Applied Geochemistry 25 (2010) 1464–1465

Contents lists available at ScienceDirect

Applied Geochemistry

journal homepage: www.elsevier.com/locate/apgeochem

Reply

Reply to the comment "Bottled drinking water: Water contamination from bottle materials (glass, hard PET, soft PET), the influence of colour and acidification" by Hayo Müller-Simon

Clemens Reimann [a,*], Manfred Birke [b], Peter Filzmoser [c]

[a] Norges geologiske undersøkelse (NGU), P.O. Box 6315 Sluppen, N-7493 Trondheim, Norway
[b] Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Stilleweg 2, 30655 Hannover, Germany
[c] TU Wien, Institut für Statistik, Wiedner Hauptstr, 8-10, 1040 Wien, Austria

1. Introduction

In his comment Hayo Müller-Simon points out that diffusion from glass is not a likely physical process to cause the concentration differences found for the same water bottled in PET and in glass containers for elements like Pb. According to Müller-Simon (2010) these values would instead have to be caused by corrosion of the glass. He points out that the observed concentration differences might also be caused by diffusion into PET. In their original article the authors stated that observed differences "can also be caused by adsorption and desorption reactions of certain elements with the bottle walls or be due to the formation and dissolution of colloids in the water during storage".

The authors want to thank Müller-Simon for an interesting contribution to their paper. For us the physical process as such was not as important as the observed concentration differences, which are a problem when planning to use bottled water as a proxy for groundwater composition at the European scale. Müller-Simon's comments demonstrate that there is ample room for further research that should be of interest to both, glass (and PET) producers as well as the bottled water industry in order to provide the consumers with as "clean" and "natural" a water as technically possible.

2. Is glass "contaminating the bottled water with lead (and other elements)?

The authors not only compared the same brand of water sold in glass as well as PET bottles but also carried out a leaching test on a large number of glass and PET bottles using high purity demineralised water (18.2 MΩ). Fig. 5 in the original article (Reimann et al., 2010) shows the results. Here, Fig. 1 presents once again (and in a more detailed scale) the measured Pb concentrations in high purity, demineralised, acidified and non-acidified water that is in contact with two bottle materials: clear glass and clear soft PET. For the PET bottles all results are close to the detection limit and just show random variation at the detection limit (with the exception of possibly two bottles that vary around 0.01 μg/L Pb). The same water in contact with glass bottles contains much more Pb from day 1 – the majority of bottles show values above 0.01 μg/L Pb up to a maximum concentration of 0.6 μg/L reached after 150 days of leaching. This is clearly one extreme case most other bottles leach much less. However, the majority of glass bottles show increasing Pb concentrations over time. All results discussed in the paper are based on facts: (i) the direct comparison of the same water sold in glass and PET bottles and (ii) the leaching of the bottles with high purity demineralised water.

According to Fig. 1 in Müller-Simon (2010) diffusion of Pb from glass into water is theoretically impossible due to the exceedingly small diffusion coefficients. However, the values are extrapolated over a very large temperature gradient and realistic values at low temperatures would still need to be established. In addition, the authors' measurements suggest that quite substantial differences exist between different bottles, probably depending on the production process and/or the life-cycle of the bottles. The measured concentrations in high purity water after leaching between 1 and 150 days and the significant difference in concentration range between glass and PET-bottles (Fig. 1) cannot be discussed away. The maximum value of 0.6 μg/L Pb observed in the leaching test is indeed a high value in relation to what would have to be expected as a background Pb concentration in natural water (e.g., Shotyk and Krachler, 2007).

However, as pointed out in the original paper all leaching results are by at least a factor of 10 below the drinking water action levels as defined by the European authorities (EU directive 98/83/EC, EU directive 2003/40/EC/16-5-2003).

3. Conclusion

Whether "physically possible" or not, the observed Pb concentrations and the time trends during the leaching test indicate clearly that glass bottles contaminate the bottled water to a certain extent (though well below the drinking water action level) with Pb (and a number of other-elements). For PET bottles Sb (rather than Pb) is the main problem. The results display surprisingly large differences between individual bottles; it is here where more

* Corresponding author. Tel.: +47 73 904 307; fax: +47 7392 1620.
E-mail address: clemens.reimann@ngu.no (C. Reimann).

0883-2927/$ - see front matter
doi:10.1016/j.apgeochem.2010.07.006

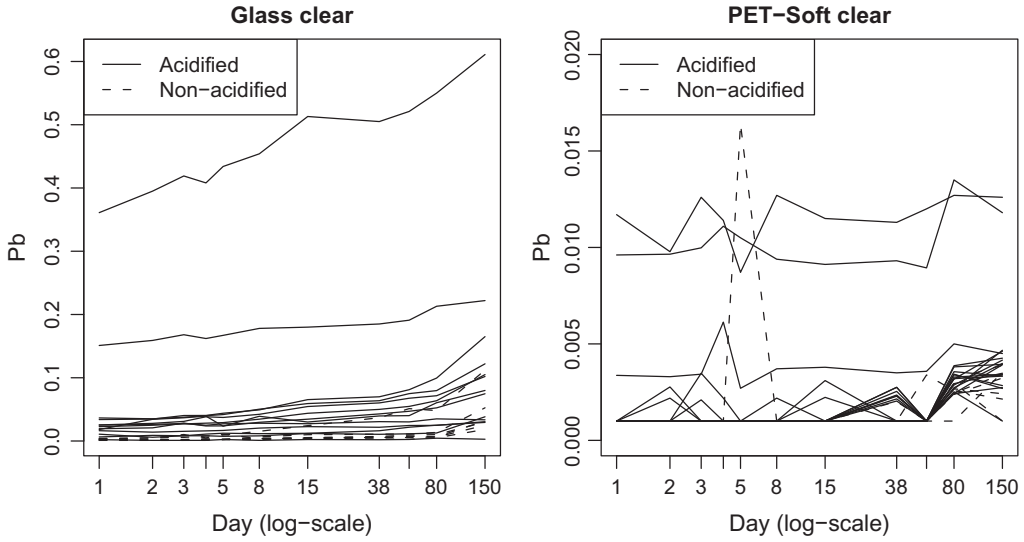

Fig. 1. Results of the 150-days leaching test for bottle materials clear glass and clear soft PET, analytical results in µg/L. See Reimann et al. (2010) for details on method and analysis.

research might be justified. Migration of Pb into the PET bottles can not explain the results of the leaching test.

References

EU-directive 98/83/EC of 3rd November 1998 on the Quality of Water Intended for Human Consumption. Official Journal L 330, 05/12/1998, pp. 32–54.

EU-directive 2003/40/EC/16-5-2003/ Establishing the List, Concentration Limits and Labelling Requirements for Mineral Water.

Müller-Simon, H., 2010. Comment on: "Bottled drinking water: water contamination from bottle materials (glass, hard PET, soft PET), the influence of colour and acidification" by C, Reimann, M. Birke and P. Filzmoser. Appl. Geochem 25, 1461–1463.

Reimann, C., Birke, M., Filzmoser, P., 2010. Bottled drinking water: water contamination from bottle materials (glass, hard PET, soft PET), the influence of colour and acidification. Appl. Geochem. 25, 1030–1046.

Shotyk, W., Krachler, M., 2007. Lead in bottled water: contamination from glass and comparison with pristine groundwater. Environ. Sci. Technol. 41, 3508–3513.