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Linking Phosphorus forms in emissions and loads for disentangling measure efficiencies and eutrophication effects in surface waters of Germany

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Differences in quality, form and bioavailability of P originating from different sources are well known. Though, there is still a gap between different research disciplines addressing bioavailability of P in emissions, in surface waters and their resulting impact on aquatic primary producers and water quality. On river basin scale, longitudinal transport and transformation, time lags, changing hydrological conditions and the continuous mixing of upstream loads with laterally added emissions make the identification of links between DP emissions and ecological impacts a demanding task.

In spite of extensive measures to reduce anthropogenic P emissions from agricultural areas, waste water and urban systems, excess Phosphorus is still a major threat to aquatic ecosystems. Recent studies even revealed that implemented measures partly showed unexpected or even unwanted effects. Consequently, the effect of measures to reduce emissions and the procedure in selecting the best measure is suggested subject to re-evaluation. Rather than discussing the general effect of measures to reduce total P emissions, we contemplated the potential effects of reducing readily bioavailable P forms to increase the effect of management measures.

By applying the nutrient flux model MONERIS to Germany we identified the spatial distribution of total and dissolved P emissions and the share of the contributing sources and pathways. Subsequently, internal transport and retention processes have been modelled and the resulting concentrations compared to the observed concentrations as well as the change of relative shares of PO4 on TP (DP-TP-ratio).

Our studies revealed the importance of P stored in agricultural soils and a clear spatial pattern in the DP-TP-ratio in emissions. However, this pattern showed clear, often contradictory, divergences from the observed DP-TP-ratio in surface waters. By using boosted regression tree approaches we identified slope, specific run-off and catchment size as main drivers explaining the observed DP-TP-ratio. Though, a correlation between the observed DP-TP-ratio in emission and such observed in surface waters could only be found for alpine and some hilly regions. Our results further indicate that major shares of P entering surface waters in particulate forms are easily transformed into bioavailable forms. As a consequence reduction needs shall not only be derived from the amount of emitted P (eutrophication potential) or the sole concentration in surface waters, but by the eutrophication effect, which is predominately dependent on the hydro-morphological characteristics.