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Understanding Polycyclic Aromatic Hydrocarbon transfers at the catchment scale combining chemical and fallout radionuclides analyses

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Contamination of river water and sediment constitutes a major environmental issue for industrialized countries. Polycyclic Aromatic Hydrocarbons (PAHs) are a group of persistent organic pollutants characterized by two or more fused rings. In recent years, studies dealing with PAHs have grown in number. Some PAHs present indeed a high risk for environment and human health because of their carcinogenic and mutagenic properties. However, most of these studies focused on measuring PAH concentration in the different compartments of the environment (air, soil, sediment, water, etc.) In this context, there remains a lack of understanding regarding the various processes responsible for PAH transfers from one environmental compartment to another.

Our study aims to quantify PAHs transfers at the catchment scale by combining chemical analysis with gamma spectrometry. Air, soil, river water and sediment samples (n=820) were collected in two upstream sub-catchments of the Seine River basin (France) during one year. Chemical analyses were carried out to determine PAHs concentrations in all samples. Furthermore, measurement of fallout radionuclides (Beryllium-7, Lead-210, Caesium-137) in both rainfall and river sediment provided a way to discriminate between freshly eroded sediment vs. resuspension of older material that previously deposited on the riverbed. This information is crucial to estimate PAH residence time and transfer velocities in the Seine River basin.

The results show that the PAH behaviour varies from one subcatchment to the next. PAH transfers depend indeed on both the characteristics of the catchment (e.g. topography, presence of drained cropland in catchments) and the local anthropogenic pressures. A significant increase in atmospheric deposition of PAHs is observed during winter due to a larger number of sources (household heating). The 14-month study has also highlighted the seasonal variations of PAH fluxes, which are mainly related to the hydrological regimes (i.e. low flow vs. flood periods). The behaviour of the PAHs mainly depends on their molecular mass. The lightest ones tend to quickly migrate to rivers whereas the heaviest slowly accumulate in soils throughout the low-flow period. Then, an increase in PAH export associated with sediment is observed during the winter floods, when rivers are heavily loaded with suspended matter. The downstream exports of PAHs are controlled by the main erosion processes that occurred in the catchments. Results show that PAH fluxes are more important when material is mostly supplied to rivers by soil surface erosion processes than when they are delivered by gully or riverbank erosion.

Despite the reduction in PAH emissions since the 1960s, there is still a significant storage of PAHs in the upstream part of the Seine River basin. In this context, WFD objectives are unlikely to be reached by 2015.