Project information

Keywords

Siloxanes, Environmental modeling, Arctic,

Project title

From FRAM research to sound policy making: Assessment of siloxane use and its potential risk to Arctic environments

Year

2016

Project leader

Nicholas A. Warner (NILU)

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)

70^{O}N 23^{O}E

Participants

Fram Centre partners

- Nicholas A. Warner **(Project leader)** / NILU (nicholas.warner@nilu.no)
- Ingjerd Sunde Krogseth/ NILU (Ingjerd.Sunde.Krogseth@nilu.no)
- Knut Breivik/NILU (knut.breivik@nilu.no)
- Guttorm Christensen / Akvaplan-niva (guttorm.christensen@akvaplan.niva.no)
- Anita Evenset / Akvaplan-niva (anita.evenset@akvaplan.niva.no)

International partners

- Mick J. Whelan / University of Leicester, United Kingdom (mjw72@leicester.ac.uk (United Kingdom)
- Emma Undeman / Stockholm University (emma.undeman@aces.su.se)

Flagship

Hazardous Substances

Summary of Results

Funding support received through the Fram Centre together with funding through the NRC project, NORDIC LACS: **Nordic La**ke exposure to **C**yclic **S**iloxanes: Assessment of transport, distribution, and fate; project number 22259) aided in the communication and publication of findings from the project.

Findings from the NORDIC LACS project evaluated the environmental fate on cyclic volatile methylsiloxanes (cVMS), octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5) and dodecamethylcyclopentasiloxane (D6) in a Sub-Arctic lake (Storvatn, Hammerfest) impacted by intermittent wastewater discharges. cVMS were not detected in the water column during winter (ice covered lake) or summer. However, the sediment compartment was heavily contaminated with average concentrations of 207 ± 30, 3775 ± 973 and 848 ± 211 ng g^{-1} organic carbon for D4, D5 and D6, respectively. Measurements were rationalized by using a fugacity-based environmental multi-media model for lake environments (QWASI). Predicted behavior of cVMS was highly sensitive to the organic carbon – water partition coefficient (K_{oc}) and its temperature dependence. Lower overall environmental persistence of cVMS was predicted by models with decreasing temperature due to enhanced partitioning from sediments to water. This work has recently been accepted for publication in Environmental Science & Technology.

Data from this project has been incorporated into a review chapter on Siloxanes in the Arctic monitoring and assessment programme (AMAP) – Chemicals of Emerging Arctic Concern report. This report is currently in press.

In addition to studying the environmental behavior of cVMS in the physical environment, a benthopelagic model was developed to help rationalize measured concentrations in biota within Storvatn and identify key mechanisms in biomagnification behavior. All cVMS investigated were detected in biota with D5 being the most dominant oligomer with average concentrations reaching as high as 18 µg/g lipid. The benthopelagic model over-estimated concentrations in all biota investigated but reproduced well the concentration relationships observed in the measured concentrations between different species. Temperature dependency on K_{oc} was found to be important in model predictions, leading to several differences in bioaccumulation behavior between PCBs and cVMS. This was particularly pronounced in the benthic linkages of the model indicating that temperature plays an important role in differences in sediment derived exposure and bioaccumaltion between cVMS and known persistent organic pollutants. The manuscript for this work is nearing completion and will be submitted in early 2017.

Data analysis and interpretation of sediment core data collected under the NORDIC LACS project and Flagship project NORDIC LACS 2.0 is currently being assessed. This work will be used to assess persistence of cVMS within Storvatn after wastewater discharges to the lake have decreased due to recent renovations to the wastewater infrastructure. Sediment core collected under NORDIC LACS 2.0 has been dated. However, work on this manuscript has been delayed during the first half of 2016 as the project leader was away on parental leave.

Data collected on cVMS in Tromsøysund under previous Flagship projects will be compared to data collected

in Storvatn to investigate how different environmental characteristics will effect environmental fate of cVMS. Bioaccumulation behavior of cVMS in both Tromsøysund and Storvatn will utilize the benthopelagic model developed under NORDIC LACS. Once the model developed for Storvatn has been submitted for publication (early 2017), construction of this manuscript will begin with submission planned in late 2017.

Master and PhD-students involved in the project

None

For the Management

One of the key findings from this project was the effect of temperature on the partitioning of cVMS between organic carbon and water. Contrary to known legacy contaminants (i.e., PCBs), environmental model predictions indicate that cVMS partitioning to water will increase with a decrease in temperature. This results cVMS having lower overall environmental persistence at colder temperatures. Furthermore, the sensitivity of K_{oc} to temperature was shown to be important in bioaccumulation model predictions, where differences in bioaccumulation behavior between cVMS was observed. This knowledge may help explain findings shown in previous field studies where bioaccumulation of cVMS occurred to a lesser extent (or not at all) compared to PCBs. Despite cVMS having similar physical/chemical properties to known legacy contaminants, model predictions indicate that these parameters are not enough to provide proper assessment of cVMS environmental persistence and bioaccumulation behavior.

Published Results/Planned Publications

1. Krogesth, I. S.; Whelan, M. J.; Christensen, G.; Breivik, K.; Evenset, A.; Warner, N. A. (2016). Persistence of cyclic volatile methyl siloxanes in a high-latitude lake is dermined by poorly constrained organic carbon-water portioning. *Environ. Sci. Technol.* (accepted 15.11.2016).
2. Warner, N. A. (2016). Siloxanes. In, *Arctic monitoring and assessment programme (AMAP) – Chemicals of Emerging Arctic Concern report (in press)*. Oslo, Norway
3. Krogesth, I. S.; Whelan, M. J.; Christensen, G.; Breivik, K.; Evenset, A.; Warner, N. A. The role of sediment for biotic exposure of polychlorinated biphenyls and cyclic volatile methylsiloxanes in a sub-Arctic lake (in preparation, submission planned early 2017)

Communicated Results

N. A. Warner, I.S. Krogseth, M. J. Whelan, G. Christensen, A. Evenset, K. Breivik. Environmental behavior of cyclic volatile methyl siloxanes in a high latitude lake: A modelled and measured approach. Oral presentation at the 36th International Symposium on Halogenated Persistent Organic Pollutants (DIOXIN). Florence, Italy. 2016.

I.S. Krogseth, E. Undeman, A. Evenset, G. Christensen, M. Whelan, K. Breivik, N. A. Warner. Modelling the behavior of cyclic volatile methyl siloxanes in an Arctic benthopelagic freshwater food web. Poster presentation at the 26th annual meeting of the Society of Environmental Toxicology and Chemistry (SETAC) Europe. MO223. 2016

NILU yearly report (årsrapport). (2016). Solbakken, C. Storvatnet: Sewage, chemicals, and a source of knowledge (Storvatnet: Kloakk, kjmikalier, og en kilde til kunnskap).

Interdisciplinary Cooperation

The intern-disciplinary cooperation was essential in this project. Analytical method development for the measurement of cVMS in the various environmental matrices provided data in which constructed models could be evaluated. The contributions from Dr. Mick J. Whelan and his experience with environmental modelling were key in the model development. These were used to help rationalize observed concentrations and help provide insight into key environmental fate processes occurring, which would not have been possible with measurements alone. In addition to this, construction and parameterization of the benthopelagic model was greatly aided by knowledge on biology and fish behavior provided by Guttorm Christensen and Anita Evenset.

Budget in accordance to results

The funding from the Fram Centre was essential to finalize several publications within the NORDIC-LACS project, which finished earlier this year. This funding continues to support writing hours for the remainder of 2016 for additional publications.

Could results from the project be subject for any commercial utilization

No

Conclusions

Perspectives of this work have been summarized in section 11. Future work will continue on publishing the remaining data obtained within NORDIC LACS and associated Flagship projects. Models developed within this project will be utilized and built upon by the **N**ordic **E**nvironment **M**odel (NEM, project leader: Knut Breivik) project funded by Norwegian Research Council.