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Perfluoroalkyl acids (PFAAs) and their source apportionment along the Indus drainage system in Pakistan

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Perfluoroalkyl acids (PFAAs) are of global interest due to their persistency particularly in the aquatic environment. In this study, we assessed PFAAs in the Indus drainage system and discern their sources for the first time in Pakistan. Seventeen PFAAs including 13 perfluoroalkyl carboxylic acids (PFCAs) with carbon lengths C4-C18, and 4 perfluoroalkyl sulfonates (PFASs) were analyzed in the surface water and sediments of the drainage system. Σ PFAAs contamination in surface water and sediments of the drainage system ranged from 2.28-221.75 ng/L and 0.78-29.19 ng/g d.w., with mean value 70.28 ng/L and 3.37 ng/g, respectively. The general PFAAs contamination was considerably high in River Chenab, followed by River Soan, Ravi, Indus, Kabul and Swat, respectively. The riverine water Σ PFAAs mean concentration was significantly high in River Chenab (29%) followed by Soan (25%) >Ravi (18%) >Indus (18%) >Kabul (09%) >Swat (01%) with frequently detected compounds PFBA followed by PFPeA > PFHxA > PFOA > PFHpA > PFBS > PFNA > PFDA > PFDoDA > PFOS > PFUnDA > PFHxS, respectively. While, the sediments concentrations were high in the River Chenab (43%) followed by Indus (23%) >Soan (11%) >River (08%) >River (06%) with frequently detected compounds PFHxA followed by PFPeA > PFOA > PFBA > PFBS > PFHpA > PFOS > PFNA > PFDA > PFHxS > PFUnDA > PFDoDA, respectively. Significant spatial variations were plotted among the PFAAs in water and sediments, suggesting PFAAs persistency and additional inputs along the entire drainage system. Industrial discharge, municipal wastewater, agricultural and surface runoffs from the urban localities was the major potential sources. Moreover, the individual PFAA contamination in the drainage system was within the risk threshold, however, the Σ PFAAs flux (55.78 kg/day) and water concentration 1827.36 ng/L of the drainage may not be underestimated that might pose chronic risks to the regional ecosystem and humanities.

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