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Interactive comment on "Spatial variability of heavy metal concentration in urban pavement joints – A case study" *by* Collin J. Weber et al.

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Dear Referee #1,

Many thanks for your time and efforts to read and comment on our current manuscript. You have raised some very important points, for which we are very grateful. According your remarks as well as the notes of Referee 2, we have changed and hopefully improved several parts of our manuscript. Below we will reply to each of your comments point by point.

1. Authors wrote about importance of joints, but readers still don't know, why they are important? Due to risk for humans or for environmental quality? Which kind of risk for humans do you mean (exposure)? This question is important if you try to apply any

legal treshold! Why did you apply this for playgrounds? Is there similar people/children exposure? Each treshold is calculated taking into account e.g. the exposure time and exposure path/way. Is the paved square comparable to any unpaved playground?

⇒ Thank you for this comment and your questions. First of all, we think that the joints are important for environmental quality in urban areas as we stated clearly for example in l. 69-75 (infiltration or partly soil functions) or in l. 226 (function of "topsoil" in sealed areas). Secondly, we think, that the potential accumulation of heavy metals found in pavement joints poses different risks to humans and the wider environment in the surrounding of urban areas. As we see your concerns about the application of different legal thresholds and the overall importance of the risk assessment, we have made different changes in our manuscript, to overcome your concerns regarding this point. First, we added an additional chapter before the conclusion, where we discuss different risks and potential exposure pathways. Out from this new risk assessment, we also discuss the usefulness of the available legal thresholds for the special case of urban pavement joints.

2. Authors decided to use the geochemical indexes. I'm afraid, it may not have the sense! Geochemical background, in particular in its current understanding, must be identified for soil - not for geological substratum. Background soil and soil under comparison should be comparable - also in terms of soil processes. Are the pavement joints comparable to any more or less natural soil, in terms of biological activity, bioaccumualtion processes, nutrient and water cycling? Rather not. It means, calculating the Igeo and other indexes, which were constrcucted taking into account real soils, has no sense. If youy cannot determine reliable geochemical background for soils under comparison - calculation of indexes whoch reqire such background – is simply impossible...

⇒ Thanks that you state this very important point. In our first version of the manuscript, we searched for a successful way how we can overcome the several problems regarding the evaluation of heavy metal loads in urban pavement joints without any com-

parative values. Therefore, we decided to apply some of the well-known geochemical indices with the best available background soil, knowing the many limitations of this approach. ⇒ After your concerns and the concerns of Referee 2, which stated the same point, we decided to remove the calculation of Igeo, PLI and RI completely! Instead we are working with the absolute concentrations (given in mg/kg) within our assessment and interpretation. For the analyses of spatial relationships, we decided to calculate the ExF according to BÄĚbelewska (2010), as it provides an information where, in a given study area, the highest metal loads are located. We think, that the calculation of this index is appropriate, as it is based on absolute metal concentrations and average contents at each sampling site (without any geochemical background value). Calculation and reasons for the selection of this index will be stated clearly in the revised method section.

3. So, any comparison to legal tresholds/intervention values and indexes have a sense if you can combine it with a kind of risk. If you cannot explain how the accumulated metals may influence humans or environment - you don't know if the scales are applicable...

⇒ Thank you for this remark. In general, we think that the accumulated heavy metals could pose a risk to humans on different pathways (e.g., direct soil-human contact in the case of playing children or the indirect contact including soil-air pathway by dust emissions). We stated this point in l. 74 or l. 419. Regarding the environmental risks, we see the main risk in the accumulation and therefore storage of heavy metals in pavement joints and a potential output through surface runoff (e.g., during stormwater events). In l. 355-361 we clarified, that urban surface runoff seems to play an important role for the spatial distribution of heavy metals in pavement joints. Therefore, it is thinkable, considering the existing literature as well (e.g., Drake et al., 2014 or Wessolek et al. 2011), that accumulated heavy metals could be relocated during stormwater events and reach urban surrounding areas (like river systems, floodplains). This point was stated in l. 417-418. ⇒ Since we noticed that this point was apparently not communi-

cated clearly enough, we made it clear at various points in the manuscript what kind of risk is meant. In addition, as mentioned above, we have included the additional chapter on risk assessment.

4. Authors tried to combine the soil contamination in the joints with water cycling. But we know, that the pavement materials are commonly laid on the stabilised ground, often with admixture of cement, or mechanically compacted. All these stabilisations lead to impermeability. Thus, even if the pavement is not continuous, the underlying layers may be impermeable and thus all the cover is impermeable for water and roots. Such cover may have some capacity for rain/melting water (in joints and subsequent layers), but it may not mean permeability and cycling... Other authors suggest protective role of pavement for underlying soil - already due to pavement impermeablity for water and solutes... Charzy′ nski, P., Plak, A., & Hanaka, A. (2017). Influence of the soil sealing on the geoaccumulation index of heavy metals and various pollution factors. Environmental Science and Pollution Research, 24(5), 4801-4811. Mendyk, Ł., & Charzy′ nski, P. (2016). Soil sealing degree as factor influencing urban soil contamination with polycyclic aromatic hydrocarbons (PAHs). Soil Science Annual, 67(1), 17-23. (I do not agree with all statements and conclusions presented in the above cited papers, but I think Authors should at least read these opinions)

⇒ Many thanks for this comment and especially for the literature references. We enjoyed reading the papers and reflecting on the opinions. First of all, a small clarification seems to be necessary at this point: If we are talking about "surface runoff" (line 336) or "urban drainage and surface runoff with stormwater runoff" (line 353) as a potential transport medium of heavy metals and a possible factor that explains the enrichment at certain points (e.g., lowest points, drainage accumulation points), then permeability through underlaying layers plays only a minor role. Of course, you are right, that pavement materials laid on a stabilized ground. In the case of our study area, we found crushed stone (coarse and fine stones) as well as sand under the pavement, without cement (line 220). These materials are stabilized, but not impermeable for water and

roots. In general, the underlaying layers have to be separated from the joints itself, as the pavement joints show totally different characteristics like organic material and more heterogeneous grain sizes, which enables capacity for rain water / surface runoff as well as heavy metal retention (line 404). ⇒ Regarding the "water cycling" we think that a partwise infiltration of water, possibly with dissolved heavy metals, in underlaying layers, could be possible, as one of main function of pavement areas is the partly permeability compared to fully sealed surfaces (line 436). More important for us, however, is the conclusion that heavy metals that accumulate in the pavement joint material can be washed out again directly on the surface by heavy rain events. An infiltration to underlaying soils is not needed, as the surface runoff in urban areas could be directly reach the sewerage at the pavement surface (line 418). If this runoff has absorbed heavy metals from pavement joints, the contamination can reach other places inside the urban area or influence river ecosystems in urban surroundings. ⇒ The "protective role" of pavement for underlying soils, stated in the publication of Charzy′ nski et al. (2017) is an interesting opinion, but not directly transferable to our study area, as the side constructions seems to be very different. Again, in our recent study, we didn't try to combine heavy metals loads in pavement joints with insurance to deeper soil layers by water. We have considered only processes that occur at the surface or pavement joint layer and that can be important for a) the spatial distribution of the metal concentrations or b) the discharge out of urban areas (over a large area).

5. Authors don't have informations about the mobility of metals in the joints, thus any conclusions referring the their translocation should take into account the general knowledge and confirmed affinity of (some) metals to organic matter, in particular under neutral/alkaline reaction.

⇒ Finally, we would like to thank you also for this last remark. Of course, we don't have information about the mobility of meals in joints. In chapter 3.4 of our manuscript (line 367) we discuss the possible sources and translocation tendencies of different metals out from a correlation with organic matter and pH milieu. The discussion as well as the

conclusions out of this paragraph are based, exactly as you demand in your comment, on the general knowledge about heavy metal mobility in soils.

Sincerely,

Collin J. Weber (on behalf of the authors)

Please also note the supplement to this comment:
https://soil.copernicus.org/preprints/soil-2020-39/soil-2020-39-AC1-supplement.pdf

Interactive comment on SOIL Discuss., https://doi.org/10.5194/soil-2020-39, 2020.