Screening studies on POP levels in freshwater environment within the joint Russian-Norwegian border area

Tatiana Savinova[1], Vladimir Savinov[1], Guttorm Christensen[1], Galina Chernik[2], Lyudmila Alexeeva[2], Dmitry Samsonov[2], Nikolay Kashulin[3]

[1]Akvaplan-niva, Polar Environmental Centre
[2]SPA "Typhoon"
[3]INEP

Introduction

The joint border area between Norway and Russia has unique environmental qualities and rich natural resources. The area is however under severe anthropogenic influence, particularly from extensive mining and metallurgic industry, but also from water regulations and other human impacts. Smelting of copper-nickel ore at Kola Peninsula has significant pollution effects on the environment in the border areas. The impacts of the emissions on the environment are largest on the Russian side of the border, closest to the pollution sources - both with respect to the severe effects and to the geographical extent of the observed effects - but also the easternmost parts of Norway are affected by the emissions. This area also has been identified by the Arctic Monitoring and Assessment Programme (AMAP) as a key area in which pollution emissions and their effects are to be monitored.

Investigations carried out in the early 1990s revealed numerous acidified and heavy metal polluted lakes in the border areas [1, 2]. In addition to the air pollution, the mining activity has a direct discharge to the Kolosjoki River which enters into Lake Kuetsjarvi in the Pasvik River watercourse. High levels of heavy metal contamination have been recorded in water and sediments in the vicinity of the smelters[2, 3], possessing a threat to fish and other biota[4, 5] , and potentially also a health problem for humans consuming fish from the watercourse. In addition to heavy metal contamination in the vicinity of smelters were found elevated levels of PAHs in soil[6]. However levels of persistent organic pollutants (POPs) in the Pasvik watercourse have not been studied so far.

A modernization of the smelters is under development, and the goal is to reduce the emissions by 90% [2]. In order to be able to document and evaluate the effects of possible reductions in emission levels there is a need for establishing new reference values of the environmental status prior to modernisation of the smelters. The aim of this study was to analyse freshwater sediments and fish in the lakes in the border area of Russia and Norway for different POP groups, including new compounds.

Materials and Methods

Three sites (Kuetsjarvi) on the Russian side and 4 sites (Pasvik area) on the Norwegian side have been chosen for sampling of sediments and fish. Recommendations of the Arctic Monitoring and Assessment Program[7] for core sampling were used during the fieldwork.

Sediment samples were taken with the Skogheim gravity corer and divided into 1-cm slices for further analyses of established and new POPs. Different trophic level fish (pike, whitefish and perch) were also collected for contaminant analyses (liver, muscle samples).

The analytes were: polycyclic aromatic hydrocarbons (PAHs) – 21 compounds; basic POPs - PCBs (50 o*rtho*-substituted congeners; including all congeners recommended by AMAP), DDT-family (6 isomers), hexachlorobenzene (HCB), hexachlorocyclohexane (HCH; *a*-, *b*- and *g*-isomers), chlordane compounds (heptachlor epoxide, oxychlordane, *cis*- and *trans*-chlordane, *cis*- and *trans*- nonachlor, heptachlor, endrin, dieldrin, mirex); “new” compounds - coplanar PCBs,polybrominateddiphenyl ethers (PBDEs), and dioxins/furans (PCDD/PCDF).

Analyses were carried out at Typhoon Analytical Centre (Obninsk, Russia). The laboratory has national accreditation

within the framework of Russian Analytical Laboratories Accreditation System (ALAS) for POPs and mercury in abiotic and biotic environmental media (fresh- and seawater, air, soil, bottom sediments, biological material, include humans tissues). Laboratory has also successfully participated in the QUASIMEME International interlaboratory study on POPs and heavy metals in biological samples (2000-2002). Moreover, in 2001-2002 the laboratory took part in the intercalibration analyses organized by Department of Energy DOE (MAPEP-2001-2002), USA; NIST/NOAA-NS&T/EPA-EMAP QA Program; AMAP Ring Test (Round 1-2 at 2002 and Round 1 at 2002; 6-th and 7-th Round International Intercalibration Study by MTM Research Center Orebro University, Sweden (for DIOXIN 2001 & 2002); Second Italian Free Intercalibration Round. Detailed information on standards, chemicals, clean-up, QC/QA procedures, instrumentation and quantification are published elsewhere[8].

Results and Discussion

Only PAHs, HCB, DDT and metabolites, *cis*- and *trans*-nonachlor were detected in the sediments among all established POPsanalysed. HCH, endrin, dieldrin and mirex were not detected in sediments from all locations studied. The highest levels of all detected established POPs were found in the bottom sediments from Kuetsjarvi Lake. A tendency of decreasing of PAH and PCB levels (including planar and *mono-ortho* substituted PCB congeners) with a distance from the smelter was found. The comparison of different PAH ratios calculated for sediment samples from Kuetsjarvi Lake and other stations within the Pasvik River basin was made for identification of PAH contaminant source.Predominance of anthropogenic input into PAH level formation was shown for sediments from Kuetsjarvi Lake.

The highest PBDE levels were detected in sediments from Kuetsjarvi Lake (104 pg/g dw). Differences in PBDE composition suggesting the different source of these compounds are shown in *Figure 1.*

The highest levels of PCDD/PCDFs were also found in the bottom sediments from Kuetsjarvi Lake. However, PCDD levels, in general, were comparable within the study area, while PCDF levels in Kuetsjarvi Lake were 1.5-2 times higher compared to the other Pasvik watercourse sites studied. PCDD/PCDF levels in sediments from Kuetsjarvi Lake were comparable to those from area near Kirkenes, when high PCDD/PCDF levels were found in freshwater bottom sediments [9, 10].

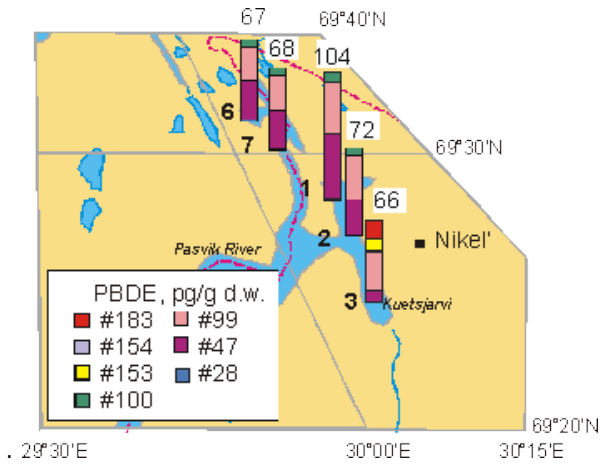

Figure 1. Polybrominateddiphenyl ether levels and contribution of different PBDE congeners into ΣPBDE in bottom sediments , pg/g dry weight, (August-September 2003). Contributions.

In order to estimate the total toxic equivalents (TEQ) in bottom sediments, different toxic equivalent factors (TEF) were calculated for each station. As can be seen from *Figure 2*, the highest TEQs were calculated for Kuetsjarvi Lake. PCDFs were the major contributors to the TEQ.

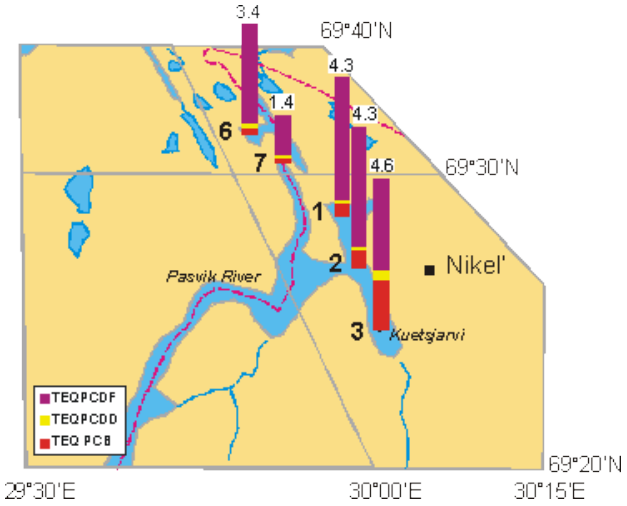

Figure 2. Contributions of PCDF, PCDD and PCB into the Total TCDD toxic-equivalent (pgTEQ/g dry weight) in bottom sediments, August-September 2003.

Analyses of fish from the study area are underway and results will be available by August 2005.

This first screening study on POP levels showed the presence of established and new persistent organic compounds in the freshwater environment within the Pasvik watercourse area. More studies are planned this year in order to identify possible contaminant sources.

Acknowledgements

We would like to thank the INTERREG KolaArctic Programme and Environmental Department of Finnmark County (Norway) for financial support and staff of the Norwegian College of Fishery Science and INEP for help during field expeditions.

References

1. SFT (2002). Air Pollution Effects in the Norwegian - Russian Border Area. Norwegian Pollution Control Authority. *TA 1860/2002*

2. Dauvalter V. and Rognerud S. (2001). Heavy metal pollution in sediments of the Pasvik River drainage. *Chemosphere* 42:9-18.

3. MoiseenkoT.I. (1994). Acidification and critical loads in Surface Waters; Kola, Northern Russia. *Ambio*, 23:. 418-424.

4. Amundsen,P.-A., Staldvik F., Lukin,A., Kashulin N., Reshetnikov Y. S. and Popova, O.A. (1997). Heavy metal contaminations in freshwater fish from the border region between Norway and Russia. *The Science of the Total Environment* 201: 211-224.

5. Lukin A., Duvalter V., Kashulin N., Yakolev V., Sharov A. and Vanysh O. (2003). Assessment of copper-nickel industry impact on a subarctic lake ecosystem.. *The Science of the Total Environment* 306: 73-83.

6. Reimann C., Äyräs M.,, Chekushin V., Bogatyrev I., Boyd R., Caritat P., de Dutter R., FinneT.E., HallerakerJ.H., Jæger Ø., Kashulina G., Lehto O., Niskavaara H., Pavlov V., Räisänen L., Strand T. and Volden T. (1998). Environmental Geochemical Atlas of the central Barents Region. NGU-GTK-CKE special publication: 745 pp.

7. AMAP. (2002). Report on the Experts Meeting on Sampling and Analysis of Persistent Toxic Substances (PTS), St. Petersburg, Russia, 28 May - 1 June, 2000. *AMAP Report: 6*

8. Muir D., Savinova T., Savinov V., Alexeeva L., Potelov V and Svetochev V. (2003). *Sci Tot Environ*.306: 111-131.

9. Skotvold, T. & Schlabach, M. 1997, PCDD/PCDF I innsjø-sedimenter på Varangerhalvøya og Kolahalvøya. *Akvaplan-niva Rapport* 514.974: 49 pp. (In Norwegian).

10. Skotvold T., Savinov V. 2003. Regional distribution of PCBs and presence of technical PCB mixtures in sediments from Norwegian and Russian Arctic Lakes. *The Science of Total Environ.* **306** (2003):85-97.