

Mercury in Nordic Freshwater Fish: An Assessment of Spatial Variability in Relation to Atmospheric Deposition.

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Abstract: Data on mercury levels in freshwater fish (mainly pike, perch, trout and char), from Norway, Sweden and Finland have been collected in a common database to assess spatial patterns as well as relationships with environmental factors such as atmospheric mercury deposition. A preliminary evaluation of fish Hg data from >1500 lakes shows that Hg levels referring to a 1-kg pike are highest in low-altitude lakes of the southern regions S. Norway, S+C. Sweden, and C. Finland, where regional medians are 0.5-0.8 mg/kg fw. In these regions, about 50-80 % of the lakes exceed 0.5 mg/kg and about 5-20(40) % of the lakes exceed 1.0 mg/kg. Fish Hg levels in high-altitude lakes are lower than in low-altitude lakes in the corresponding region.

Key words: mercury, fish, precipitation, regional patterns.

INTRODUCTION

Contamination of freshwater fish by mercury remains an environmental problem of concern in the Nordic countries. Previous studies have demonstrated a link between atmospheric deposition of mercury and methylmercury levels in Swedish freshwater fish (e.g. LINDQVIST *ET AL.*, 1991, MEILI *ET AL.* 2003). Here we examine a large dataset of mercury in fish from >1500 lakes in Sweden, Finland and Norway. Future investigations will include mercury levels in catchment soils and sediments and evaluation of possible links between environmental loading, catchment characteristics and mercury concentrations in fish.

RESULTS AND DISCUSSION

Most fish Hg data from Sweden were taken from the national database at IVL (www.ivl.se). This database contains results from national and regional monitoring programmes as well as regional surveys performed by county and local administrations. Finnish and Norwegian data

were compiled from national and regional monitoring programmes. For each lake, Hg concentrations were normalized to refer to the flesh of a 1-kg pike (*Esox lucius*), a predatory fish commonly used for Hg surveys. These values were then used to prepare a map of standardized mercury levels in freshwater fish in the Nordic countries (Figure 1).

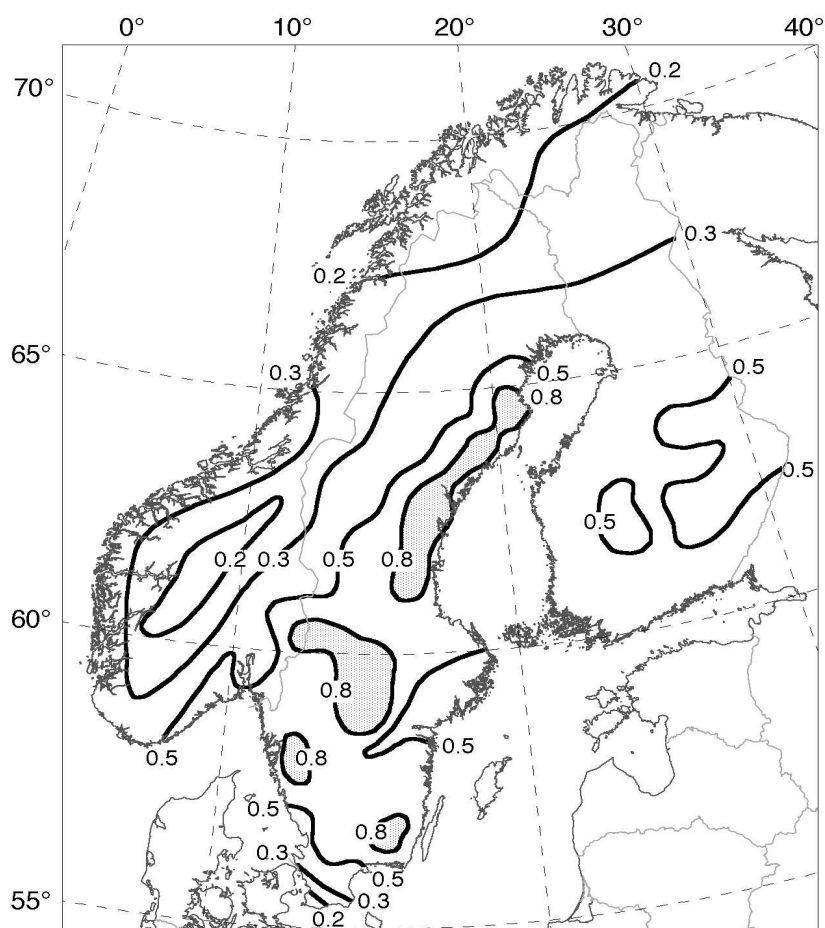


Figure 1. Mercury concentrations in freshwater fish in the Nordic countries. Preliminary map based on data from >1500 lakes and referring to the concentration (mg/kg fw) in a 1-kg pike (*Esox lucius*).

The main features of the geographical pattern is decreasing levels from south to north with the high concentrations also found in central Sweden and along the Swedish coast of the Gulf of Bothnia. The elevated concentrations in Central and Northern Coastal Sweden may be influenced by historical emissions of mercury to both water and air. However, specific ecosystem characteristics also contribute to the variability in fish Hg between regions. This is also true for the southernmost part of Sweden where very low concentrations were found despite a larger influence of atmospheric pollution. This area is mainly agricultural and the freshwater bodies mainly eutrophic where methylmercury accumulation in fish is not so evident.

The geographical patterns of atmospheric deposition have been presented by IVERFELDT (1991) and MUNTHE *ET AL.* (2001). Data from Nordic monitoring sites are available from the

late 1980's and clear decreasing trends for the following years at the southernmost stations have been attributed to reduced emissions in central Europe (MUNTHE *ET AL.* 2001). In recent years/ since 1997, the temporal trend has levelled out. A latitudinal gradient still exists, and Hg concentrations in precipitation are about twice as high in the south than in the north. In Figure 2, data from sites operated within the Swedish and Finnish national monitoring network are presented.

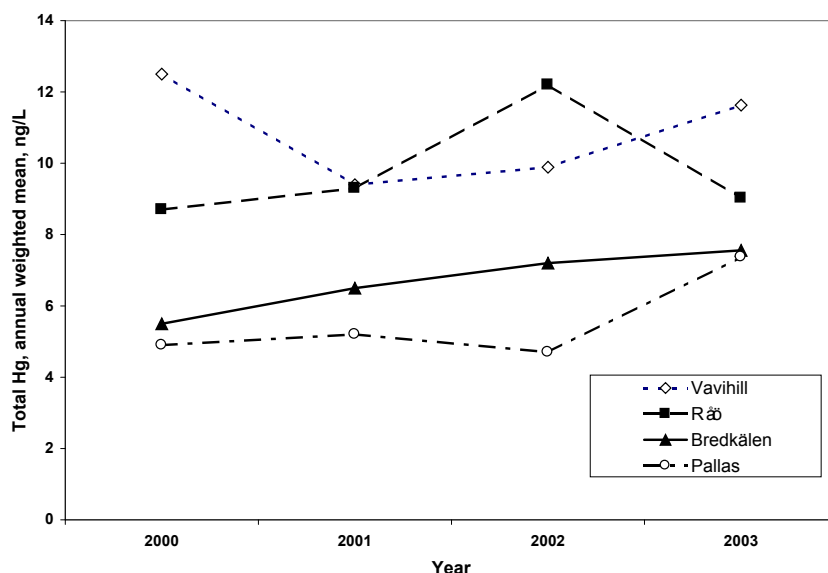


Figure 2. Annual volume-weighted mean concentrations of total mercury in precipitation at monitoring stations in Sweden and Finland. The stations are located in a south to north gradient: Vavihill, Rää, Bredkålen, Pallas. The Rää station was moved about 2 km from Rörvik to Rää in 2001.

The concentrations of total mercury in precipitation still exhibit a decreasing trend from south to north although the magnitude of the gradient is not as large as in earlier studies. Any apparent trends over the years are not considered to be significant (*e.g.* apparent increase in Bredkålen). Higher calculated annual mean concentrations are often influenced by single monthly samples with high concentrations, which do not represent the general concentration levels observed at the site or at neighboring/adjacent sites.

CONCLUSIONS

This new compilation of fish mercury data from Sweden, Norway and Finland shows that large geographical areas are affected by mercury contamination, which is enhanced in regions of high susceptibility. Furthermore, the general pattern of contamination follows a similar pattern to current and previous atmospheric deposition and pollution. Large areas have fish with Hg concentrations exceeding the WHO-based EU health advisory guideline of 0.5 mg/kg, thus restricting their use for human consumption. In Table 1, a summary of median fish concentrations and exceedance of the guideline value are presented for different regions.

Table 1. Summary of fish Hg concentrations collected since 1988 in different regions of the Nordic countries, and fraction of lakes with levels exceeding the WHO-based EU guideline for most fish species.

Country	Region ¹⁾	Number of lakes	Median Hg in Fish, mg/kg fw	Fraction of lakes with Hg >0.5 mg/kg fw
Norway	S >800m	17	0.16	0%
Norway	C >800m	12	0.20	0%
Norway	N	21	0.23	5%
Norway	C <800m	21	0.26	25%
Norway	S <800m	98	0.55	60%
Sweden	N	102	0.35	25%
Sweden	C	221	0.82	80%
Sweden	S	801	0.66	70%
Finland	N	30	0.39	10%
Finland	S	140	0.48	50%

¹⁾ S= south, C= central, N= north, altitudes usually <800 m

An evaluation of mercury concentrations in precipitation indicates that the influence from anthropogenic sources from Central European areas is still significant. The data also suggest that the previously observed decreasing trends in the deposition of mercury in Scandinavia are no longer evident.

A more comprehensive assessment of factors influencing levels of methylmercury in fish has to include a number of other parameters such as catchment characteristics (e.g. relative size, presence of wetlands), contents and fluxes of DOC in soil run-off and surface waters as well as methylation potential within ecosystems.

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REFERENCES

- IVERFELDT, Å. (1991) Occurrence and turnover of atmospheric mercury over the Nordic Countries. *Wat. Air Soil Pollut.* **56**, 251-265.
- LINDQVIST, O., JOHANSSON, K., AASTRUP, M., ANDERSSON, A., BRINGMARK, L., HOVSENIUS, G., HÅKANSON, L., IVERFELDT, Å., MEILL, M. AND TIMM, B. (1991) Mercury in the

Swedish environment -Recent research on causes, consequences and corrective methods. *Wat. Air Soil Pollut.* **55**, 1-261.

MEILI, M., BISHOP, K., BRINGMARK, L., JOHANSSON, K., MUNTHE, J., SVERDRUP, H. & DE VRIES, W. (2003): Critical levels of atmospheric pollution: criteria and concepts for operational modelling of mercury in forest and lake ecosystems. *Sci. Total Environ.* **304**, 83-106.

MUNTHE, J., KINDBOM, K., KRUGER, O., PETERSEN, G., PACYNA, J. AND IVERFELDT, Å. (2001). Examining source-receptor relationships for mercury in Scandinavia – modelled and empirical evidence. *Wat. Air Soil Pollut. Focus* . **1**, 299-310.
