Transport and retention of dissolved silica in rivers of the conterminous USA

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Dissolved silica (DSi) is an important nutrient in freshwater and coastal ecosystems. The availability of DSi in aquatic ecosystems is governed by mobilization from the terrestrial system and fluvial transport. Part of the mobilized DSi is retained in the rivers, associated lakes and wetlands due to biotic uptake and sedimentation.

On large scale, fluvial DSi fluxes to coastal zones have been assessed mainly based on data from sampling locations at or near the mouth of major world rivers, while for the limnic retention of silica only first-order estimates exist (e.g. Beusen et al., 2009). DSi fluxes from small basins are often neglected in analyses.

For the conterminous USA, the mobilization of DSi has recently been analyzed by Jansen et al. (2010), who described an empirical DSi mobilization function trained on headwater catchments in which limnic DSi retention is less likely to occur. It is here hypothesized that for larger catchments retention of silica can be calculated as difference between predicted DSi mobilization and DSi fluxes derived from hydrochemical monitoring data. Based on this assumption, fluvial fluxes of DSi in the conterminous USA were analyzed distinguishing mobilization, retention, and export to the coastal zone.

River chemistry data from the USGS programs WQN and NAWQA were used to calculate annual DSi fluxes for 638 sampling locations. For each water sampling location the river catchment and its properties (e.g. lithology, land cover, lake area) were derived. DSi mobilization was estimated spatially explicitly by applying a fitted mobilization function after Jansen et al. (2010). Silica retention was calculated by subtracting DSi fluxes based on USGS data from the predicted amount of mobilized DSi. Export of DSi was estimated for distinct coastal segments. For the analyses, average annual runoffs from two different data sets, gridded UNH/GRDC data (Fekete et al., 2002) and PCR-GLOBWB (Van Beek, 2007), were used. The respective results are compared and discussed.

Using runoff after Fekete et al. (2002) (and after Van Beek, 2007) an average DSi mobilization of 1.6 t SiO_2 km^{-2} a^{-1} (1.3 t SiO_2 km^{-2} a^{-1}) was calculated for the conterminous USA. This results in a total mobilization of 12.9 Mt SiO_2 a^{-1} (10.2 Mt SiO_2 a^{-1}). 20% of the area account for up to 64% (62%) of the DSi mobilized, whereas 39% (19%) of the area account for less than 0.1% of the mobilization. Referring to 164 non-overlapping catchments covering the whole area for which DSi fluxes have been calculated (78.4% of the conterminous USA), total retention within freshwater ecosystems is estimated to be 13% (26%) of the mobilized DSi. These values are about the order of magnitude of the 21 to 22% estimated by Beusen et al. (2009) for the North American continent. Results underline that calculation of mobilization, fluvial fluxes, and retention of DSi is sensitive to the applied hydrological model.

References

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