

Tracing Heavy Metal Pollution Sources in Donghae Port Sediments Using Metal Isotopes and Statistical Model

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Major global trading ports are vital hubs for global trade but also serve as one of important contributors of heavy metal pollution to coastal marine environment due to industrial discharge and ship maintenance. This study investigated heavy metal contamination in Donghae Port sediments using metal isotopes ($^{207}\text{Pb}/^{206}\text{Pb}$, $^{208}\text{Pb}/^{206}\text{Pb}$, $\delta^{65}\text{Cu}$, $\delta^{66}\text{Zn}$, $\delta^{114}\text{Cd}$), and statistical model (PCA & PMF). A total of 20 surface sediments, 3 core sediments, and 11 potential pollution source samples were analyzed for grain size, total organic carbon, metal concentrations and isotopes.

From the contamination assessment using background concentration and marine sediment quality guidelines, Cu, Zn, As, Cd, and Pb were contaminated and enriched. PCA and PMF results categorized pollution sources into (1) industrial sources affecting Zn and Cd, (2) grain size-related factors containing natural (Cr, Ni) and contaminated (Cu, As, Pb) metals.

Pb isotope ratios showed a strong correlation with the inverse of Pb concentration, indicating zinc ore as the primary Pb source ($^{207}\text{Pb}/^{206}\text{Pb} = 0.909$). $\delta^{65}\text{Cu}$ revealed Cu contamination from background sediments, zinc ore, and antifouling paint. Elevated Cu near the naval base suggests a strong influence from ship-based activities. Dual-isotope ($\delta^{66}\text{Zn}$ - $\delta^{114}\text{Cd}$) identified Zn and Cd sources as zinc ore (65%), coal (1.7%), and background sediments (33%).

These findings highlight the complex interactions between industrial activities, ship maintenance, and sedimentary processes in heavy metal contamination.