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Critical evaluation of PAH source apportionment methods in Swiss background soil

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Organic pollutants, such as polycyclic aromatic hydrocarbons (PAHs) can threaten the soil ecosystem. To minimize their input to soil, their sources have to be identified. We critically assessed two approaches of source apportionment, i.e. characteristic PAH ratios and a linear mixing model that is based on factor analysis, by applying them to measured PAH concentrations in top soils of the Swiss soil monitoring network (NABO). The NABO consists of 105 background stations across Switzerland, covering altitudes from 200 to 2200 m.a.s.l. and various types of land use as well as soil types.

Concentrations in the NABO soils ranged from 32-1034 ug/kg$_{dryweight}$(dw, median 163 ug/kg$_{dw,}$n=99) for the Σ16 EPA PAHs. Heavy PAHs (anthracene to benzo[g, h, j]perylene) correlated significantly and positively with population density, whereas light PAHs (naphthalene to phenanthrene) did not. In contrast, light PAHs correlated in the same way with the total organic carbon content, whereas heavy PAH did not. We presume that the spatial pattern of heavy PAHs in Swiss soils is predominantly source driven, whereas the light PAHs were more evenly distributed over the country, since significant sources of preferentially light PAHs at remote places are unlikely. Analogously, the different mobilities of individual PAHs as a result of their different vapour pressures probably also influenced various PAH characteristic ratios (e.g. fluoranthene/(fluoranthene&pyrene)) often used for source apportionment. Currently, out of the range of characteristic PAH ratios, only few (e.g. perylene/(perylene&pyrene))

seemed robust in this respect and provided qualitatively plausible results. In general, fractionation processes such as varying atmospheric transport velocities or transformation in soil question the applicability of characteristic PAH ratios for the identification of pollution sources on a large scale. Thus, our study demonstrated the limit of this approach for a national dataset and we recommend an accurate calibration of this approach.

The linear mixing model revealed three evenly distributed profiles, which however did not match any of the literature sources profiles (n=300). Among the descriptive parameters, low altitude and high population density lead to high scores of the first profile, which was dominated by heavy PAHs. The second profile, characterized by relatively high concentrations of light PAHs, was related to high total organic carbon and agricultural land use. The third profile, featuring PAHs in the middle range in addition to heavy ones, was positively influenced by low altitude, high population density, and high total organic carbon.