Depuration of PAH Contamination in Sediments

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Abstract

For the best part of a century, Loch Leven (Scotland) received discharges containing polycyclic aromatic hydrocarbons (PAH) from an aluminium smelter. Sediments in the loch became contaminated with PAH, and have been sampled on a series of occasions, pre- and post-closure of the smelter, for PAH, particle size and organic carbon.

The sediments in the upper section of Loch Leven had PAH levels elevated above any reference or background concentration. The concentrations of PAH in the lower basin, while exhibiting some elevation above background concentrations, were significantly lower than those in the upper basin.

A stratified random sampling design was adopted and optimized to deliver the greatest power to detect temporal changes, within the constraints of the resources available for the programme.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are on the Oslo and Paris (OSPAR) Commission List of Chemicals for Priority Action and the European Union Water Framework Directive List of Priority Hazardous Substances. Other national and international fora have also identified PAHs as a cause for concern at environmental and human exposure levels. While PAHs occur naturally, the main environmental input is anthropogenic and their presence has implications for human and ecological health.

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PAHs enter the environment as products of incomplete combustion of fossil fuels, wood and coal burning emissions, motor vehicles, power stations, incinerators and other sources. Industrial processes historically associated with PAH emissions include the production of aluminium by electrolytic reduction in carbon lined steel cells containing alumina (ASC/AL). In an electrolyte of molten cryolite (Na3AlF6).

An aluminium smelter at Kinlochleven, at the head of Loch Leven, Scotland has been in operation for more than 50 years. The smelter has produced aluminium from its ore using a smelting electrolytic process since 1951. The main products of this process are aluminium and by-products such as alumina, fluorspar and salt. The by-products are used in a variety of industries, including the manufacture of aluminium alloys and refractory materials.

The performance of the 2004-06 surveys, expressed as a % CV, was mixed. For the upper basin, the CVs were typically around 40%, but for the lower basin, the CVs were around 15% in 2005 and 2006 and as low as 35% in 2004.

Improved estimates of surface area data from bathymetric data, and of stratum means and CVs from the 2004-06 data, have been used to refine the survey design (Table 2). Five samples have been re-allocated from the upper basin and from stratum 1 to improve survey performance in the lower basin.

In particular, samples have been re-allocated from the upper basin and from stratum 1 to improve survey performance in the lower basin. Even more samples might have been re-allocated, but the priority is to make inferences about the upper basin, where concentrations are higher.

Conclusion

Elevated concentrations of PAH persist in Loch Leven, particularly in the upper basin. It is too early to say whether any depuration has occurred. The data collected so far have been used to improve the power of the monitoring programme.

References


