In silico methods to prioritize chemicals with high exposure potential

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Academic dissertation for the Degree of Doctor of Philosophy in Applied Environmental Science at Stockholm University to be publicly defended on Thursday 18 January 2018 at 10.00 in Nordenskiöldsalen, Geovetenskapens hus, Svante Arrhenius väg 12.

Abstract

Chemicals offer a wide range of desired functions and are used in a variety of consumer goods and industrial sectors. The number of individual synthetic organic chemicals produced and the total global chemical production volume are increasing. The majority of these anthropogenic chemicals are not monitored in environmental matrices nor in the indoor environment even though some are associated with undesirable consequences and the range of possible chemical impacts is still far from being fully understood. Chemicals that remain in the environment for a long time and/or distribute over a large area have *high exposure potential*, and will present particularly acute challenges if a currently unknown undesirable effect is discovered.

This thesis describes the development of a set of in silico methods to identify and prioritize chemicals with high exposure potential that are currently not subject to national or international restrictions. In brief, we i) compiled databases of contaminants of potential concern, ii) established models to predict key properties to fill data gaps in the absence of experimental data, and iii) developed and applied methods to screen chemicals to identify those that should be assigned high priority for future study.

Paper I delivers screening-level models to predict partition ratios of organic chemicals between polymeric materials commonly found indoors, and both air and water. These models can be used in high-throughput exposure assessment studies, passive sampling experiments, and models of emissions, fate and transport of chemicals.

Paper II presents a scoring method to prioritize 464 organic chemicals of emerging Arctic concern for their potential to fit a set of four exposure-based hazard profiles. These four profiles represent persistent organic pollutants (POPs) regulated under the Stockholm Convention, very persistent and very bioaccumulative substances (vPvBs) regulated under REACH and for two novel and unregulated profiles derived from the planetary boundary threats framework; airborne persistent contaminants (APCs) and waterborne persistent contaminants (WPCs). APCs and WPCs are chemicals that are mobile in air and water, respectively, and that contaminate the environment in a poorly reversible manner due to their persistence. The prioritization method is based on a reference set of 148 chemicals that is used to contextualize the scoring results.

Paper III describes the prioritization of 8,648 chemicals that were reportedly produced in five OECD countries. **Paper III** elucidates the relationship between the elemental composition of these chemicals and the exposure-based hazard scores, and presents a strategy to disentangle overlaps among the four exposure hazard profiles by categorizing chemicals according to the spatial coverage of profiles they best fit.

Paper IV focuses on refining the prioritization method described in **Papers II** and **III** using a set of 5,600 hypothetical chemicals. The refined method is used to prioritize the chemicals from Papers II and III, and an additional 4,567 chemicals from the REACH database.

The in silico methods developed in this thesis can be applied to conduct screening-level exposure assessments using only chemical structures as a starting point. Substances prioritized as having high potential to be POPs, vPvB, APC, or WPC should be considered for more detailed study to unequivocally determine their identity and physicochemical properties.

Keywords: *free energy relationship, solvation parameters, polymers, materials, partitioning, octanol, Arctic contaminants, AMAP, POPs, Stockholm Convention, vPvB, REACH, OECD, QSAR, planetary boundaries, persistence, bioaccumulation, long-range transport.*

Stockholm 2017
http://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-149358

ISBN 978-91-7797-065-1
ISBN 978-91-7797-066-8

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