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Ecological indicators for mercury biomonitoring using fish: Insights from compound-specific nitrogen and stable mercury isotopes

YO HAN YANG AND **SAE YUN KWON**

Pohang University of Science and Technology

Presenting Author: saeyunk@postech.ac.kr

Mercury (Hg) is a globally distributed toxic heavy metal, which biomagnifies to elevated levels in aquatic food webs. Reports of fish Hg in regional and global waterbodies have grown substantially since the Minamata Convention. Among various objectives, *Article 19* emphasizes the need to monitor Hg levels in diverse environmental media and to select bioindicator species for Hg to evaluate the performance of the convention. We employed compound-specific nitrogen isotope ($\delta^{15}N_{Glu}$, $\delta^{15}N_{Phe}$) and stable Hg isotopes (δ^{202}Hg δ^{199}Hg) to identify ecological factors governing the level and variability of Hg concentration and Hg sources in largemouth bass (LB) and pike gudgeon (PG) across four riverine systems in Korea. LB and PG are characterized as invasive opportunistic feeder and benthic specialist, respectively, and the comparison of Hg level and sources between two species is expected to provide insights into the selection of appropriate bioindicator species for Hg. PG displayed uniform Hg concentration (56-137 ng/g), $\delta^{15}N_{Phe}$ (7-13‰), and trophic position ($TP_{corrected}$; 2.6-3.0, n = 8) across the riverine system, consistent with their benthic specialist feeding behavior. LB showed wide ranges in Hg concentration (45-693 ng/g), $\delta^{15}N_{Phe}$ (1.3-16‰), and $TP_{corrected}$ (2.8-3.8, n = 14), reflecting their opportunistic feeding behavior. Similarly, Hg sources assessed using Hg isotopes reveal that PG have low and uniform δ^{199}Hg (0.20-0.49‰), indicative of methylmercury (MeHg) produced from the local sediment and those that have near-zero δ^{199}Hg. LB show site-specific patterns in δ^{202}Hg (-0.61 to -0.04‰) and δ^{199}Hg (0.53-1.09‰), reflecting Hg sources delivered via precipitation, industrial releases, terrestrial runoff, and mixtures of multiple sources, depending on the site. The δ^{199}Hg of LB also correlate negatively with the $\delta^{15}N_{Phe}$ ($r^2 = 0.45$, $p < 0.05$), used to differentiate between atmospheric and allochthonous nitrogen sources. The elevated δ^{199}Hg are linked with low $\delta^{15}N_{Phe}$, consistent with both Hg and nitrogen being delivered from the atmosphere, relative to the low δ^{199}Hg and high $\delta^{15}N_{Phe,}$ reflecting allochthonous sources. We suggest that LB, despite their opportunistic nature and variable Hg concentration, better captures site-specific Hg sources and may serve as an appropriate bioindicator species for Hg sources relative to PG, with site-uniform Hg level and ecological characteristics.