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Metal contamination and source apportionment of river and lake sediments affected by mining and smelting activities in South Korea

DONG-JIN JOE[1], MAN-SIK CHOI[1], JUNG-HYOUN LEE[2] AND CHAN-KOOK KIM[3]

[1]Chungnam National University

[2]Environmental Human Research & Consulting (EHR&C)

[3]Marine Environment Research Institute, OCEANIC C&T Co., Ltd

Presenting Author: djjoe@naver.com

Human activities, such as mining and smelting, can lead to metal contamination of river and lake sediments, posing a threat to aquatic ecosystems and human health. Therefore, it is crucial to identify the sources of metals in these sediments and perform a quantitative assessment for the implementation of source control and restoration tactics. In this study, we collected river (n=58) and lake (n=105) sediments upstream of Andong Lake in South Korea to investigate sediment contamination by cadmium (Cd), zinc (Zn), copper (Cu), lead (Pb), arsenic (As), mercury (Hg), nickel (Ni), and chromium (Cr) and to identify sources of contamination in Andong Lake and its associated river system. Compared to South Korean sediment quality guidelines, river and lake sediments contained the highest overall contamination levels of Cd and As. The potential identification and apportionment of contaminant sources were compared using positive matrix factorization (PMF) and an empirical model of metal concentration ratios. The PMF model effectively predicted metal concentrations and identified two major sources of contaminants in river and lake sediments. Factor 1 was characterized by Cd (84.6%) and Zn (70.3%), with a very high contribution in sediments near the smelter, so it was inferred to be a source of smelting-derived materials (SDM) such as dust, dust-contaminated soil and smelter-derived groundwater. Factor 2 showed high proportions of the rock-forming metals Cr (89.7%) and Ni (85.4%), with significant contributions to As (79.6%), Cu (69.2%) and Pb (61.2%), which were interpreted as a source of tailings-contaminated sediments (TCS), a mixed source of mine tailings and a geogenic source. SDM and TCS sources contributed 52.8% and 47.2% to river sediments and 18.8% and 81.2% to lake sediments, respectively. Cd/Pb and Zn/Pb concentration ratios were used to effectively identify SDM and TCS sources in the empirical model. The empirical source apportionment results for Cd and Zn were in good agreement with those from the PMF model. The relative contributions of SDM to Cd and Zn in sediments by the two models were 77.1-90.8% for Cd and 68.8-71.0% for Zn in river sediments, and from 47.0-66.8% for Cd and 27.4-30.8% for Zn in lake sediments.