Integrated monitoring of particle-associated transport of persistent organic pollutants (PAHs as case study) in contrasting catchments in Southwest Germany

Barbara Beckingham [1,2] *, Peter Grathwohl [1,2], Hermann Rügner [2], Marc Schwientek [2], Bertram Kuch [2,3]

[1] Center for Applied Geoscience, University of Tübingen; [2] Water Earth System Science (WESS) Cluster, Tübingen, Germany; [3] ISWA, University of Stuttgart, Stuttgart, Germany
* Currently at College of Charleston, Charleston, SC

Introduction

Strongly sorbing hydrophobic pollutants such as polycylic aromatic hydrocarbons (PAHs) are primarily subjected to particle-associated transport and thus are mobilized especially during high flow conditions when soils and sediments undergo erosion and urban runoff is intensified. Whereas soil pollutants reach rivers only slowly by erosion, untreated surface runoff from sealed urban space and stormwater releases are major immediate sources of particle bound pollutants.[1,2] Chemical loads to rivers in general may increase with increasing population density or urban development of watersheds due to abundance of sources and impervious surface.[3-5] Given the scope of anthropogenic impact, integrated and cost-effective strategies for contaminant monitoring in catchments are needed.[6]

Hypothesis

Transport of PAHs is dominated by urban particles (loaded with PAH concentration $C_{sus,u}$) compared to less polluted background particles. PAH concentrations on suspended solids (C_{sus}) are expected to be proportional to catchment population (Inh) per mass flux of suspended particles ($_M TSS$).

$$C_{sus} = C_{sus,u}\, b\, \frac{Inh}{{}_M TSS}$$

Sampling Campaigns

- Monthly water samples were collected in 2009 – 2011 at approx. 40 locations within 5 catchments in southern Germany
- Turbidity, unfiltered water PAH concentrations, dissolved organic carbon (DOC) and total suspended solids (TSS; only during 4 sampling events) were measured.
- Discharge was obtained from gauging stations near catchment outlets.
- Total sediment PAH concentrations at 35 locations in the Goldersbach and in the Ammer (main stem, tributaries) were measured in 2010.

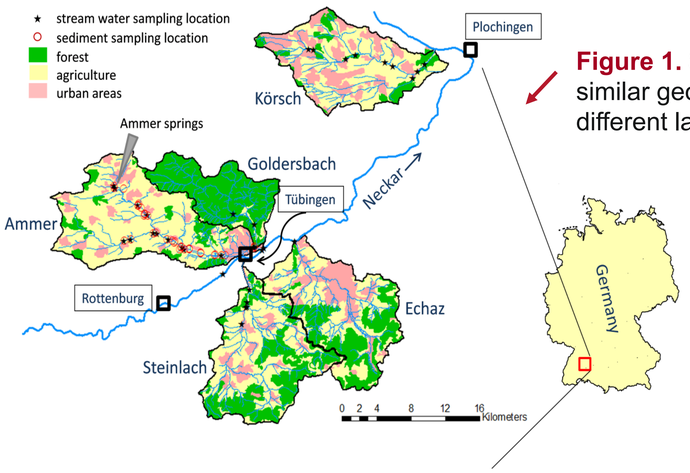


Figure 1. Selected catchments: similar geography/climate but different land use.

Results

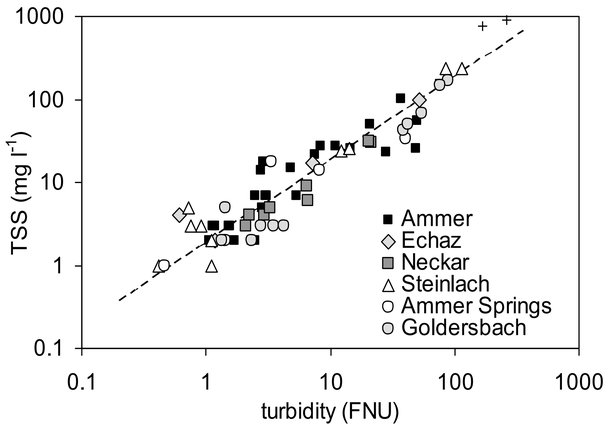
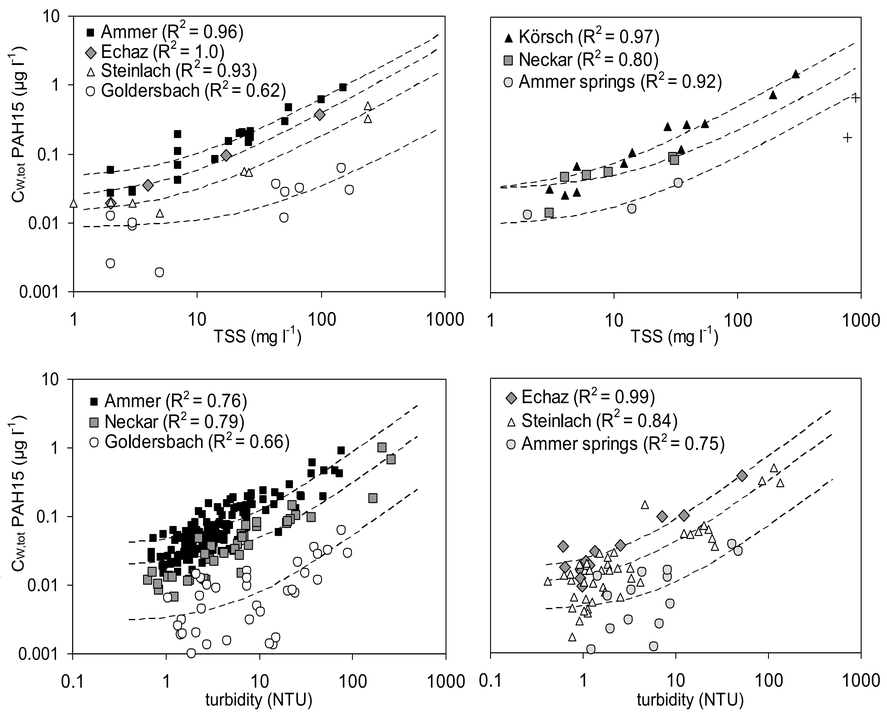


Figure 2. TSS and turbidity are well correlated across all catchments investigated.

Figure 3. From linear regressions of total PAHs in water vs. particle load (TSS or turbidity) suspended solids PAHs (C_{sus}) are calculated. These are different in different catchments.



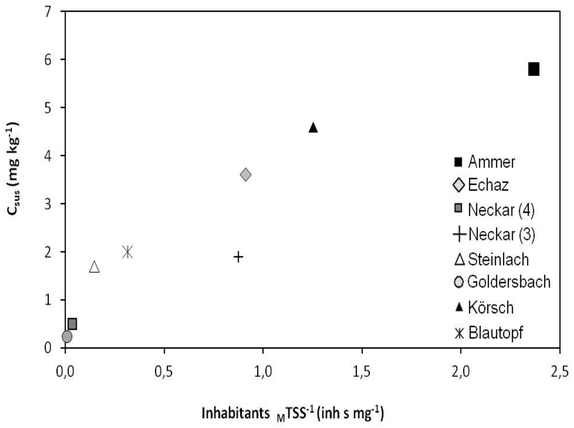


Figure 4. Suspended solids PAHs increase with the number of inhabitants per unit of TSS flux for catchments.

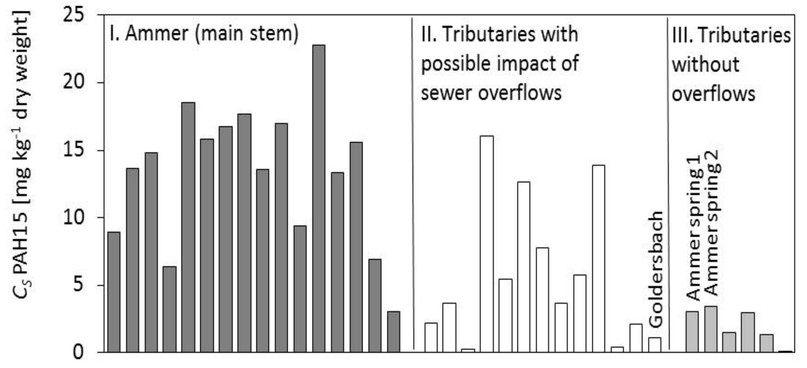


Figure 5. Springs and tributaries without impact of sewer overflows/waste water treatment plants typically have lower sediment PAH concentrations.

Conclusions

- Strong linear correlations between total PAHs in water and suspended solid loads indicate predominance of particle-facilitated transport in catchments.
- The degree of urban pressure in catchments influences the loading of hydrophobic contaminants like PAHs. This relationship should be tested in catchments with more varied land use, geology and climate characteristics.
- TSS correlation with turbidity highlights a convenient measure for assessing particle associated fluxes of pollutants with high temporal/spatial resolution.

Contact
* **Dr. Barbara Beckingham**
College of Charleston
Department of Geology & Environmental Geosciences
202 Calhoun St. Charleston, SC 29401
beckinghamba@cofc.edu

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