Exploring the possible implications of exports of waste towards developing regions for global emissions of PCBs

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Background and objective

Global production of PCBs (polychlorinated biphenyls), which mainly occurred in rich industrial regions, ceased decades ago. However, surprisingly high levels and even increasing trends[1] have more recently been reported in some developing regions in southeast Asia[2] and West Africa[3] where PCBs were neither extensively produced nor used. This has led to the hypothesis of a possible transition in global source regions, attributed to exports of waste towards developing regions in sub-tropical and tropical areas[4].

The goal of this study is to update an existing global historical PCB emission inventory to account for exports of waste electrical equipment (EE) towards developing regions were it becomes subject to informal recycling and disposal.

Methods

A dynamic mass balance model, previously developed to derive global historical atmospheric emission scenarios for 22 selected PCB congeners in 114 countries[5], was modified to account for exports of PCBs in EE (Fig 1).

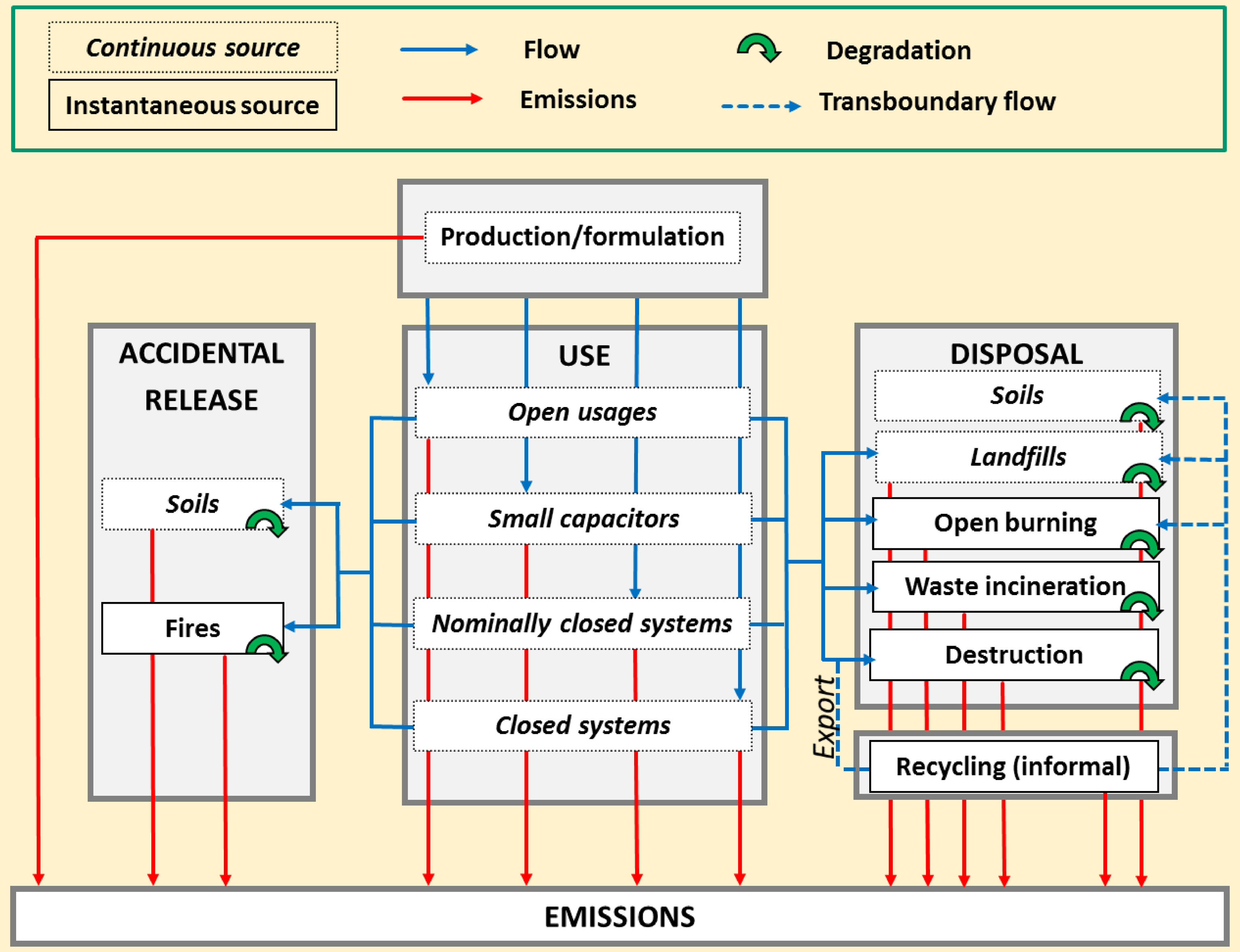

Figure 1: *Mass balance model further developed and applied to develop emission scenarios for selected PCBs. Modifications to account for emissions due to export of EE (small capacitors & closed systems) towards developing regions are shown with a dashed blue line.*

A recent inventory of the global generation (M_{GEN}) and flows of e-waste from developed (M_{EXP}) to developing regions (M_{IMP})[6] for 2005 was used as a proxy to account for exports of wastes containing PCBs (Fig 2).

In order to reflect some of the uncertainties in input data, two emission scenarios were estimated:

- A **default scenario** which represent the best initial estimate for relevant parameters.
- A reasonable **worst-case scenario** (higher export with EE subject to process with high emission factors).

These two scenarios are compared with the **baseline scenario** (no export).

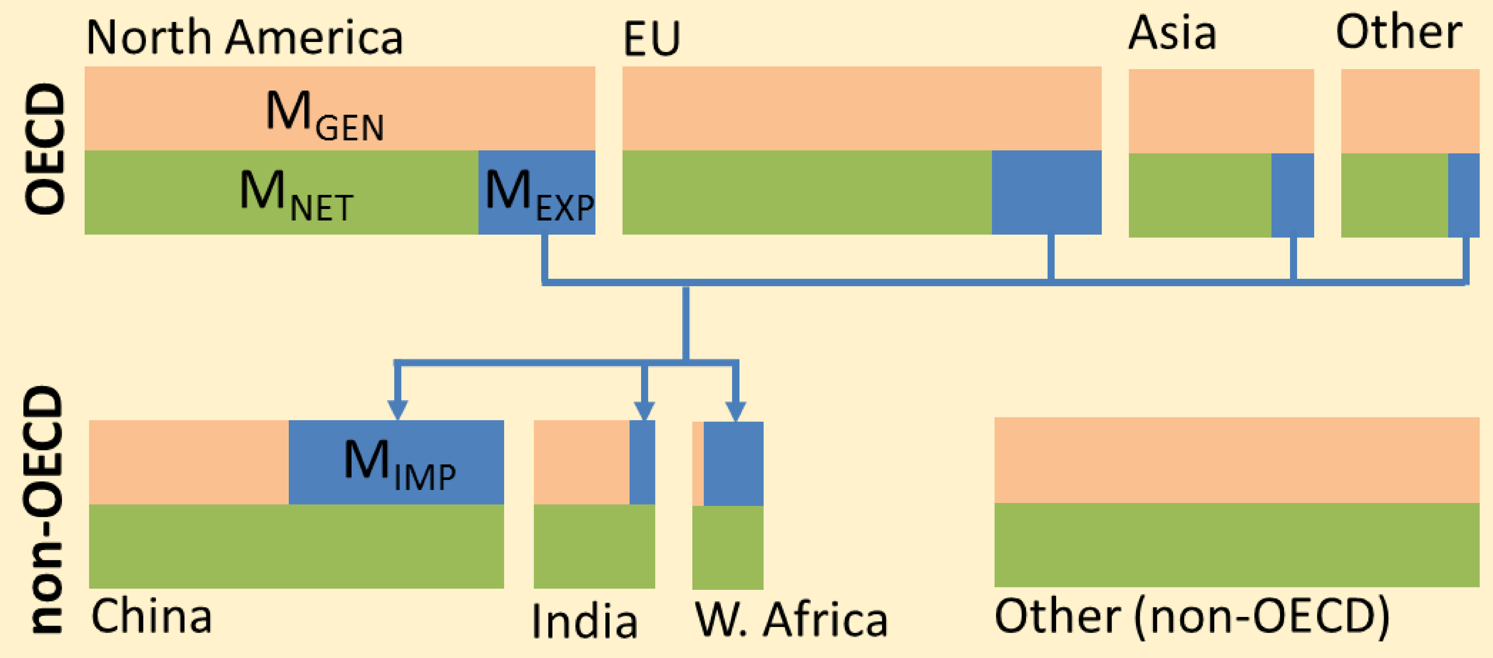

Figure 2: *Graphical representation of the e-waste mass balance*[6]*. The widths of each box are scaled to reflect M.*

Results

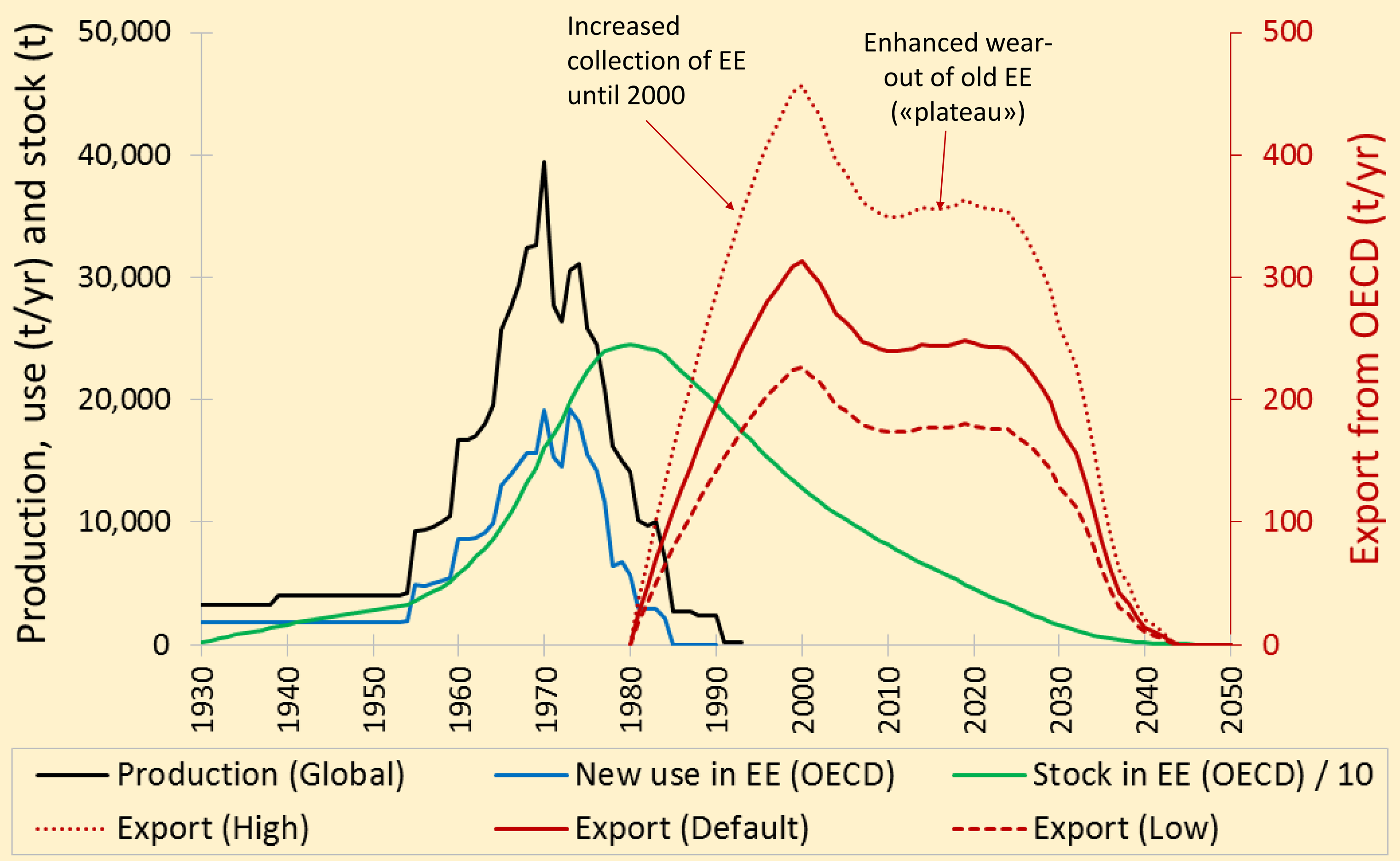

Figure 3: *Global annual production, annual new usage in EE within the OECD, stock in use in EE within the OECD (left axis) and three scenarios for export of PCBs from the OECD (right axis) from 1930 to 2050. All data refer to Σ_{22}PCBs. The trend in export is largely dictated by assumptions governing trends in formal collection of EE, stock in EE, as well as calculated EE failure rates*[5]*.*

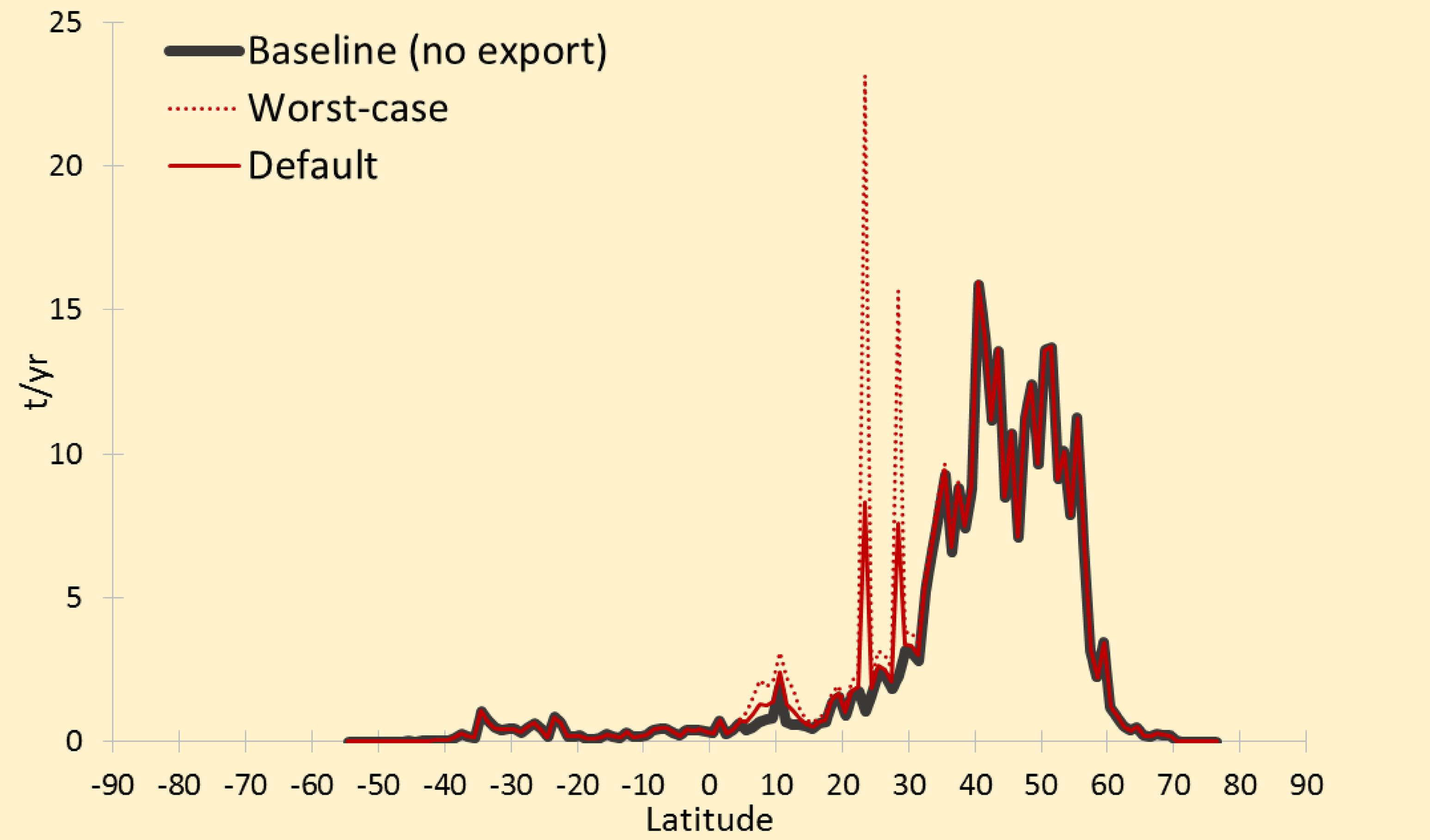

Figure 4: *Emission scenarios for Σ_{22}PCBs in 2005 by latitude. Consideration of export of waste lead to enhanced emissions at southern latitudes in the northern hemisphere.*

Discussion

Exports of obsolete electrical equipment towards developing regions are likely to increase global atmospheric emissions of PCBs beyond the baseline scenario (no export) because of informal recycling and disposal practices, combined with enhanced volatility experienced due to elevated temperatures in sub-tropical and regions.

Key sources of uncertainty in these scenarios include:

- The magnitude of the increase in emissions is particularly sensitive to the fraction of EE which become subject to open burning because of a high emission factor[5] (Fig 1).
- The source-receptor relationship for exports / imports of waste (Fig. 2) refer to the situation around 2005[6]. Potential shifts in sources and destinations in time remain to be accounted for.

Implications for global environmental transport, trends and fate of PCBs are discussed in an accompanying poster (**RP036**).

References: [1]Asante *et al.* 2011. Environ Int 37: 921-8 [2]Wong *et al*. 2007. Environ Pollut: 149:131-40 [3]Gioia *et al*. 2014. Environ Sci Pollut Res: 21:6278-89 [4]Breivik *et al.* 2011 Environ Sci Technol 45: 9154-60 [5]Breivik *et al.* 2007 Sci Total Environ 377: 296-307. [6]Breivik *et al.* 2014 Environ Sci Technol 48: 8735-43.

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