

Heavy metal contamination in rivers across the globe: an indicator of complex interactions between societies and catchments

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Abstract Metal contamination (i.e. a deviation from the natural content) of river particulates is closely associated with human history. Natural contents of Cd, Cr, Cu, Hg, Ni, Pb, Sn and Zn in pristine streams depend on basin lithology. Their quantile distributions ($C_{10\%}$, $C_{50\%}$, $C_{90\%}$, in parts per million) in French pristine streams are similar to those observed for 178 pristine large rivers, whose medians are very close to average shale composition. In another set of 400 rivers of unknown status or under human pressure, $C_{90\%}$ values are close to levels observed in very contaminated water bodies (harbours, sewers), a confirmation of the metal issue severity at the global scale. In Western Europe, metal contamination history as archived in river sediments, shows: (i) a similar order of metal sensitivity to human pressures ($Hg = Cd > Pb = Zn > Cu > Cr > Ni$); (ii) a maximum contamination state from 1950–1970, and; (iii) an effective decontamination for sensitive metals since 1980 or earlier, as a result of technological changes, metal recycling, decreased use of coal and environmental measures. Current state indicators, contents and enrichment factors, are favourable compared to 1940, and depend on the dilution by river sediment loads. Leakage rates of metals, which define the pressure/driver ratio, range in the River Seine between 0.1% and 10%, depending on the metal and time periods. *Per capita* excess loads, expressing the pressure, were found to be similar for a given metal, in Western Europe, the Danube and Mississippi river basins and were highest around the 1970s. Meanwhile, contamination is increasing in newly-industrialised countries (e.g. the Yangtze River, China). World rivers have entered the Anthropocene era. Regional surveys performed within short periods should now be preferred to the traditional approach of reporting global averages, and these new surveys should encompass pristine, degrading and recovering river basins.

Key words metal contamination; river basins; fluvial sediment; leakage rate; per capita excess load; Anthropocene