Hindawi Publishing Corporation
Journal of Chemistry
Volume 2016, Article ID 8923183, 10 pages
http://dx.doi.org/10.1155/2016/8923183

Research Article

Assessment of Heavy Metals in Water, Sediment, and Fishes of a Large Tropical Hydroelectric Dam in Sarawak, Malaysia

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Received 11 November 2015; Accepted 18 January 2016

Academic Editor: Yuangen Yang

Bakun Hydroelectric Dam in Sarawak is one of the world highest concrete rock filled dams. This paper reports the heavy metals concentrations in water, sediment, and fishes of Bakun Dam. Water and sediment samples were collected from 11 stations and 6 fish species were caught. The samples were digested with open acid digestion and the metals contents were analysed using an atomic absorption spectrophotometer and mercury analyser. The method was validated based on certified reference materials. A higher concentration of Fe and Mn was detected in downstream water with significant longitudinal variation. Cu, Zn, and Hg were present in trace amount. All elements analysed were consistently found in sediment with no risk of contamination. For fish, *Hemibagrus planiceps* was characterised by higher affinity for Hg accumulation. The concentrations detected in all fish species were within the permissible guideline of 0.5 mg/kg. The health risk assessment suggested that *Barbonymus schwanenfeldii*, *Puntioplites waandersii*, *Cyclocheilichthys apogon*, and *Hemibagrus planiceps* were characterised by hazard index > 1 implying possible adverse effects. The amount of fish recommended for adults and children was in the range of 500–775 g/week and 33–135 g/week, respectively.

1. Introduction

Dams and reservoirs are mainly built for irrigation, power generation, flood control, and water supply. There are currently more than 58,000 dams built all over the world with China recording the highest number. In Malaysia, there are about 80 existing dams and the number is anticipated to increase due to the escalating demand for electricity [1]. A dam is considered a large dam if it is greater than 15 m with a storage capacity of more than 1 Mm^3.

Dams and reservoirs can serve as a sink for accumulation of heavy metals. Their mobility and availability in aquatic environments are primarily controlled by water quality parameters including pH, dissolved oxygen and organic matter content. In anoxic hypolimnion, the ubiquitous Fe^{3+} and Mn^{4+} in sediment are readily reduced into dissolving Fe^{2+} and Mn^{2+} leading to elevated concentrations in overlying water [2]. As the elements diffuse upward into oxic level, they are oxidized and reprecipitated. Al is also an element that is naturally abundant in sediment, occurring as insoluble silicoaluminate. When pH of the water is low, the dissolution of Al is enhanced thereby increasing its concentration in water. Dams and reservoirs also play an important role in facilitating the transportation of heavy metals. When water is released from a dam, resuspension of deposited sediments under high flow rate tends to carry heavy metals downstream. In Peru, the acid mine drainage from adjacent mining district was flushed downstream from Upamayo Dam, contributing to high concentrations of copper (Cu) and zinc (Zn) in sediment [3].

Impoundment of a dam inevitably involves large area of inundation that fosters an environment with accelerated microbial decomposition. This, in turn, may trigger the transformation of inorganic Hg to organic mercury that can be bioaccumulated and biomagnified along the food chain [4]. Fishes affected by mercury accumulation have been found to take 20–30 years to restore to the background level after impoundment [5, 6]. Considering the possible consequences, the geochemical behaviour of heavy metals in dams and reservoirs has been continuously reported worldwide: