Risk for POP mixtures in an Arctic food chain

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2011, the year of mixtures

- WHO Meeting on combined toxicity. London February 2011

- SETAC Workshop on mixtures. Brussels March 2011

- ECETOC Workshop on mixtures. Berlin July 2011


- UNEP-POPRC. Case studies to be developed on mixtures of POPs
The case study
POP mixtures in the Arctic

In the frame of the activities of the Stockholm Convention's Persistent Organic Pollutants Review Committee (POPRC) a case study has been developed in order to answer to the following questions:

- May the composition of mixtures of Persistent Organic Pollutants be determined and quantified in remote areas?
- May the ecotoxicological response to POP mixtures be predicted?
- Is the risk from POP mixtures matter of concern for the Arctic ecosystem?
Approaches for predicting mixture response

No interactions among chemicals

- The Dose/Concentration Addition (CA) approach. It applies to chemicals with the same mode of action.
- The Independent Action (IA) or Effect Addition approach. It applies to chemicals with different mode of action.

Interactions among chemicals

- Synergism and antagonism. They cannot be predicted. They are relatively infrequent, particularly at low exposure levels.
CA as an acceptable default approach

A precise knowledge of modes of action is rarely available.

The complexity of toxicological modes of action of POPs makes the problem even more difficult.

The CA approach overestimates the toxicological response, so it may be assumed as a conservative worst case.

It may be theoretically demonstrated and experimentally supported that the ratio CA/IA is generally relatively low.

Therefore, if the available information is not sufficient for a scientifically based selection between the CA and IA models, there is large consensus on accepting by default the CA approach as a realistically acceptable conservative approach.
The chemicals

**The dirty dozen**

Chlorinated insecticides
1. Aldrin
2. Chlordane
3. Dieldrin
4. DDT
5. Endrin
6. Heptachlor
7. Mirex
8. Toxaphene
9. HCB
10. PCDDs (75 congeners)
11. PCDFs (135 congeners)
12. PCBs (209 congeners)

Other chlorinated and brominated compounds
13. HCHs
14. PCP
15. PCNs (75 congeners)
16. PBDEs (209 congeners)

Perfluorinated compounds
17. PFOS
18. PFOA
The exposure hypothesis

It may be hypothesized that in remote areas (e.g. Arctic, Antartica) far from emission sites, POP exposure depends exclusively upon long range atmospheric transport.

Therefore, POP concentrations in different sites within the Arctic Circle should be relatively homogeneous.

The hypothesis has been checked and confirmed by comparing, when available, monitoring data, in the same matrix and in comparable time window, from different sampling sites.

Main sampling areas are indicated in the figure by a red dot.
The Arctic food chain

Data on POP concentrations in different levels of the Arctic food chain, sampled in the decade 1996-2006, were collected in the literature.

The following risks have been calculated:
- Fish exposed through water
- Seal eating fish
- Bear eating seal
- Baby bear eating milk

Zooplankton data are relatively scattered.
Dietary toxicity data for fish are scarce.
Fingerprint of the composition of the POP mixture in water and in the organisms of the Arctic food chain.
The toxicological endpoints

For fish, only the short term (96h) LC50 was available for all the chemicals. So, risk was calculated using the TUs approach applied to acute LC50.

For mammals several short and long term endpoints were available. However, the comparability of methods and endpoints was very difficult. In absence of suitable data on the same relevant end point for all chemicals, it was decided using the Hazard Index (HI) approach instead of TU.

Hazard Quotients (HQs) for individual chemicals were calculated using as Reference Values (RVs) the ADI (Admissible Daily Intake) proposed for protecting human heath by international organisations (WHO, FAO, US EPA).
Risk for fish trough water

TUs of the total mixture are about four orders of magnitude lower than the acute toxicity level. Risk for fish may be assumed as negligible.
Risk for seals eating fish

The HI of the total mixture is about ten times higher than the threshold of 1. Considering that HQs are based on the very conservative ADI, the risk for seals is likely to be very low.
Risk for bears eating seals

The HI of the total mixture is two orders of magnitude higher than the threshold of 1. The risk for bears is likely to be significant.
Risk for baby bears eating milk

The HI of the total mixture is three orders of magnitude higher than the threshold of 1. The risk for baby bears is likely to be very high.
Value and limitations of the study and needs for improvement

The Case Study represents a first tier assessment based on many default worst-case assumptions.

It needs to be refined. However, the risk for the highest levels of the trophic chain is likely to occur.

Endocrine disorders in baby polar bears is documented in the literature (Vos et al., 2000; Wiig et al., 1998).

The next step will be a comparison between these relatively recent data and older ones (starting from 1970s) in order to reconstructing the time course of the last four decades and to check the effectiveness of control measures.
Acknowledgements

The work has been performed and supported in the frame of the activities of the Stockholm Convention's Persistent Organic Pollutants Review Committee (POPRC).

UNEP/POPS/POPRC