Inputs of Mercury, Cadmium and Lead via Water and Air to the Greater North Sea

MSFD Descriptor: 8 - Concentration of contaminants
MSFD Criterion: 8.1 - Concentration of contaminants

Key Message Total inputs of the heavy metals mercury, cadmium and lead to the Greater North Sea have reduced, since 1990. However, improved analytical procedures for mercury and cadmium since 1990 make it difficult to be certain what proportion of observed changes are due to reduced discharges and emissions

Background

OSPAR's strategic objective with regard to hazardous substances is to prevent pollution of the OSPAR Maritime Area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim to achieve concentrations in the marine environment near background values for naturally occurring substances and close to zero for manmade synthetic substances. Heavy metals are hazardous because they can cause adverse biological effects on an organism's activity, growth, metabolism, reproduction or survival. Three of the most toxic heavy metals – mercury, cadmium and lead – are on OSPAR's List of Chemicals for Priority Action owing to their high toxicity and potential to cause harm to marine life.

Mercury, cadmium and lead are emitted through a range of natural, industrial and agricultural processes, for example fertiliser can be a source of cadmium (**Figure 1a**). Heavy metals are most often transported as, or tightly bound to, fine particles and the particles can be blown into the air from exposed soils and earth, and also from the surface of the sea. As a result, heavy metals are subsequently transported via the atmosphere. Unlike other heavy metals, mercury can also evaporate and be transported as a gas. In addition, mercury and cadmium can accumulate in the food chain (**Figure 2**), whereas lead does not.

Waterborne inputs of mercury, cadmium and lead are monitored by OSPAR countries. Atmospheric inputs are modelled by OSPAR countries (**Figure 1b**), based on annual emissions reported under European Union Emissions Directives and the United Nations Convention on Long-range Transboundary Air Pollution.

Figure 1: (a) Mineral fertiliser is a significant source of cadmium in many parts of Europe © Graham Horn; (b) An atmospheric monitoring station

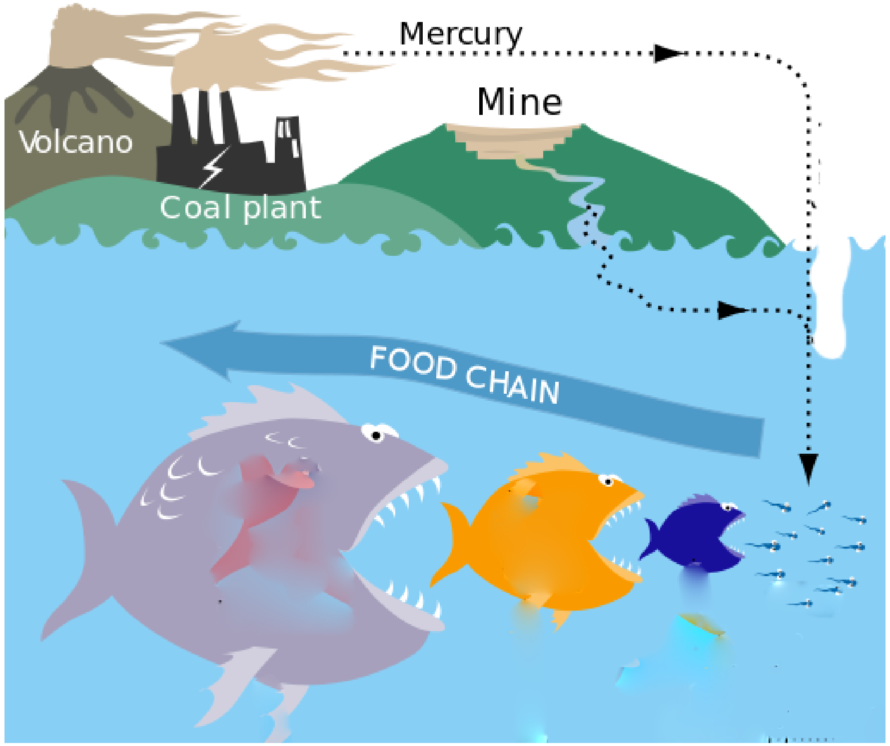

Figure 2 (right): Mercury from coal-fired power plants and other sources is transported through the atmosphere and water. Mercury, in the form of methylmercury, can bioaccumulate through the marine food web reaching high concentrations in top predators

Results

Although inputs of mercury, cadmium and lead to the Greater North Sea appear to have more than halved since the start of the 1990s (**Figure 3** overleaf), advances in analytical methods resulting in improved (lowered) detection limits mean that while there is a downward trend in inputs, the change is certainly overestimated. However, it is not possible to determine by how much. Overestimation occurred in the past because the limit of quantification for an analysis was higher than the actual concentration of the substance in the environment. Similarly, some countires have changed their metal analysis, for example from total metals to dissolved metals, since the introduction of the European Union Water Framework Directive in 2000. This has also resulted in an apparent input reduction. It is unclear whether similar issues affect the atmospheric deposition data, which are dependent on the quality of reported emissions, the accurate description of meteorological and chemical processes, and the quality of the validation data.

Inputs of Mercury, Cadmium and Lead via Water and Air to the Greater North Sea

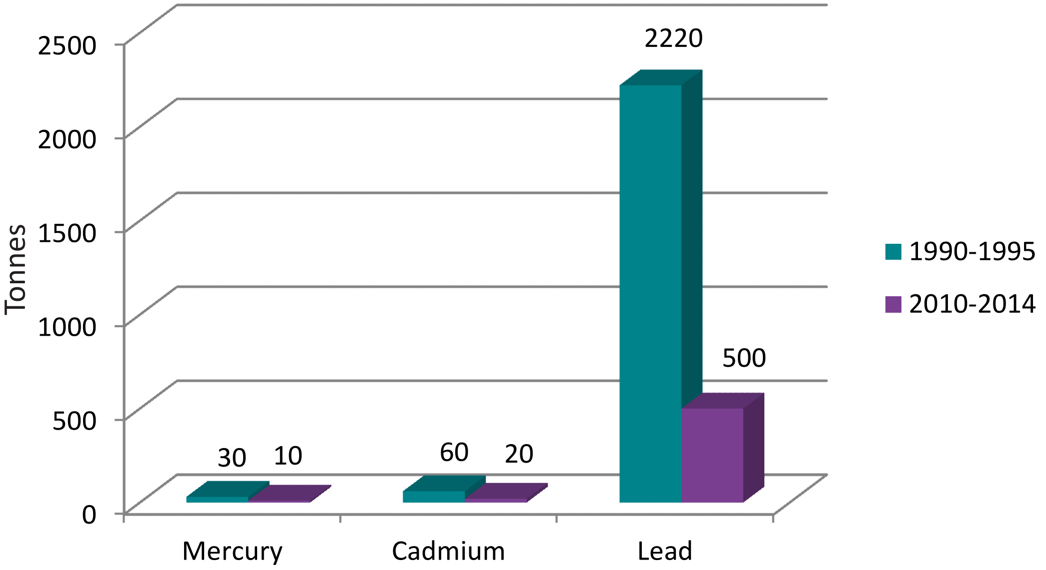

Figure 3: Estimated total inputs (riverine and atmospheric) of mercury, cadmium and lead to the Greater North Sea in 1990–1995 and 2010–2014. Values are in tonnes, rounded to the nearest 5 tonnes (100 tonnes in the case of lead)

Results cont...

Mercury inputs via water have approximately halved between 1990–1995 and 2010–2014 and air inputs have reduced by approximately one-third, noting a proportion of this is likely to be due to improved analytical techniques. Cadmium inputs via air and water have both reduced by two-thirds. Waterborne lead inputs have more than halved while airborne lead deposition is less than a third of the level it was in 1990.

All OSPAR countries have made substantial reductions in waterborne mercury inputs between 1990–1995 and 2010–2014. The Netherlands and Germany have made the greatest reductions in waterborne lead inputs, accounting for half the total waterborne reduction between them.

Airborne inputs of all three heavy metals have reduced significantly between 1990–1995 and 2010–2014. Mercury inputs due to countries' emissions are now significantly lower than inputs from 'non-OSPAR' countries. These non-OSPAR inputs come from outside the OSPAR Maritime Area as well as from re-suspended material; such as from exposed soils, and urban, arable and marine surfaces both within and outside the OSPAR Maritime Area.

There is moderate confidence in the methods and low confidence in the data used for this assessment.

Conclusion

OSPAR countries have made significant efforts to reduce emissions and losses of mercury, cadmium and lead to both air and water. These results appear to show significant progress towards the OSPAR objective to 'prevent pollution of the Maritime Area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances'.

OSPAR countries have been most successful in reducing atmospheric lead inputs to the Greater North Sea. Secondary atmospheric pollution from re-suspended material and from sources outside the OSPAR Maritime Area are now the major sources of airborne pollution and there is a need for cooperation beyond OSPAR's boundaries to manage these in addition to the waterborne inputs.

Heavy metal input estimates are very uncertain, particularly for mercury and cadmium. Quantification limits vary between laboratories within countries, and as laboratories or methods change. This causes substantial changes in the estimated inputs. These uncertainties were greater at the beginning of the analysis period. Despite the methodological issues for mercury and cadmium, with measurement techniques that are close to detection limits, the monitoring data for the suite of heavy metals shows substantial input reductions.

Knowledge Gaps

Strict quality controls are needed in laboratories analysing heavy metal samples. High detection limits can lead to an overestimation of inputs and an inability to detect changes. The effect on quantification limits should be assessed whenever a change in analysis laboratory is considered.

There is a mismatch between the requirements of the European Union Water Framework Directive to measure metal concentrations in the dissolved fraction and the OSPAR Agreement to quantify total heavy metal inputs.

Knowledge gaps remain concerning the retention and export of heavy metals in estuaries, limiting knowledge of the proportion of metals that reach the marine environment.

There is limited knowledge of losses of heavy metals from harbours, shipping, historical dumping and other potential sources.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments