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Lauriane Vilmin, José M. Mogollón, Arthur H.W. Beusen, Alexander F. Bouwman

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Forms and subannual variability of nitrogen and phosphorus loading to global river networks over the 20^{th} century

Lauriane Vilmin[a], José M. Mogollón[a], Arthur H. W. Beusen[a,b], Alexander F. Bouwman[a,b]

[a] *Department of Earth Sciences – Geochemistry, Utrecht University, P.O. Box 80021, 3508TA Utrecht, the Netherlands*

[b] *PBL Netherlands Environmental Assessment Agency, P.O. Box 30314, 2500GH the Hague, the Netherlands*

Abstract

Nitrogen (N) and phosphorus (P) play a major role in the biogeochemical functioning of aquatic systems. N and P transfer to surface freshwaters has amplified during the 20^{th} century, which has led to widespread eutrophication problems. The contribution of different sources, natural and anthropogenic, to total N and P loading to river networks has recently been estimated yearly using the Integrated Model to Assess the Global Environment - Global Nutrient Model (IMAGE-GNM). However, eutrophic events generally result from a combination of physicochemical conditions governed by hydrological dynamics and the availability of specific nutrient forms that vary at subyearly timescales. In the present study, we define for each simulated nutrient source: i) its speciation, and ii) its subannual temporal pattern. Thereby, we simulate the monthly loads of different N (ammonium, nitrate+nitrite, and organic N) and P forms (dissolved and particulate inorganic P, and organic P) to global river networks over the whole 20^{th} century at a half-degree spatial resolution. Results indicate that, together with an increase in the delivery of all nutrient forms to global rivers, the proportion of inorganic forms in total N and P inputs has risen from 30 to 43 % and from 56 to 65 %, respectively. The high loads originating from fertilized agricultural lands and the increasing proportion of sewage inputs have led to a greater proportion of DIN forms (ammonium and nitrate), that are usually more bioavailable. Soil loss from agricultural lands, which delivers large amounts of particle-bound inorganic P to surface freshwaters, has become the dominant P source, which is likely to lead to an increased accumulation of legacy P in slow flowing areas (*e.g.*, lakes and reservoirs). While the TN:TP ratio of the loads has remained quite stable, the DIN:DIP molar ratio, which is likely to affect algal development the most, has increased from 18 to 27 globally. Human activities have also affected the timing of nutrient