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Accumulation and risk assessment of heavy metals employing species sensitivity distributions in Linggi River, Negeri Sembilan, Malaysia

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ABSTRACT

The constant increase of heavy metals into the aqueous environment has become a contemporary global issue of concern to government authorities and the public. The study assesses the concentration, distribution, and risk assessment of heavy metals in freshwater from the Linggi River, Negeri Sembilan, Malaysia. Species sensitivity distribution (SSD) was utilised to calculate the cumulative probability distribution of toxicity from heavy metals. The aquatic organism's toxicity data obtained from the ECOTOXicology knowledgebase (ECOTOX) was used to estimate the predictive non-effects concentration (PNEC). The decreasing sequence of hazardous concentration (HC_5) was manganese > aluminium > copper > lead > arsenic > cadmium > nickel > zinc > selenium, respectively. The highest heavy metal concentration was iron with a mean value of 45.77 μg L^{-1}, followed by manganese (14.41 μg L^{-1}) and aluminium (11.72 μg L^{-1}). The mean heavy metal pollution index (HPI) value in this study is 11.52, implying low-level heavy metal pollutions in Linggi River. The risk quotient (RQ) approaches were applied to assess the potential risk of heavy metals. The RQ shows a medium risk of aluminium (RQ_m = 0.1125) and zinc (RQ_m = 0.1262); a low risk of arsenic (RQ_m = 0.0122) and manganese (RQ_m = 0.0687); and a negligible risk of cadmium (RQ_m = 0.0085), copper (RQ_m = 0.0054), nickel (RQ_m = 0.0054), lead (RQ_m = 0.0016) and selenium (RQ_m = 0.0012). The output of this study produces comprehensive pollution risk, thus provides insights for the legislators regarding exposure management and mitigation.

1. Introduction

Heavy metal pollution is a threat to the global ecosystem and human health due to heavy metal's toxic and mobile characteristics (Kamaruzaman et al., 2017; Razak et al., 2018). Moreover, heavy metals such as aluminium, cadmium, copper, iron, lead, manganese, nickel, selenium, and zinc persist in the environment because they cannot be destroyed or degraded (Selvi et al., 2019). The indiscriminate discharge of domestic sewage and anthropogenic activities (smelting which discharges arsenic, copper, and zinc; pesticide applications which release arsenic; and fossil fuel combustion which emits nickel and selenium) leads to the accumulation of heavy metal concentrations. These concentrations enter freshwater ecosystems via runoff or aerial deposition (Gall et al., 2015; Masindi, 2018). Surface water such as rivers, lakes, and reservoirs become primary water sources for living organisms. River water also assimilates and transports anthropogenic wastewater, swiftly impacting human health (via drinking water) and the lives of aquatic organisms (via raw water) (Wee et al., 2016). Based on reports from World Health Organization (WHO), the worldwide occurrence concentration ranges of aluminium, arsenic, copper, iron, and zinc in the freshwater environment is between 0.1 and 0.2 mg L^{-1}, 1–2 μg L^{-1}, 0.005–30 mg L^{-1}, 0.5–50 mg L^{-1} and 0.01–0.05 mg L^{-1}, respectively (World Health Organization, 2017a). Moreover, the reports also stated the worldwide occurrence concentrations of cadmium, lead, manganese, nickel, and selenium in the natural freshwater environment is less than 1 μg L^{-1}, 5 μg L^{-1}, 0.1 mg L^{-1}, 0.02 mg L^{-1} and 10 μg L^{-1} respectively. Thus, various modern treatment techniques have been developed to remove heavy metals from wastewater including coagulation, ion exchange, chemical precipitation, and foam flotation (Aris et al., 2020; Razak et al., 2020).

Heavy metal exposure has been well documented to have several

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