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Controlling parameters of fluorescent tracer sorption on soils and sediments

Marcus Bork (1,2), Markus Graf-Rosenfellner (1), Jens Lange (2), and Friederike Lang (1)

(1) Soil Ecology, Faculty of Environment and Natural Resources, University of Freiburg, Freiburg, Germany (marcus.bork@bodenkunde.uni-freiburg.de), (2) Hydrology, Faculty of Environment and Natural Resources, University of Freiburg, Freiburg, Germany (marcus.bork@bodenkunde.uni-freiburg.de)

Fluorescent dyes like uranine (UR) and sulforhodamine B (SRB) have been widely used, especially for tracing hydrological processes. In the recent past, efforts have intensified to use fluorescent tracers also in soils, for example as proxies for organic pollutants. However, the sorption properties of both organic pollutants and fluorescent tracers have to be exactly known to succeed. Yet existing knowledge for soils is still incomplete and poorly standardized. For this reason, we carried out laboratory batch experiments to determine sorption isotherms of UR and SRB with varying pH, soil texture and organic carbon content (OC).

As sorbents we used a sandy sediment with low OC, a silty loamy topsoil with 2.8 %-OC and a similar textured subsoil containing 0.6 %-OC. For both tracers six concentration steps each were prepared and shaken with the suspended sorbent for 42 h using a sorbent:solution ratio of 1:5. During the equilibration, the pH was repeatedly adjusted to 5.5, 6.5, and 7.5 by adding hydrochloric acid (HCl) or sodium hydroxide (NaOH). Subsequently, the tracer-sorbent-suspension was centrifuged and the fluorescence of the tracer in the supernatant was measured. In order to examine the influence of OC and the clay fraction on the tracer sorption, batch-experiments at pH 7.5 were also conducted with manipulated sorbents: top- and subsoil samples were treated with H_2O_2 to remove organic matter and the clay mineral montmorillonite was added to the sandy sediment to achieve final clay contents of 0.1 %, 0.5 %, 1 %, 2 %, 2.5 %, 5 % and 10 % clay.

We observed a negative relationship between the linear sorption coefficient K_d and pH, which was stronger for UR than for SRB. Increasing numbers of negative sorption sites and functional groups of both tracers and sorbents with increasing pH might be the reason for this observation. Besides the pH-value, quantity and quality of clay and OC had a crucial influence on the sorption of UR and SRB in soils and sediment. As expected, increasing clay content, which is associated with an increasing specific surface and therefore more sorption sites, led to an increasing sorption of UR and SRB. Here, after the addition of 4 % of the clay mineral montmorillonite, nearly 100 % of both tracers were sorbed. Furthermore, OC influenced the sorption of UR and SRB in different ways: while the sorption of UR increased, the sorption of SRB decreased with increasing OC.

In conclusion, the sorption behaviour of the fluorescent tracers UR and SRB in soils is very complex, and for appropriate application, the physico-chemical properties of the respective soils or sediments have to be considered. These conditions essentially determine if the respective tracer shows a conservative or non-conservative behaviour. With these aspects in mind, applying SRB and UR has the potential to be a cheap and fast method to estimate the fate of pollutants in soils or sediments.