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RESPONSE TO COMEMNTARY

Response to "Commentary by J. B. Richardson on 'Anthropogenic mercury sequestration in different soil types on the southeast coast of China' by Zhang et al. (*J Soils Sediments* 15:962–971. doi:10.1007/s11368-015-1062-1, 2015)"

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In his comments, Richardson (2017) questions the accuracy of using the anthropogenic Hg pool to indicate Hg accumulation in the soils of the Yangtze River Delta (YRD) and Pearl River Delta (PRD) regions in Zhang et al. (2015). We hope that our answers to these queries will reinforce the conclusions in the original paper.

Firstly, Richardson asserts that "Normalization of Hg to an immobile element describes the loss or gain in Hg with respect to the immobile element but cannot be used to describe sourcing." We agree that the normalization method is not able to describe the anthropogenic sources of Hg directly. However, it may be used to describe the geochemical baseline of Hg in the soils of a certain region. In the study of Tack et al. (1997), the baseline levels of several trace elements for the soils in Flanders, Belgium, were determined by using normalization of the elements to clay and organic carbon contents. The same methods were also used by Tam and Yao (1998) and Teng et al. (2003) in their studies although different reference elements were used. Since the baseline level can distinguish between the pedogenic origin and anthropogenic origin of trace elements in environmental compartments (Darnley 1997; Salminen and Tarvainen 1997; Martin et al. 2016), the anthropogenic Hg concentration in the horizon soil can therefore be estimated by Eq. (1) in the original paper.

Secondly, a preliminary relationship between local Hg emission and the soil Hg pool was intended for exploration by comparing the emission ratio between the YRD and PRD regions to the soil Hg pool ratio. Current results indicate that the higher Hg emission region also had a higher soil Hg pool. However, we agree that more data are required to determine such a trend unequivocally.

Thirdly, we used correlation analysis between Hg and soil properties (Fe_o, SOM, CEC, and humic acid) to support the difference in the soil Hg pool among the various soil types. The Hg content in soils may be different among the different soil types although the anthropogenic inputs were the same because soil Hg can be transformed into the species that was prone to volatilization and leaching from the soil (Scholtz et al. 2003). Therefore, soil properties are important in the accumulation of Hg in soils. Zhou et al. (2015) estimated the soil Hg pool in an acidic subtropical forest of southwest China, and their results also support the conclusion that soil pools of mercury were strongly correlated with the stocks of soil organic matter.

Fourthly, as mentioned in the first point, we estimated the soil Hg pool by subtracting the pedogenic Hg from the total measured Hg in the soils and assumed that the estimated soil Hg pools were strongly related to human activities. Because we sampled the soil on only one occasion, the estimate shows the current status of the soil Hg pool and compares it among the different soil types in the region. The soil Hg pool might change with time, but it requires repeated investigation to show the trend as Richardson (2017) proposes in his comment.

Fifthly, we agree that ecosystem properties affect mercury distribution. However, we focused on the Hg distribution and accumulation in the different soil types in our paper. Our analysis was based on the Hg concentration in the topsoil, depth distributions, and soil Hg pool in the origin paper (Zhang et al.

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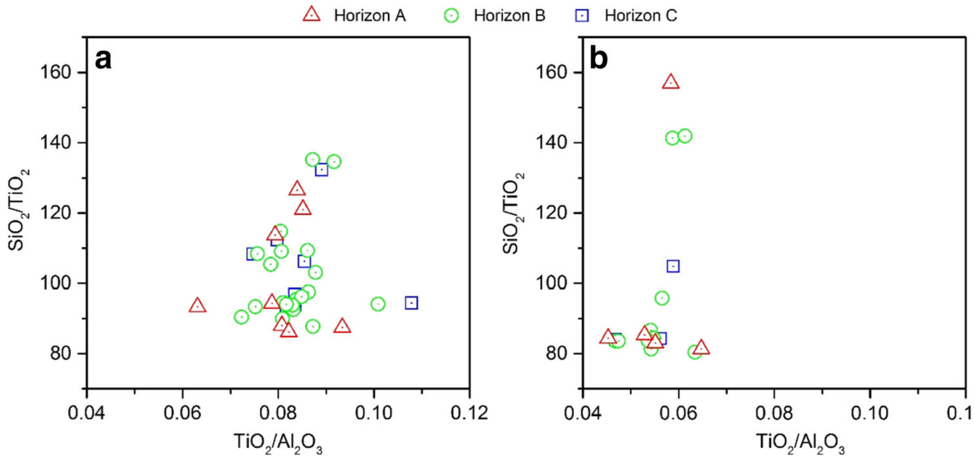

Fig. 1 Binary pattern of molar ratios of the mineral elements in the different pedogenic horizons of the soils in **a** the Yangtze River Delta and **b** the Pearl River Delta regions

2015). Ecosystem properties such as hydrology, vegetation, and parent material are also key factors determining the development of soil types and their properties (Chesworth 2008). As for the homogeneity of the soil parent material through the soil profile, all the soil profiles were selected from sites where soil development was continuous and stable. This ensures that the soil horizon samples collected were not disturbed by human activities (e.g., solid waste disposal). In addition, the molar ratio of the elements (e.g., SiO_2/TiO_2, TiO_2/Al_2O_3) is a good source indicator of soil parent materials (Sheldon and Tabor 2009). Figure 1 shows the element ratio of the different pedogenic horizons in the Anthrosols and Cambisols developed from alluvial parent materials in the two regions. Almost no difference in the ratio values can be observed among the different horizons in both regions, and this implies that the soil parent materials were homogeneous throughout the profile.

References

Chesworth W (2008) Encyclopedia of soil science. Springer, Dordrecht ISBN 978-1-4020-3994-2

Darnley AG (1997) A global geochemical reference network: the foundation for geochemical baselines. J Geochem Explor 60:1–5

Martin AP, Turnbull RE, Rattenbury MS, Cohen DR, Hoogewerff J, Rogers KM, Baisden WT, Christie AB (2016) The regional geochemical baseline soil survey of southern New Zealand: design and initial interpretation. J Geochem Explor 167:70–82

Richardson JB (2017) A commentary on "Anthropogenic mercury sequestration in different soil types on the southeast coast of China" by Zhang et al. (J Soils Sediments 15:962-971. doi:10.1007/s11368-015-1062-1, 2015). J Soils Sediments. doi:10.1007/s11368-017-1788-z

Salminen R, Tarvainen T (1997) The problem of defining geochemical baselines. A case study of selected elements and geological materials in Finland. J Geochem Explor 60:91–98

Scholtz MT, Van Heyst BJ, Schroeder W (2003) Modelling of mercury emissions from background soils. Sci Total Environ 304(1–3):185–207

Sheldon ND, Tabor NJ (2009) Quantitative paleoenvironmental and paleoclimatic reconstruction using paleosols. Earth-Sci Rev 95(1):1–52

Tack FMG, Verloo MG, Vanmechelen L, Van Ranst E (1997) Baseline concentration levels of trace elements as a function of clay and organic carbon contents in soils in Flanders (Belgium). Sci Total Environ 201:113–123

Tam NFY, Yao MWY (1998) Normalization and heavy metal contamination in mangrove sediments. Sci Total Environ 216:33–39

Teng YG, Tuo XG, Ni SJ, Zhang CJ (2003) Environmental geochemistry of heavy metal contaminants in soil and stream sediment in Panzhihua mining and smelting area, Southwestern China. Chin J Geochem 22(3):253–262

Zhang H, Li Y, Luo Y, Christie P (2015) Anthropogenic mercury sequestration in different soil types on the southeast coast of China. J Soils Sediments 15:962–971

Zhou J, Wang Z, Zhang X, Chen J (2015) Distribution and elevated soil pools of mercury in an acidic subtropical forest of southwestern China. Environ Pollut 202:187–195