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Characteristics of Heavy Metal Distribution in Sediments of Youngil Bay, Korea

Mikyung Lee[1*] · Wookeun Bae[2] · Hoisoo Jung[3] · Jaehwan Ahn[1] · Seogku Kim[1] · Hyungsuk So[1]

[1]*Construction Environment Research Department, Korea Institute of Construction Technology*
[2]*Department of Civil and Environmental Engineering, Hanyang University*
[3]*Marine Geoenvironment and Resources Research Division,*
Korea Ocean Research and Development Institute

e-mail: mklee@kict.re.kr

ABSTRACT

Semi-enclosed coastal sediments were sampled in summer and winter at and around the Youngil bay, Korea, to assess the major controlling factors affecting the metal distribution patterns in the sediments. The mean grain size (Mz) values of the sediments were 3 φ at the Hyungsan river mouth, 4 φ at the Youngil bay, and 5 φ at the Old port. The highest organic carbon content (C_{org}) was observed at the Old port (2.0%). The coefficients of determination (r^2) between Mz and C_{org} were 0.74 and 0.88 in the summer and winter samples, respectively. The average concentrations of Al, Fe, K, Ca, and Sr in the sediments of the Old port were similar to those of the other areas. However, the concentrations of Zn, Cu, Cd, and Sn (370, 115, 4, 6 μg/g) were clearly higher compared to the other areas (87, 11, 0.4, 3 μg/g). To characterize the mobility of heavy metals in the sediments, the metals in the sediments were fractionated into the lattice and the labile fractions. The mineral lattice fraction was high in the order of Al=K (94.5%) > Cr (78.3%) > Li (73.7%) > Sr (64.3%) > Fe (64.1%), while the labile fraction, that could be released to the overlying water, was in the order of Pb (83.8%) > Zn (82.1%) > Cd (78.5%) > Cu (72.0%) > Ca (66.0%) > Sn (58.7%). The total concentration of Al, Fe, Cr, and Pb was strongly constrained by the grain size effect. On the other hand, that of Zn, Cu, Cd, and Sn was affected by the process of anaerobic decomposition of organic matters, and metal sulfide formation. With regard to the change of total carbon and metal contents in SPM (Suspended Particulate Matter) by season, total carbon content in spring and summer increased by 10%, which is more than twice of fall and winter, and Cd, Cu, Zn, Sn, and Pb increased in spring and summer confirming these metals are identified as organophilic

metals. Fe concentration in the seawater was 12 ppb in the Old port representing five times higher than other sea areas. This is because reduced Fe^{2+} ion were released through the early diagenesis in sediments. From distribution feature of sulfur stable isotope ($\delta^{34}S$), the forming of pyrite (FeSx) in the Old port could be proven. This suggests that Cd^{2+}, Cu^{2+} and Zn^{2+} in seawater could be accumulated in the form of metal sulfide complexes such as CdS (Greenockite), CuS (Covellite) and ZnS (Sphalerite) in sediments, provided that contained organic matter content in sediments is high and anaerobic environment is formed at the Old port. The common ranges of pH and Eh for those metal sulfide complexes were about 6~6.5 and -0.2~0 mV, respectively, which were feasible to occur in the anaerobic environment of the Old port. The geoaccumulation index, I_{geo}, indicating relative metal pollution, was lower than 0 for the study area except for the Old port where the I_{geo} values for Zn, Cu, Cd, and Sn were in the range of 1 to 3. Those high values indicated a severe metal pollution in the Old port area.

Key words: sediments, labile fraction, lattice fraction, $\delta^{34}S$, geoaccumulation index