RISKCYCLE

Risk-based management of chemicals and products in a circular economy at a global scale

Application of the multimedia environmental model QWASI for evaluating exposure pathways in areas of informal e-waste recycling

S. Heise[1], H. Tien[1,], J. Casal[2], X. Seguí[2], R. M. Darbra[2] , M. Schuhmacher[3], M. Nada[3], J. Rovira[3], N. Suciu[4], M. Trevisan,[4] E. Capri [4]

[1] Faculty of Life Sciences, Hamburg University of Applied Sciences, Lohbruegger Kirchstraße 65, 21033 Hamburg, Germany, [2]Dept. Chemical Engineering. Universitat Politècnica de Catalunya, Diagonal, 647, 08028 Barcelona, Spain , [3]School of Chemical Engineering, Universitat Rovira i Virgili, Av. Països Catalans 26. 43007 Tarragona, Spain, [4]Institute of Agricultural and Environmental Chemistry. Università Cattolica del Sacro Cuore. Via Emilia Parmense, 84. 29100. Piacenza, Italy

Abstract

Environmental modelling was applied in order to identify important exposure pathways of Pb^{2+} and decaBDE from the informal disposal site Guiyu to the aquatic envionment. Using data from a Substance Flow Analyses as annual emissions, exposure due to leaching from disposal sites were the most important pathway for Pb^{2+} and decaBDE, while the atmospheric route after burning also provided important transfer to the quatic system.

Introduction

The region of Guiyu is one of the most important areas of informal E-waste recycling in China. Informal recycling is usually accompanied by insufficient protection of workers and of people living in the surrounding area. Various hazardous substances in E-waste can potentially be released via various pathways during the different recycling processes (leaching to water, via burning to air, from plastics, from CRT glass, from solid residues, by dust). If advice is supposed to be given, the significance of exposure pathways need to be evaluated and prioritized. In this study, we focused on Pb^{2+} and DecaBDE as additives, of which 150 000 and 186 t/year, respectively, are deposited around Guiyu.

Method

QWASI, the Quantitative Water, Air Sediment Interaction model by Mackay et al. (1983) is a fugacity III model (Version 3.10, 2007) with adaptation to ionic substances (Type 2).

Landscape Geography (*assumptions in italic*)

River of *5 m depth*, 60 m wide, *5 km long*. Active sediment layer: *0.05 m, organic content: 3 %*, *burial rate: 0.6 g/m²/day*, Water flow: 40 m³/s. Average rain rate: 2.2 m/year (0.02 – 4.4 m/year).

Input Data

Pb^{2+} : emissions to water: 9020 kg/a (the majority from dumped CRT glass, based on SFA for Guiyu (Tien et al, subm). Impact of atmospheric concentrations were simulated.

DecaBDE: Different emissions to water (0 to 30 kg/a) and to atmosphere (0.01 to 2 ng/m³) were simulated.

Modelling Results Applying QWASI

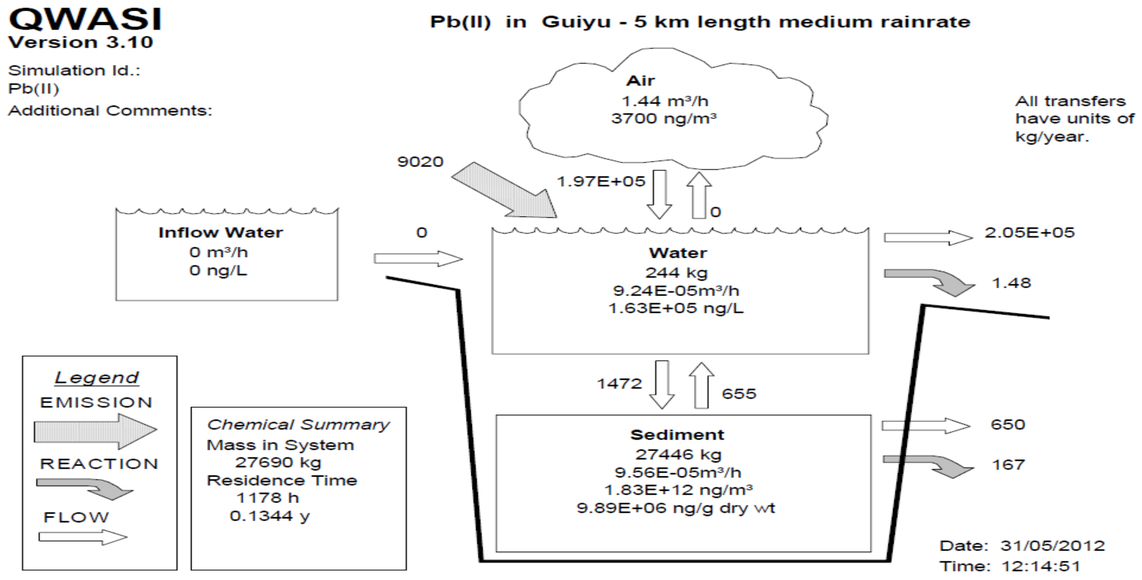

Fig. 1: Results of a simulation of Pb^{2+} partitioning in the assumed Guiyu system at medium rain rate and atmospheric concentration.

Range of sediment concentrations (Luo et al. 2007)

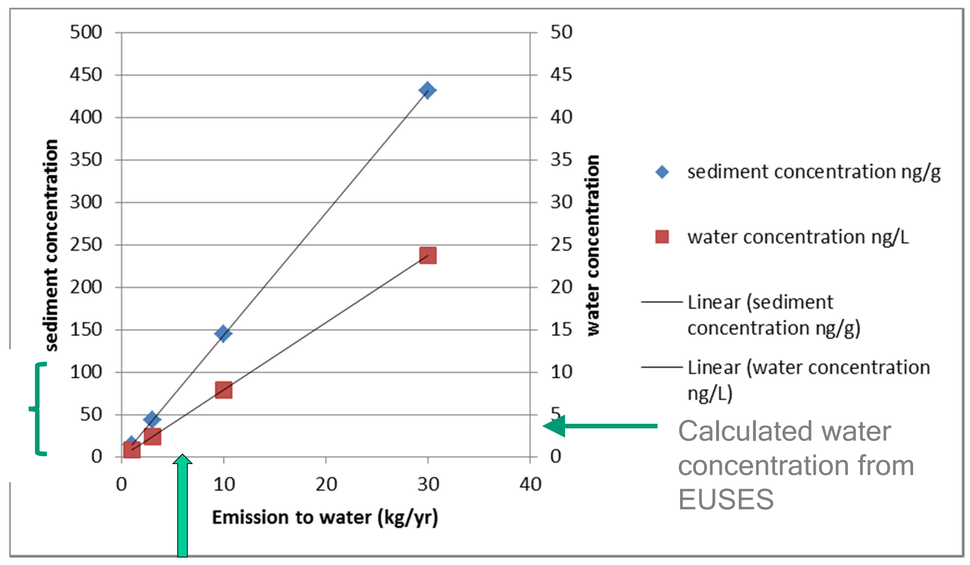

Fig. 2: Relationship between direct discharges of decaBDE to water in kg/a and partitioning of the substance between sediment and water.

- Atmospheric input was no significant pathway for decaBDE in the estimated range (other models' results and literature data), but very important for Pb^{2+} as pathway to water and sediment (one scenario exemplarily shown in Fig. 1).
- An emission of 6 kg of decaBDE is likely, based on these model results and data from EUSES modelling and literature (Fig. 2) . This supports a leaching rate of 0.003 % (Choi et al, 2009) if SFA results of 186 t/a are assumed.

Conclusions

- DecaBDE concentrations in water (modelled) and sediment (measured) suggest significant leaching rates of this BFR from disposed material, leading to increased risk from waste disposal in Guiyu
- Pb concentration in water and sediment is strongly dependent on atmospheric concentration and rain rate, rendering pathways from disposal sites via air (burning) and leaching very important.

References

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