Heavy metal contamination, fractionation and mobility in marine sediments of Kilindini-Port Reitz Harbour, Kenya

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Heavy metals are considered as the main inorganic contaminants in the environment due to their negative impact on living organisms and their disordering of the environmental balance. Port terminals and harbours have been known to play important roles in the economy worldwide through the transport and storage of traded goods; however, port activities are often associated with aquatic pollution and the spreading of contaminants along the different environmental compartments, such as the water, sediment and biota. Kilindi-Port Reitz Harbour study was aimed at capturing the effects of industrial and maritime activities along the creek, including the influence from River Mwache, which drains its waters into the creek. The study was conducted in November/December 2016 at six sampling stations to investigate the concentrations of eleven metals (As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, V, and Zn) in surface sediments in order to assess their quantity, distribution, contamination levels, anthropogenic impacts, ecological risks and speciation of sediment components as well as their sources. The results ranked the concentrations of total metals in surface sediments in descending order as: Fe > Mn > Zn > V > Cr > Pb > Ni > Cu > Co > As > Cd. Sediment ecological risk assessment showed metals were higher than the background levels, LAL but lower that ERL and thus summarized as: metal > LAL < ERL. Contamination factor (CF) and pollution load index (PLI) values categorized the sediments as polluted due to anthropogenic influence, whereas Geo-accumulation index ($I_{geo}$) values indicated unpolluted sediments. The risk assessment code (RAC) found that sediments at various at various were considered to be highly dangerous to the Kilindini-Port Reitz creek system or living organisms and these metals can also readily enter the food chain. Correlation analysis and hierarchical cluster analysis (HCA) showed that metals had common behavior, principal component analysis (PCA) showing that the major sources of metals in Kilindini-Port Reitz creek are engineering works, shipping activities, petrochemical industries, industrial activities, fuel tankers, gas carriers, atmospheric deposition and construction works within and around the creek system. The results further show that most metals were bound to the residual fraction (F4), meaning they are fixed in the crystalline phase suggesting that these metals originate from the natural sources, with low chances of release, hence can only be only be available after weathering or decomposition. However, the situation might worsen in future if not managed, given that there is already evidence of the presence of bioavailable metals in the creek system.
**Key words:** Heavy metals, contaminants, speciation, sediments, assessment