Project information

Keywords
Cyclic siloxanes, Arctic Lakes, Persistence,
Project title
Assessment of environmental residence times for cyclic volatile methyl siloxanes (cVMS) within a Nordic Lake environment: A case study of Storvatn, Hammerfest.
Year
2015
Project leader
Nicholas Warner
Participants

Fram Centre partners

• Nicholas A. Warner (Project leader) / NILU (nicholas.warner@nilu.no)

• Ingjerd Sunde Krogseth/ NILU (Ingjerd.Sunde.Krogseth@nilu.no)

• Guttorm Christensen / Akvaplan-niva (guttorm.christensen@akvaplan.niva.no)

International partners

• Mick J. Whelan / University of Leicester, United Kingdom (mjw72@leicester.ac.uk (United Kingdom)

Flagship
Hazardous Substances
Summary of Results

This project was a follow-up investigation regarding cyclic volatile methylsiloxane (cVMS) contamination within the Lake Storvatn in Hammerfest. As part of the Norwegian research council project, NORDIC LACS (project number: 222259), environmental contamination and fate of cVMS has been previously determined in the Storvatn aquatic environment. Emissions of cVMS to Storvatn were occurring through overflow events (heavy rain or snow melting) and leakages of wastewater from the existing wastewater infrastructure. However, this infrastructure was upgraded in July 2014, which should significantly reduce emissions and exposure of cVMS to Storvatn. The purpose of this project was to 1) assess the impact such renovations had on cVMS contamination and exposure in Storvatn and 2) assess environmental residence time of cVMS in Storvatn one year after emission have ceased.

Sediment samples were taken from the same locations investigated under the NORDIC LACS project. cVMS under investigation include octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5) and dodecamethylcyclohexasiloxane (D6). D5 was the dominant compound detected in sediment samples. Comparison of sediment concentrations both before (June 2014) and after (June 2015) emissions showed higher concentrations of D5 to occur after emissions have ceased to Storvatn (Figure 2). Similar findings were also observed for D4 and D6. This is partly attributed to lower dry weight and organic carbon content in sediment collected in June 2015 compared to June 2014, resulting in higher concentrations when normalized on a dry and organic carbon weight basis. However, patterns in concentration and sediment characteristic profile (dry weight, organic carbon content) was consistent to that observed at all sampling sites between 2014 and 2015. This would indicate that elevated concentrations observed in 2015 are likely a reflection of environmental/spatial variation and do not indicate that emissions are still occurring to Storvatn.

Similar findings were also observed in sediment core comparisons taken in March 2014 and June 2015. Sediment concentration of D5 at each individual core slice in 2015 were higher compared to those observed in 2014 (Figure 3). However, the pattern in concentration decrease between the two cores was similar and that higher concentrations detected in 2015 are likely a reflection in environmental/spatial variation within the lake.

Biota was also collected for comparison to findings collected under the NORDIC LACS project. Species collected included: sticklebacks(Gasterosteus aculeatus), Brown trout(Salmo trutta), and Arctic char(Salvelinus alpinus). As observed in sediment, D5 was found at the highest concentration within biota followed by D4 and D6. cVMS concentrations found in fish collected in June 2015 were in good agreement to those detected in June 2014 with no statistical differences observed between years (Figure 4). Larger variation was observed in Sticklebacks for D5 in 2014 compared to 2015. Reason for this remains unclear, although concentrations between the two

sampling periods overlap and are considered not statistically different.

Similar concentration profiles in biota between 2014 and 2015 indicate that exposure to cVMS from the Storvatn environment has remained unchanged. This is likely attributed to the slow removal/degradation of cVMS from sediment compartments as supported by surface sediment and core profile concentrations. This indicates that exposure to cVMS may occur for extended period of time even though emissions have ceased.

For the Management

Key findings from this project indicate that significant contamination of the Storvatn aquatic environment still remains after one year, despite stoppage of emissions through wastewater infrastructure renovation. Findings within the sediment indicate slow removal/degradation of cVMS from this compartment are in good agreement with previous model predictions carried out under the NORDIC LACS project. Persistence within the sediment compartment will result in ongoing exposure to cVMS to aquatic biota despite stoppage in emissions. This is supported by comparable concentrations found within biota during pre- (2014) and post (2015) emission stoppage scenarios, highlighting that continued exposure to aquatic biota will occur due to the considerable persistence of cVMS in sediment compartments.

The results from this project help provide insight into the behavior of these chemicals in Arctic environments, and how their exposure and removal are affected under these conditions. These findings are key to current evaluations being conducted by the European Chemical Agency (ECHA) surrounding restrictions on production and use of D4 and D5 due to their environmental persistence and bioaccumulation potential. These aspects continued to be debated between industry, regulators, and academia where little information is known about how environmental factors affect their overall behavior. Understanding of how environmental conditions affect their overall persistence in both Arctic and non-Arctic regions will be key in making appropriate decisions regarding future use of these chemicals

Published Results/Planned Publications

Planned publications:

1. Persistence of cyclic volatile methylsiloxanes within Arctic Lake sediments. To be submitted to Environmental Science & Technology (in preparation)

2. Assessment of cVMS exposure to aquatic biota in both a pre and post emission stoppage scenario. To be submitted to Environmental Science & Technology (in preparation)

Communicated Results

None at this time

Interdisciplinary Cooperation

The project greatly benefited from the biological expertise of Guttorm Christensen and his extensive knowledge of the Storvatn aquatic environment. His knowledge feeding behavior of the various fish species helped provide insight into potential differences in cVMS exposure. In addition, this information is being used to help develop environmental models that will be used to describe the biological fate of cVMS in Storvatn as part of the NORDIC LACS project.

Disciplines involved: Analytical/environmental chemistry, biology, environmental modeling

Budget in accordance to results

Funding provided by the Fram Centre helped fund costs associated with sampling, chemical analysis, as well as research hours for evaluating the data.

Could results from the project be subject for any commercial utilization

No

Conclusions

Future research plans are to communicate these findings through peer-reviewed scientific journals to key stakeholders responsible for chemical regulation in Norway and within Europe. This is particularly important regarding current discussions within the EU through the REACH progamme on proposed restrictions to the use of these chemicals.

A future sampling campaign is tentatively planned for June 2017 to assess the contamination and environmental response after a 3 year stoppage in cVMS emissions.