CoZMoMAN: a Dynamic Mechanistic Model of the Link between Environmental Emissions and Human Body Burdens of Organic Contaminants

Knut Breivik[1,2], Gertje Czub[3], Michael S. McLachlan[3], Frank Wania[4]

1 Norwegian Institute for Air Research; 2 University of Oslo, Norway; 3 ITM, Stockholm University, Sweden; 4 University of Toronto Scarborough, Canada

Introduction

Different factors affect how organic contaminants released into the environment over time distribute and accumulate, enter various food-chains, and potentially cause toxic effects in wildlife and humans. A sound chemical risk assessment thus requires the determination of the quantitative relationship between emissions and human exposure.

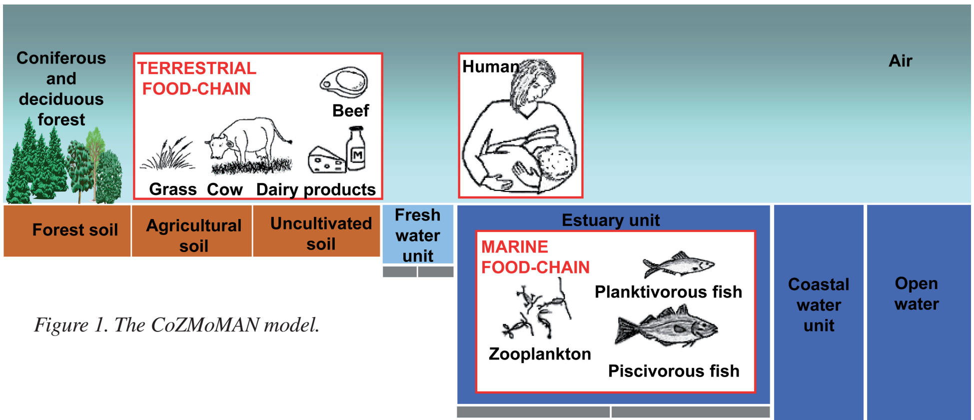

Figure 1. The CoZMoMAN model.

Methods

An integrated, mechanistic, non-steady state environmental fate and human food chain bioaccumulation model (CoZMoMAN) has been developed [1], see Figure 1. It was created by linking the CoZMo-POP 2 model, which predicts organic chemical fate in the physical environment [2] with ACC-HUMAN [3], which describes organic chemical bioaccumulation in the human food chain.

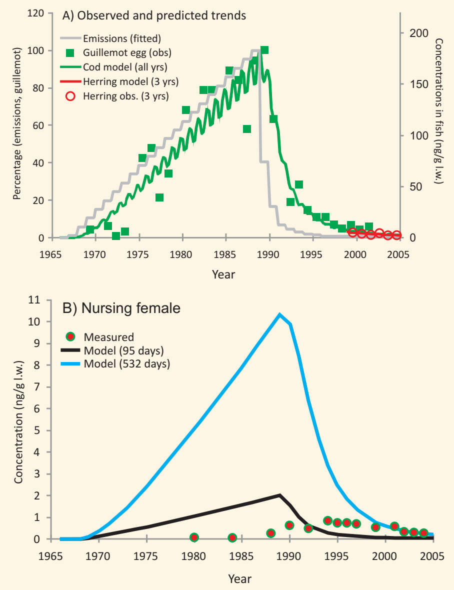

Figure 5. A) Estimated time trend in emissions of BDE-99 on the basis of observed trend in guillemot egg (left y-axis, [4]), and fish (right y-axis [5]). B) Observed [6] and simulated time trend in a nursing female using two different metabolism rates (95 and 532 days).

Results

Confidence in a model is gained when its predictions are compared with observed contaminant behaviour. An overall model evaluation for selected polychlorinated biphenyls (PCBs) in the western part of the Baltic Sea drainage (Fig. 2) revealed that CoZMoMAN predicted PCB concentrations in 11 key model compartments to typically within a factor of 2 to 4 of measured values (Fig. 3).

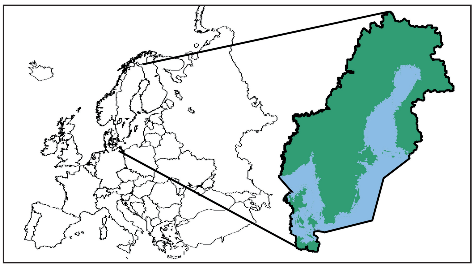

Figure 2: Map of Europe (left) and selected model domain (right).

CoZMoMAN was further used to explore the validity and implications of the steady-state assumption frequently made in similar models. It showed that a steady-state approach may fail to properly describe the long-term behaviour of more persistent organic contaminants in environmental media that respond slowly to emission changes (e.g. soil, humans) – see Figure 4.

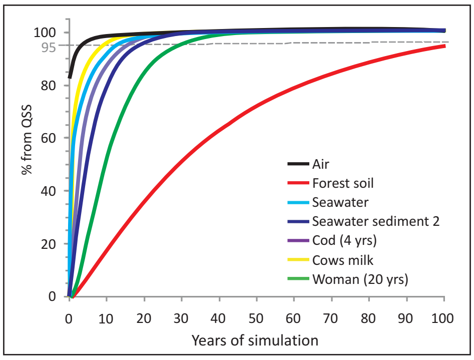

Figure 4: Calculated development towards quasi steady-state for PCB-118 in selected model compartments over 100 years, assuming constant emissions to air.

A non-steady state model like CoZMoMAN may also be used in concert with observations to reveal insights that allow us to refine our understanding of chemical behaviour. For example, if an empirical long-term temporal trend of a compound in a fast responding medium is available, this trend can be combined with CoZMoMAN to derive estimates of historical emissions. These emissions could in turn be used to predict levels and temporal trends in slowly responding media as exemplified for BDE-99 (2,2',4,4',5-pentabromodiphenyl ether), see Figure 5.

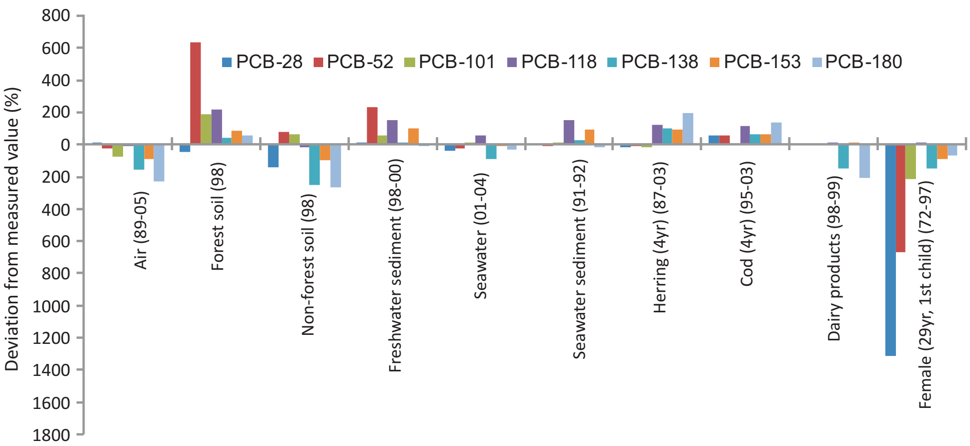

Figure 3: Overall model evaluation for seven PCBs in eleven key model compartments. Numbers in parentheses list the sampling period of measured data for which the comparison is based.

Acknowledgements

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Model availability

The CoZMoMAN model will be available free of charge via the internet at http://www.utsc.utoronto.ca/~wania.

References

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