes symbols and short descriptions of the variables used throughout the manuscript as in Bouchez et al. 2013. This table supports the additional schematic figure (see comment 1).

3. Comment: Repetition: page 5 line 145: The abundance of ... of XRD.

3. Reply: We could not find a repetition in this sentence.

4. Comment: Typo: page 8 line 220: Section 4.9 instead of 3.9.

4. Reply: The typo will be corrected as suggested.

5. Comment: Equation 2. is generally hard for me to understand, why deltaMg of creek water (deltaMg_diss) is used? How it is comparable with the closed system in Black et al. (2008)? Shouldn't the calculation of fraction (given % as in the manuscript) be based on mass fraction rather than delta values? Similar question is raised for Eq. 4.

5. Reply: Both equations (2) and (4) stem from mass balance models for the interpretation of isotope data, and thus relate isotope ratios to relative fluxes / mass fractions. Equation (2) is a mass balance equation frequently used in stable isotope geochemistry to calculate the partitioning of an element into two distinct compartments in a "closed system" (meaning one in which the element can freely exchange between two compartments, with no external inputs to or outputs from these two compartments). Equation (4) is derived from Bouchez et al. 2013 (where the considered system is an "open flow through box model" representing the weathering zone) and expresses this compartment separation in terms of relative fluxes. Mathematically it is identical to equation (2). To make this clearer, we will add an explaining sentence to section 4.1.

In contrast, equations (5) to (8) and (12) use measured fluxes to calculate how relative mass fractions of elements partition within an ecosystem. The accurate measure of these fluxes requires long-term monitoring programs, which are cost-intensive and time-consuming and hence not always available. However, in our field site (part of a "Critical Zone Observatory") these fluxes have been determined. The novel approach of our manuscript is thus to compare these metrics to those derived from stable isotope measurements, in order to establish methods that avoid the necessity of data from long-term monitoring programs. Therefore, we show that the Mg flux fractions in an ecosystem can be quantified by isotope analyses with much less effort.

6. Comment: page 7 line 187-188: The combination of ... to the transient growth of biomass. Please explain.

6. Reply: For using mass balance equations based on isotopes it is important to clarify under which conditions they can be applied; e.g. steady state of all or some of the considered compartments. The equation involving the two rightmost terms of equation (3) does not require that the biomass and plant litter compartments are at steady state: if there is net biomass Mg increase in the ecosystem the associated Mg uptake into plants would be accurately quantified with this equation. However, for these two terms to be equal to the leftmost term in equation (3), another condition has to be matched: the biomass and the litter Mg pools have to be at steady state. To clarify this point, we will slightly rewrite paragraph 4.2, and will split equation (3) into two equations (one valid even out of steady biomass + litter Mg, the second valid only for steady state conditions). Moreover, we will extend the sentence from line 187-188 by the phrase “such as forest growth after deforestation” at the end of the sentence.

7. Comment: Typo: page 10 line 293: Sect. 4.3 instead of 3.3

7. Reply: The typo will be corrected as suggested.

8. Comment: sect. 4.6, Na is a nutrient, why not taken up by plants, as indicated on page 11 line 304-305? The percentage of those elements in streams dissolved load should be re-considered.

8. Reply: Generally, Na can be considered as a beneficial element in halophylic and C4/CAM plants (Marschner et al. 2011) and in plants that are under K deficient conditions (Pilon-Smits et al. 2009). Since the main tree species at SSCZO are pine trees, we argue that Na plays no significant nutritive role. Therefore, values of the DEFX (the only metric where Na is used for normalisation) are assumed not to be affected by Na uptake which in any case would be minor. To clarify this, we added text to the manuscript

9. Comment: page 11 line 309, such as and for example are repetition

9. Reply: The repetition “for example” will be removed.

10. Comment: line 318: ... by chemical weathering that results in ...

10. Reply: The typo will be corrected as suggested.

11. Comment: Sect 4.7, if 60% K solubilized from rock is in the streams dissolved load, how K is relatively highly recycled compared with other elements studied? What the relation between DEF and Rec?

11. Reply: The DEFX and the RecX are fully independent from each other. This independency arises because an element X can become recycled (meaning uptake of nutrients released from plant litter) many times compared to this element’s weathering flux W_τ^X. This number of cycles is quantified by RecX. In contrast, DEFX quantifies the fraction of an element X that is lost from the ecosystem in the dissolved river load relative to the fraction of X that was initially solubilised by chemical weathering. Thus (if there are no atmospheric inputs) DEFX can vary only between 0 and 1, whereas RecX can vary between 0 and a large number. To clarify these relations, we will add text to the manuscript.

12. Comment: Fig. B1 is not very high quality, may be replaced by above mentioned schematic of the fluxes in the system.

12. Reply: In the revised manuscript, we will improve the resolution of figure B1.

Additionally, we will add a schematic figure (see comment 1).

Two other changes (addition of text) have been made since the original submission.

The importance of dust inputs:

Concerning dust inputs, Aciego et al. (2017) recently suggested that P supply by dust deposition outpaces local bedrock P supply at the SSCZO in P-poor bedrock. However, the role of the dust input on the nutrient dynamics (especially P) at our sites differ from the findings of Aciego et al. (2017) in two ways: a) the total denudation rate of 220 t km-2 yr-1 (Dixon et al. 2009) at our sites is higher than the range of 103 - 175 t km-2 yr-1 used in Aciego et al. (2017), an important difference with respect to bulk dust flux at 3 to 36 t km-2 yr-1 (Aciego et al., 2017) b) the P bedrock concentration is higher as we excluded the P-poor bedrock at site D102 ("Duff Creek") from our analysis. At our sites, the ratio of elemental dust deposition to the local elemental supply flux amounts to less than 4 % for K, Ca and Mg and to 5.3 % for P, agreeing with data shown in Aciego et al. (2017) for the P-rich bedrock. Therefore, the atmospheric supply flux of mineral-derived nutrients can be considered to be insignificant relative to the local long-term supply fluxes, leaving our initial interpretation unaffected.

The potential transience of the forest ecosystem:

We have become aware of the fact the Providence Creek forest was managed up to the 1960s (in addition to having been wholesale clear cut at the end of the 19th century). Therefore, the forest biomass is likely still re-growing. This growth might accumulate the strongly biocycled elements and provide an explanation for the portioning of 26Mg over 24Mg in biomass. We now explain this scenario as an additional mechanism to the one suggested in the submitted version: erosional export of leaf litter, phytoliths, and coarse woody debris from the watershed. While the former mechanism might be in operation today, the latter might have been significant in pre-forest management times.

References cited in this reply:

Bouchez, J., von Blanckenburg, F. and Schuessler, J. A.: Modelling novel stable isotopes in the weathering zone, Am. J. Sci., 313, 267-308, 2013.

Marschner, H. (2011). Marschner's mineral nutrition of higher plants. Academic press.

Pilon-Smits, E. A., Quinn, C. F., Tapken, W., Malagoli, M., & Schiavon, M. (2009). Physiological functions of beneficial elements. Current opinion in plant biology, 12(3), 267-274.

Sincerely yours, David Uhlig and co-authors

Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-521, 2017.