Dear Reviewer:

Thank you for your comments on this manuscript. We tried to address each point and answer your questions one by one. All Figures and Tables can be found at the end of this file.

Here are the answers to the questions:

Line 20 and general - To improve readability I would use no abbreviations for the soils, there is enough space to use e.g. "limestone soils" instead of LS.

Answer: Yes. We will correct them in the abstract.

Line 30 How much occluded OM was present in these soils? Thus is aggregation at all relevant for OM storage in these soils in contrast to mineral association?

Answer: We have no idea of the amount of occluded POM because the POM cannot be separated using density fraction in the ASs. When sonication was used for the ASs, organic material was suspended in the Na polytungstate solution (1.6 g cm^{-3}). We tried many ways (including long-time centrifuge) to separate the organic materials but always failed. Thus, we had to change the way (i.e. incubation with aggregate intact and crushed) to estimate the OM occluded in aggregates. This way is indirect but still widely used to estimate OM protected by aggregates. As we found no difference in SOC mineralization between intact and crushed aggregates, therefore we proposed that occlusion in aggregates was not the major way that OM was stabilized in our soils.

Line 40 The Andes stretch over 7000 km, please be more specific on the location of your work.

Answer: This is meant as a general statement as in general these functions are valid for the alpine grassland (paramo-jalca-puna system) from Venezuela all the way to Bolivia, as they provide the arid western coast of South America with water and are a biodiversity hotspot, and high SOC stocks.

However, to clarify the exact location, we will add a more detailed description of the field sites at the end of this paragraph.

Line 44-47 Again, the Andes stretch over vast distances, its clear that there are drastic climatic differences. But even at one location you get changes with exposition and elevation. Please be more specific!

Answer: We will add information on this by extending this line with “and in this study we focus on two contrasting sites in the Andes in Northern Peru”.

Line 50-51 This is redundant in itself, OM and OC is stabilized and of course is tightly linked.

Answer: This will be corrected.

Line 54-56 Again, this is highly dependent where you are in the Andes. In the Southern Andes you0ll have soils that are completely dominated by particulate OM rather than mineral-associated OM.

Answer: We will specify this with: Peruvian and Ecuadorian Andes.

Line 93 describe shortly Puna and Jalca

Answer: We will add in the site description: Wet Puna or Jalca is present between the tree line (3500 m asl) and the ice-covered region, having precipitation above 500 mm. For more ore information the reader is referred to the literature and the following contents in the M&M.

Line 103 Are there records about a longer consistent land use at the sampling sites? Or do you have indices that show a longer sustained land use type?

Answer: Please see our answer to Line 122.

Line 122 So there was a mixture of different land uses between the three site replicates? Was this detectable in the soil profiles or SOM properties?

Answer: Yes, samples were collected from grassland and abandoned cropland. A previous study showed that SOC stocks were not clearly affected by land use type (e.g. grassland vs. cultivation). This is because the local farmers rotate the land in the order of cultivation, abandoned cultivation, cultivate grassland and grassland in a period of several years. They repeated this cycle. This may keep the SOC stock high and in a dynamic balance. (Yang et al. 2018, Catena). We will modify the text to make this clearer.

Line 147 How was the gravel content calculated, thus how did the authors differentiate between large aggregates (>2mm) and stones of this size range?

Answer: The fraction larger than 2mm was obtained by sieving and stones were picked out by hand. From the remaining aggregates the fractions >5 mm and 2-5 mm were obtained after the dry sieving.

Line 157-158 Why you analyse in the one approach the fraction <63 _m, but don0t use it in the incubation? Please describe here.

Answer: The finer fraction (<0.25 mm) were by far less abundant, especially for the limestone soils. The fraction was therefore not incorporated in the analysis.

Line 162 By this approach you are not only crushing aggregates, but also rock fragments. How did you account for the different content of pure mineral constituents in relation to aggregates?

Answer: We will replace the word “grinding” with “crushing” here, as this is actually what we did. If rock fragments are defined as size >2mm, this approach will not break rock fragments because rock fragments were removed before the aggregate crushing. We cannot account for the differences between mineral particles and aggregates. Nevertheless, our purpose was only crushing aggregates. Grinding using a porcelain mortar is unlikely to destruct mineral particles.

Line 164 It was shown before that aggregate/soil disruption can lead to a rather fast spike in CO2 evolution within a few days. Did you in any way account for this CO2 loss between the different treatments during the first days of incubation before entering a sort of basal respiration?

Answer: Thank you for this question. We applied a 10-day pre-incubation, necessary because microbes in the air-dried soils need to be activated. We used slow wetting because we wanted to avoid aggregate destruction caused by fast-wetting.

For the spike in CO2 at the beginning, data from Fig. R1 indicated that the fast pulse in CO2 was not missed. This is because soils were too dry for microbes to start degradation during the early period of the pre-incubation. Furthermore, the comparisons in Table R1 showed no clear differences in early CO2 production between intact and crushed aggregates. Thus, our observation did not miss the massive CO2 during the first days, whereas our results do not support that aggregate/soil disruption caused a fast spike in CO2 evolution at the beginning.

Line 208-215 This is a nice exemplary paragraph to show how hard a text is to read for an outsider - let me summarize: "...LS is larger than AS, has more LM but minor Mi; AS has larger SM and Mi; LS were not different but wet-AS was slightly different from dry-AS..." I would really appreciate if you find a way to use even short words that are more descriptive and don0t ruin the flow of reading.

Answer: Thank you for this point. We will try to improve the wording if the manuscript if we are allowed to revise.

Line 226-227 Please also give mineralization rates normalized to the amount of OC in the individual samples. This will give a better mechanistic insight on the fate of OM with respect to aggregation. This might also level off possible differences in stone content etc.

Answer: SOC mineralization was normalized for OC contents already. We will add a line on this to the methods section: SOC mineralization rates provided were normalized for OC contents.

Line 233-234 How is this relation if you normalize OC mineralization rates with sample amount OC?

Answer: see our previous answer to the question Line 226-227.

Line 239 Also if normalized on the amount of OC in LM vs. SM?

Answer: See our previous answer to the question Line 226-227.

Line 253-256 You are using two very contrasting parent materials which foster completely different soil biological communities and soil chemistry and thus of course yield different soil structure - so far its textbook knowledge. Such statement might be more interesting if comparing Granodiorite and a Granite or Basalt etc. However, this comment is just about leaving out such "general textbook statements" and focus on the core of the story.

Answer: The statements concerning the effects of lithology on soil aggregate size distribution will be largely removed from the discussion part and moved, in a modified form, to the introduction.

Line 256-260 This could possibly find its way into the Introduction as you could put this as a rational to take these two contrasting materials. In the discussion it appears again as a redundant textbook message.

Answer: The contents will be rephrased and moved to the Introduction.

Line 262 So basically the lack of fine material causes the lack of a more advanced aggregation.

Answer: This is correct.

Line 271 You are comparing a silicate rock and a carbonate rock - I would be more than surprised if precipitation would not have a less pronounced effect.

Answer: The contents will be rephrased and moved to the Introduction.

Line 275- 280 There are in parts differences in aggregation and SOC stocks between wet and dry sites. Why are you neglecting those and talking them down as minor or biased by stoniness? If stoniness is the driving property, than how can you compare aggregate mineralization etc. at all?

Answer: We agree that there are major differences in aggregation and slight (non-significant) differences in SOC stocks. However, it is difficult to explain the differences in stoniness, as we found properties of each aggregate fractions were similar between wet-ASs and dry-AS. However, we could elaborate on the effects of differences in stoniness: root distribution will be different in stones, differences in soil moisture redistribution affecting soil microbial activity and organic matter turnover. We will more explicitly discuss the differences in aggregation between the two sites in a revised version of the manuscript.

Line 282 Given the high amount of stones and a some other constraints, the significant effects are worth taking them serious. Presumably as a result of altered soil biology and/or plant diversity / litter/root input.

Answer: Please see the answer to the previous question.

Line 294-295 Which is a function of primary production and decomposition. Please give in the M&M more details on vegetation at the respective sites.

Answer: Information on vegetation will be given in the M&M section:

The vegetation in the wet site is a typical disturbed wet Puna (or Jalca) vegetation with dominant grass species: *Calamagrostis sp.,* but also *Festuca and Agrostis sp. as well as Rumex sp. on fallow land.*

The vegetation in the dry site is a typical disturbed wet Puna (or Jalca) vegetation with *Calamogrostis sp., Stipa and Festuca sp. and Rumex sp. on fallow land.*

Line 299-304 What soil horizons comprise the low SOC values with high CO2 evolution? Are those the low C/N ratio subsoils? If so, you are mixing two opposite factors, aggregation and soil material origin. Please give specific OC mineralization normalized per amount OC. And the very low C/N ratios under 5, would mean you have pure amino acid material in the sample. Could here values around the detection limit for N play a role?

Answer: The mineralization rates were already normalized (Questions **Line** 226-227, **Line** 233-234 and **Line** 239) . In general, Dry-LS-A had the highest CO2 evolution, whereas Dry-LS-B had the lowest SOC contents. For the C/N ratios, the values were 9.34±0.52 for the Dry-LS-A and 6.86±1.14 for the Dry-LS-B (Fig. 2). Thus, soil horizons with the highest CO2 productions were not subsoils or the horizons with the lowest C/N ratios. In addition, we don't think the N contents reached the detection limit of the Elementar Analyzer because the detection limit of the Analyzer was 0.01% but the lowest N content was 0.16%.

Line 310-314 How much OM is stored within the aggregates? Do you have estimates of amounts of e.g. occluded POM?

Answer: See our answer to the question concerning line 30.

Line 315 The cited work showed a clear effect of aggregate disruption within the first days of incubation. You lack this information due to the late start after 10 days. So the low differences between crushed and intact might be due to fact that you missed the CO2 spike. Furthermore, how did you adjust comparable soil porosity/O2 diffusion and thus water contents between finely crushed/ground soil material and naturally aggregated soil?

Answer: We totally agree with that there is a fast spike in CO2 at the beginning of the incubation. However, we had to re-wet the air-dried soils to initiate the decomposition. We choose to slowly re-wet soil materials for 10 days because fast-wetting can significantly break soil aggregates. We just would like to avoid unnecessary destruction of aggregates. At the first few days of the incubation, soil materials are very dry and the SOC mineralization did not start. Thus, the fast spike in CO2 did not appear in this period.

Although we applied the pre-incubation, we believe that we did not miss the massive CO2 production at the beginning. This is because of the much higher CO2 production rates in the first few days of the measurement (Fig. R1). In many studies, the pre-incubations were 14 days. Luckily, we anticipated the fast spike in CO2 at the beginning and we try to shorten the pre-incubation time. If we pre-incubated soils for 14 days as many studies did, we would be more likely missing the CO2 spike that was found in Day 1 and Day 2 (Fig. R1).

For the adjustments of soil porosity and O2 diffusion, we did not make them comparable for crushed vs. naturally aggregated soils. OM stabilization through occluded in aggregates can be explained by physical inaccessibility to the decomposer. The inaccessibility is closely related to the microstructure of aggregates (e.g. soil porosity and O2 diffusion). The objectives of crushing aggregates were to destruct soil structure (i.e. soil porosity, O2 diffusion, etc.) that promote OM stabilization. If we made soil porosity and O2 diffusion comparable between intact and crushed aggregates, we were a bit like trying to eliminate what we want to compare.

Line 343 Do you have data on exchangeable ions?

Answer: We don’t have the data of exchangeable ions for our sample sets. However, pH is an important factor for the ratio of exchangeable Ca^{2+} and H^{+}. Thus, we use pH as an indicator. Nevertheless, we had another paper (Yang, in revision, Envir. Earth Scie.) focusing on the effects of exchangeable ions, Fe and Al on SOM stabilization.

Line 358 How is the vegetation at the sites, how is primary production, above and belowground OM input? The biggest control on SOC stocks besides soil properties are plant traits at comparable parent materials. So as stated above, please give information on vegetation data in M&M.

Answer: Information on vegetation will be given in the M&M section:

The vegetation in the wet site is a typical disturbed wet Puna (or Jalca) vegetation with dominant grass species: *Calamagrostis sp.*, but also *Festuca and Agrostis sp. as well as Rumex sp. on fallow land.*
The vegetation in the dry site is a typical disturbed wet Puna (or Jalca) vegetation with *Calamogrostis sp., Stipa and Festuca sp. and Rumex sp. on fallow land.*
Based on the information, the vegetation is similar between the wet and the dry sites.

Line 368-370 Or these compounds are just more stable at dry conditions. On top of that, plants produce e.g. more suberin in the roots as protection against drought. And without a baseline of the initial plant material above and belowground this data just tells you there are differences in these acids due to precipitation.

Answer: For the first point whether these compounds are more stable in the dry site, our unpublished data showed that they are more vulnerable in the dry-LSs. This is evidenced from the Dry-LSs having a more clear trend in the depletion in α, ω-dioic acids and ω-hydroxyl alkanoic acids (maybe also long-chain fatty acids) than the Wet-LSs (Fig. R2). If these compounds are larger and meanwhile more vulnerable in the Dry-LSs compared to the Wet-LSs, a possible reason is that their input is higher. As it is very difficult to estimate OM input in the puna grassland, we can only assess these potential differences using the data of SOM composition.

Line 376-377 There is the same amount of work showing plant species and traits having these effects on SOC storage and stability. Thus to prove the solely precipitation effect you would have to work with comparable plant species and traits.

Answer: The vegetation between the two sites is slightly different, but consists of grasses of the same functional types and genera but with different (sub-)species. We speculate that their impact on the soil is comparable. With regard to the primary production we have no data and literature on this is also very scarce but we expect that NPP is also affected by the availability of moisture.

Line 381 So how high is the OM input?

Answer: We do not know the exact OM input as it is very difficult to estimate OM input in the Andean Puna/Jalca grassland. In addition, literature on OM production or NPP is very limited (one publication for Peru on slightly drier sites indicates a NPP of about 5 Mg C / ha yr for grazed grassland and around 15 Mg C /Ha yr (Oliveras et al. 2014, Environmental Research Letters), which might give an indication of the NPP at our sites. We will include this information in the manuscript.

Line 385 You compare limestone with granodiorite, as mentioned above this of course outcompetes any effect of precipitation at same altitude and latitude.

Answer: We will rephrase it: We did not find an important effect of precipitation on aggregation, which was overshadowed by the effect of different lithologies on aggregation

Line 385-387 For this you would have to show that there is no occluded light fraction/POM, and you didn0t miss the fast pulses (>10 days) in CO_2 after soil structure disruption found by others.

Answer: For the occluded OM, as density fractionation was not applicable for the acid rock soils, incubation with aggregate intact vs. crushed is an alternative method to estimate occluded OM. For the fast pulses, data from Fig. R1 indicated that the fast pulse in CO_2 was not missed, whereas the comparisons in Table R1 indicated that SOC production in the first days was not significantly higher for crushed aggregates than intact aggregates. Thus, we can propose that SOM is unlikely stabilized by occluded in aggregates. For details, please check the answers to the questions of **Line** 30, **Line** 164 and **Line** 315.

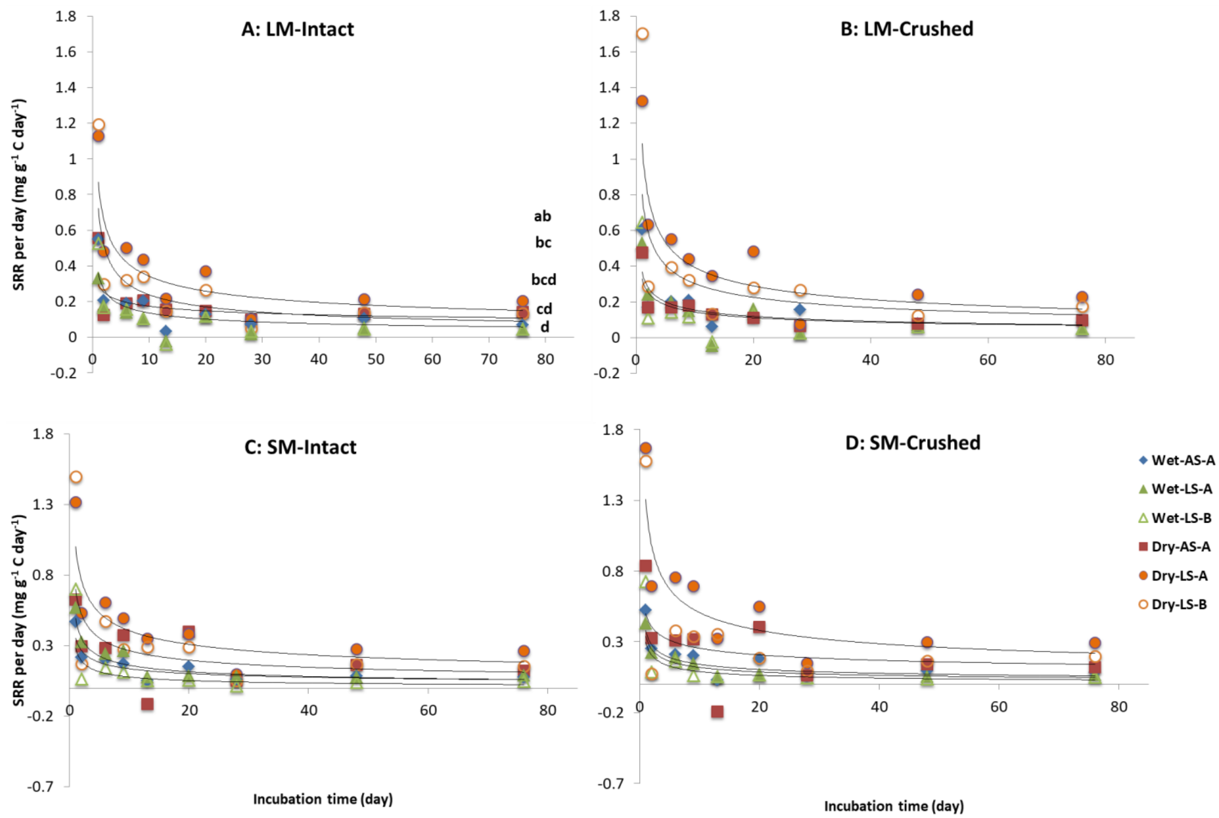

Fig. R1 Specific SOC mineralization rate per day (g C mineralized g^{-1} SOC day^{-1}). Wet: the wet site, Dry: the dry site, LS: limestone soil, AS: acid igneous rock soil, A: A horizon, B: B horizon, LM: large macroaggregates (>2 mm), SM: small macroaggregates (0.25-2mm).

Table R1 Comparisons in SOC mineralization rates (per day) between intact aggregates and crushed aggregates

		Wet-LS-A		Wet-LS-B		Wet-AS-A		Dry-LS-A		Dry-LS-B		Dry-AS-A	
		LM	SM	LM	SM	LM	SM	LM	SM	LM	SM	LM	SM
Day1	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Day2	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Day6	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Day9	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Day13	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	**In>Cr****
Day20	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Day28	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Day48	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Day76	SMR	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	SMR per day	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

SMR: specified SOC mineralization rate Wet: the wet site, Dry: the dry site, LS: limestone soil, AS: acid igneous rock soil, A: A horizon, B: B horizon, LM: large macroaggregates (>2 mm), SM: small macroaggregates (0.25-2mm).

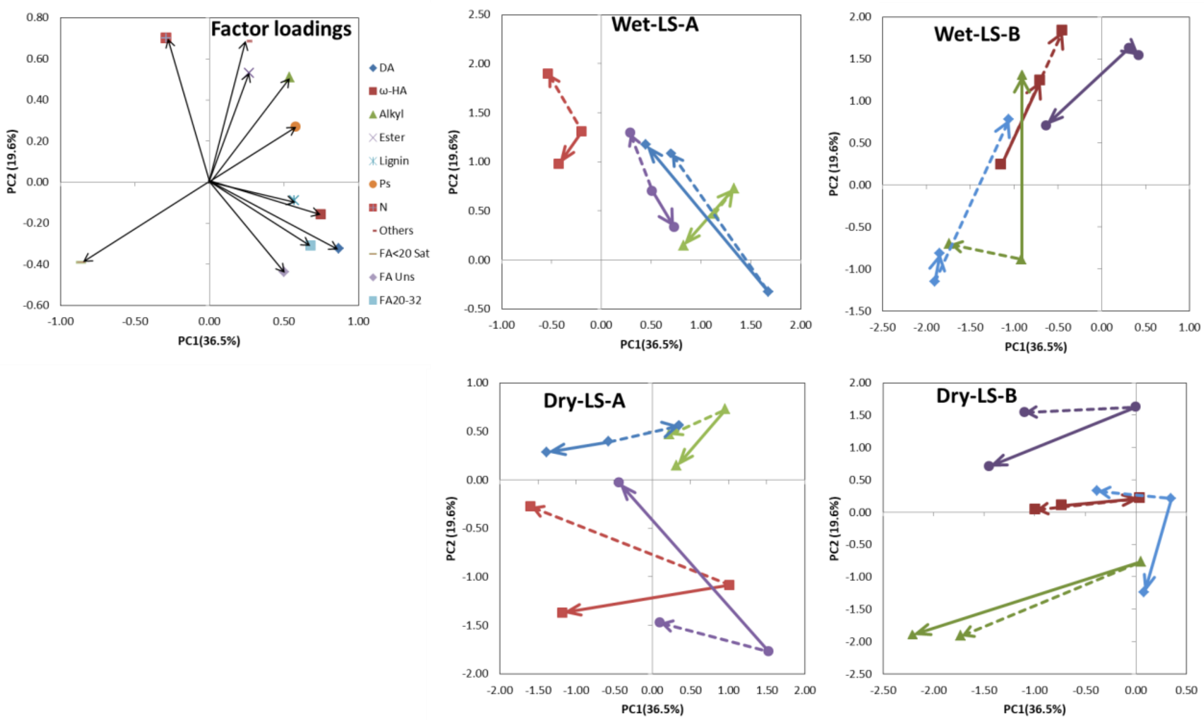

Fig. R2 Principal component analysis. DA: α, ω-dioic acid, ω-HA: ω-hydroxyl alkanoic acid, Alkyl: *n*-alkanes and *n*-alkenes, Ps: polysaccharides, N: nitrogen containing compounds, FA<20 Sat: saturated fatty acids with <20 carbon atoms, FA Uns: unsaturated fatty acids, FA20-32: saturated fatty acids with 20-32 carbon atoms, Wet: the wet site, Dry: the dry site, LS: limestone soil, AS: acid igneous rock soil, A: A horizon, B: B horizon. Arrows in solid line mean relative abundance change after incubation of intact aggregates; arrows in dotted line mean relative abundance change after incubation of crushed aggregates.