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History of bioavailable lead and iron in the Greater North Sea and Iceland during the last millennium – A bivalve sclerochronological reconstruction

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ABSTRACT

We present the first annually resolved record of biologically available Pb and Fe in the Greater North Sea and Iceland during 1040–2004 AD based on shells of the long-lived marine bivalve *Arctica islandica*. The iron content in pre-industrial shells from the North Sea largely remained below the detection limit. Only since 1830, shell Fe levels rose gradually reflecting the combined effect of increased terrestrial runoff of iron-bearing sediments and eutrophication. Although the lead gasoline peak of the 20th century was well recorded by the shells, bivalves that lived during the medieval heyday of metallurgy showed four-fold higher shell Pb levels than modern specimens. Presumably, pre-industrial bivalves were offered larger proportions of resuspended (Pb-enriched) organics, whereas modern specimens receive fresh increased amounts of (Pb-depleted) phytoplankton. As expected, metal loads in the shells from Iceland were much lower. Our study confirms that bivalve shells provide a powerful tool for retrospective environmental biomonitoring.

1. Introduction

As a marginal sea bordered by the most densely populated and highly industrialized countries, the North Sea is severely impacted by human activities (Weichart, 1973). Aside from overfishing, oil and gas exploitation, modification of the sea floor by dredging, bottom trawling, and removal of sand and gravel, pollution constitutes a major threat to the biota inhabiting the North Sea. Main sources of organic (e.g., PCB, PAH, DDT) and inorganic contaminants (heavy metals, radionuclides, REEs) include rivers, coastal industries, dumping and the atmosphere (Schlünzen et al., 1997). Some of these pollutants are water-soluble and can directly deteriorate the water quality (OSPAR, 2000, 2009b), whereas others accumulate in the sediment. Remobilization of such substances occurs during changes in the biological activity in the water column, in the sediment or near the sediment surface (e.g., enhanced downward transport of organic matter following phytoplankton blooms, increased rates of bioturbation, etc.) and associated changes in pH and DO and can result in secondary pollution effects (Kersten, 1988; Kersten et al., 1994).

To determine baseline levels of biologically available contaminants in the North Sea prior to intensified human perturbation, distinguish natural from anthropogenic environmental disturbances, and identify periods of intensified remobilization of potentially harmful substances at the sea floor, it is crucial to know how pollutant levels changed through time. Such information is indispensable for management purposes and predicting future threads of anthropogenic pollution. For this purpose, numerous sediment cores have been retrieved from various localities in the North Sea during the last decades (Förstner and Reineck, 1974; Behre et al., 1985; Irion and Müller, 1990; Irion, 1993). Results clearly indicate rising heavy metal loads toward more recently deposited strata. The major disadvantage of sedimentary deposits, however, is poor temporal resolution and dating control. Bioturbation results in significant time-averaging and obscures short-term cycles. Furthermore, continuous and undisturbed sediment records are absent in large parts of the North Sea as a result of repeated sediment reworking and resedimentation in these shallow-water settings (Kersten et al., 1988; Irion and Müller, 1990; Irion, 1993). Many records only cover the last one or two centuries or so (Förstner and Reineck, 1974; Behre et al., 1985; Irion, 1993). In addition, sediment records alone can barely provide information on levels of biologically available contaminants close to the sediment water interface where many benthic organisms are dwelling. Such data is particularly relevant from ecotoxicological perspective.

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