Fram Centre

Report from completed research project in the Fram Centre- 2020

This form is only meant for projects that have received research funding from the Fram Centre through the flagships (not incentive funding).

1. Title of Project:

PharmArctic - Sources, bioaccumulation and mitigation alternatives for pharmaceuticals in the marine environment around the settlements of Svalbard - a transdisciplinary approach

2. Project leader(s) and participants with institutional affiliation (both national and international):

Project leader: Ida Beathe Øverjordet (SINTEF Ocean, SO); Project participants: Antonio Sarno, Rachel Tiller, Lisbet Sørensen, Andy Booth (SO), Geir Wing Gabrielsen (Norwegian Polar Institute, NPI), Roland Kallenborn (Norwegian University of Life Sciences, NMBU & University Center in Svalbard, UNIS); Administrative responsible for lead institution: Mimmi Throne-Holst (SO).

3. Flagship(s):

Hazardous substances

4. Amount of funding from the Fram Centre, and any internal institutional and/or external funding (i.e. NRC, EU):

500 kNOK for 2020. No additional funding in 2020.

5. Summary of results, including 2-3 highlights from the project (max 1 A4 page, figures can be attached separately):

The funding allowed the collection of sewage and water samples in Longyearbyen and Ny-Ålesund, biota sampling in Kongsfjorden close to Ny-Ålesund and analysis of biota samples collected outside Ny-Ålesund in 2018.

1. Sewage effluent were collected form the main outlet of untreated sewage in Longyearbyen and from the sewage treatment plant in Ny-Ålesund. We collected 3 replicate effluent samples at 4 time points between June and September 2020. We also placed passive samplers in the effluent water at both sites as well as in the sea for two weeks to get time integrated data for PPCP release from sewage to the environment and in seawater.
The travel restrictions due to Covid-19 allowed us to capture samples both in a time when mainly local populations were present (June) through a gradual increase of tourism and travel activity through to September. Although the amount of tourists are expected to be significantly lower in 2020 than in a normal season (Statistics not available per November 2020) we believe the data from the sewage samples will be valuable in the interpretation of the relative contribution of the different segments (local populations and visitors).

2. Biota samples were collected in Kongsfjorden close to Ny-Ålesund by the Norwegian Polar institute between July and September 2020. New samples of zooplankton were collected as well as samples of different species of fish and blood samples of the seabird's common eider and northern fulmar. These samples will be analyzed provided funding of a second year. The results from these samples will give a broader picture of the potential bioaccumulation and trophic transfer of PPCPs in the marine food web of Svalbard.

3. Samples of invertebrates collected close to Ny-Ålesund in 2018 have been analyzed for 17 target pharmaceuticals using tandem mass spectrometry. We found quantifiable levels of diclofenac, citalopram, ciprofloxacin, nicotine, benzocaine and tricaine mesylate (Figure 1). In addition, ibuprofen and triclosan were detected in parallel samples using GC-MSMS (Figure 2). We also detected several compounds originating from personal care products in the samples using GCxGC-MS screening (results not shown here). The pattern of pharmaceuticals varies between animal groups. Ibuprofen were found in highest concentrations in all groups. For the other pharmaceuticals, the benthic scavenging amphipods had the highest concentrations. Ciprofloxacin comminated in the benthic species, while citalopram concentrations were higher than ciprofloxacin in the pelagic species. The data has not yet been thoroughly analyzed, as the results were received recently. However, the pattern of compounds in the different animal groups may indicate differences in local and distant sources, exposure levels, persistence, and bioaccumulation potential of the compounds.

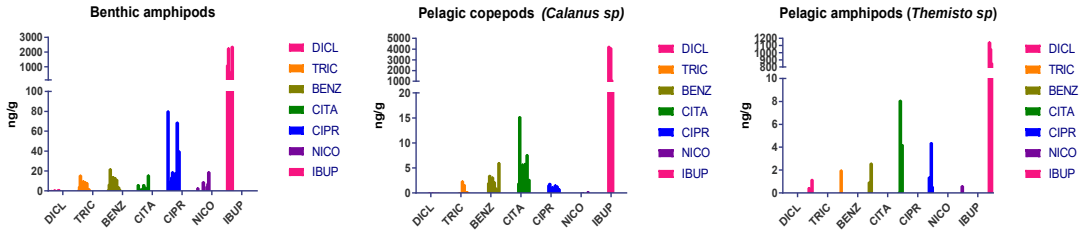

Figure 1. Concentrations of pharmaceuticals (ng/g wet weight) in benthic amphipods (left, n=13), pelagic copepods (middle, n=12) and pelagic amphipods (right, n=4) collected in Kongsfjorden close to Ny-Ålesund in July 2018. Each bar represents one sample of pooled individuals (weight range 210-950 mg per sample). Note different scale on y-axis. DICL – diclofenac, TRIC – Tricaine mesylate, BENZ – Benzocaine, CITA – Citalopram, CIPR – Ciprofloxacin, NICO – Nicotine, IBUP - Ibuprofen.
Please note that the concentrations presented here are lower than those presented in the NETS conference and in the application for funding to the FRAM centre for next year, as we unfortunately discovered a calculation error leading to too high concentrations being reported for a fraction of the samples. The relative patterns between the species remain the same, as the error was evenly distributed among the samples.

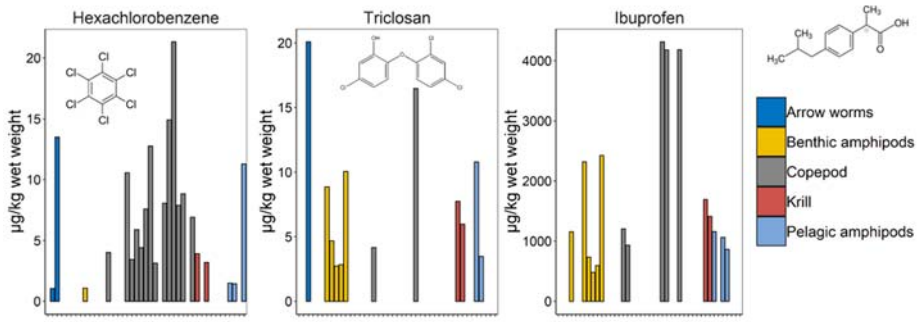

Figure 2. Hexachlorobenzene, triclosan and ibuprofen (µg/kg) detected in Arctic invertebrates collected in Kongsfjorden, Svalbard in July 2018.

The samples were also screened for 114 other pharmaceuticals, although this method is less specific and does not provide an absolute quantification. We observed signals for 19 of the screened pharmaceuticals with varying degree of certainty regarding the identity of each analyte. Notably, diazepam was detected in almost all samples with a wide species-dependent intensity range. Diazepam has shown to bioaccumulate in marine biota, indicating that the measured signal was not an artefact. Taken together, these data confirm previous studies showing pharmaceutical releases into Svalbard waters and underscore the need for more extensive studies.

6. Geographical localization of the project – in decimal degrees (max 5/project)

Field sampling of biota: Ny-Ålesund: 78.9N, 11.9E; Longyearbyen 1: 78.23N, 15.67E; Longyearbyen 2: 78.2N, 15.5E.

7. Published results/planned publication(s) - i.e. international journals, reports, abstracts from conferences/workshops (Send a copy of publications, for the database, to kathryn.donnelly@framsentret.no):

Preliminary project results were presented as a platform presentation on the 8th Norwegian Environmental Toxicology Symposium (Bergen, digital) in November 2020.
We have planned to publish the results in an international journal, preferably with some additional data from the 2020 samples. The abstract and presentation has been sent.

8. Communicated results and their channels (i.e. workshops, press, users):

We have arranged an interview with a journalist working for the research magazine Gemini (SINTEF, NTNU) next week, and we expect to have the project presented here within this year. We were in contact with Gemini before summer, but they wanted to have results before an article was made.

9. Inter-disciplinary cooperation i.e. did the project benefit from such cooperation. Include positives and negatives in this respect, and list disciplines that were actually involved in the project:

We are in the initial phase of the project where the focus has been to obtain chemistry data that will serve as a background for the planned social science work in the project. We will use the natural science data from this first year and the analytical work planned for next year in the stake holder interactions and political work planned for next year.

10. Budget in accordance to results obtained i.e:

- **In which way has the funding from the Fram Centre helped the project?**
- **Did the Fram Centre funding act as a sufficient boost for completing the project through other sources of funding?**

PharmArctic was an original project seeking funding from the Fram center only, not an additional funding of an ongoing project. The funding allowed us to collect samples in Svalbard as well as to perform initial analysis of samples collected earlier. We have demonstrated that pharmaceuticals are present in Arctic biota, which makes further work highly relevant. We do not at present have funding to cover the analytical work of his years collected samples, as well as the social science part of the project.

We did during 2020 receive funding that will cover parts of the planned work in the original PharmArctic project through the EEA Norway-Poland grant (Pharmarine project, October 2020 – September 2023). In Pharmarine the potential long-range transport of pharmaceuticals and personal care products (PPCPs) from Europe towards the Arctic will be studied, as well as the toxicity of selected PPCPs to Arctic organisms. Hence, we have removed the entire WP2 – "Toxicity testing" of the original PharmArctic in the application for further funding next year. (The work in PharmArctic did not directly contribute to the financing of Pharmarine, as the application to the EEA was sent one year ago.)

11. For the management (summary of findings that could be of interest to the management):

We have demonstrated that pharmaceuticals are present in Arctic biota collected in an area where local pollution was expected to be relatively low. This is of interest to the local

wastewater and sewage management agencies as well as both national and Arctic governing bodies.
Further analysis and data treatment should be done before we approach governing bodies, in particular analysis of the sewage samples, and further data collection on demography, local pharmaceutical use, potential contribution form tourism etc.

12. Could results from the project be subject for any commercial utilization?

No: X (if so as input to the development of Arctic sewage treatment systems).

Yes, please explain:

13. Conclusions

a) Indicate future research and/or perspectives which the project results have led to
b) List and describe new methods or techniques that have been developed during the project or that the project has revealed a need for

a) We have demonstrated the presence of several pharmaceuticals and compounds originating form personal care products in invertebrates collected in Svalbard. To our knowledge we report the first concentrations of pharmaceuticals in biota from Svalbard. The concentrations of some of the pharmaceuticals are at the same level or even significantly higher (Ibuprofen) than concentrations found in invertebrates in populated areas around the world.
As this first year was an initial screen for pharmaceuticals in biota to determine the relevance of the project, we still need more data to answer the main objectives of PharmActic. In particular perform a source mapping where we determine the concentrations in sewage effluents and seawater, as well as map demography, pharmaceutical use and routines for releases from tourist vessels.

b) Our initial analysis of biota samples for pharmaceuticals has revealed a need for further optimization of the extraction methodology, as a substantial amount of several target pharmaceuticals are lost in the procedure due to matrix effects from the invertebrates. Whole animals were homogenized, and the composition of the sample matrix varied among species/groups. It is evident that methods suited for other biota samples may not be optimal for marine invertebrate samples. Further work is planned to optimize the extraction procedure to maximize the recovery of the target pharmaceuticals, as well as increasing the number of targets for quantitative analysis. We do believe that more optimal extraction methods will increase the potential for identifying more compounds in the screening approach.

Date: 13. November 2020

Sign: Ida Beathe Øverjordet