Factors affecting metal exchange between sediment and water in an estuarine reservoir: A spatial and seasonal observation

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Water quality response in a reservoir has often been assessed using relatively restricted datasets that cannot provide sufficient information, thereby giving rise to a dramatic over- or underestimate of actual figures. In this paper we discuss how the levels of metallic elements between the sediment and overlying water in an estuarine reservoir can be influenced by aquatic parameters in response to spatial and seasonal conditions. To better elucidate the interfacial exchange between sediment and water, statistical analyses are employed to intensive data sets collected from the Yeongsan Reservoir (YSR), Korea, which has undergone widespread deterioration in water quality due to the continuous growth of anthropogenic sources. During three seasonal sampling campaigns, we found that oxygen deficiency at the bottom water layer promotes Fe and Ni accumulation in sediment, likely due to the formation of sulfide and oxide complexes under anoxic and suboxic environments, respectively. In addition, salinity levels as high as 11‰ in the bottom water layer during autumn substantially increase the release of Mn, restricting the use of YSR as a primary source of agricultural irrigation water. Although most dissolved metals are at acceptable levels for sustaining aquatic life, it is recommended that for long-term planning the elevated Fe and Mn levels in sediment should be controlled with oxygen deficiency during dry weather to ensure a sustainable water supply or, at a minimum, better coordinated operation of YSR.

Introduction

Metal contaminants, ever-present environmental pollutants, are one of the main causes of the deterioration of ambient water quality in recent years, and pose a considerable health threat to humans and aquatic life.[1] Sources of metal contamination include natural[2] and anthropogenic sources,[3,4] which once released may be localized to certain areas over various time scales, ranging from decades to centuries. Potential risks of metals and metalloids include acute or chronic exposure,[5] depending on the biological role of the metals and their cumulative effect on the organisms exposed; the scientific underpinnings of such administrative guidelines are documented well in literature.[6]

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Metals are typically partitioned between dissolved and particulate phases in aquatic environments, and naturally accumulate in sediment, water (suspended solids), and biota.[7] Surface complexation, precipitation, and adsorption are the main pathways of the metals in the particulate phase, whereas the soluble phase considerably accelerates the bioavailability of metals, such as during the uptake by plants or organisms.[7,8] Since most metals have a high affinity with organic matter, metal oxides, and clay minerals, they can be effectively accumulated in benthic sediment over time. This accumulation becomes more apparent when there is less hydraulic energy for mobilization and transport, such as in a reservoir that has a severely restricted circulation pattern.[9]

Water chemistry may also play an important role in the partitioning characteristic of metals, determining spatial and temporal evolution across the sediment-water interface.[10] In this case, Eh, pH, salinity, water hardness, particulate load, and

Environmental impact

Water quality response in a reservoir has often been assessed using relatively restricted datasets that provide insufficient information, giving rise to a dramatic over- or underestimate of the real figures. This manuscript statistically elucidates how the levels of metals in sediment and overlying water are influenced by aquatic parameters with special reference to seasonal and locational conditions. The study was conducted in the Yeongsan Reservoir (YSR), Korea, a region that has undergone widespread deterioration in water quality over the past two decades due to the continuous growth of anthropogenic sources, among other factors. Based on the analysis of intensive datasets, we have found that our paper can assist not only in the illustration of an interfacial exchange of sediment-water in a semi-estuarine environment, but also can be used to reduce the existing knowledge gap between lab-scale findings and field-scale observations.

