Geophysical Research Abstracts
Vol. 16, EGU2014-9964, 2014
EGU General Assembly 2014

Hydrologic controls on the export dynamics of dissolved and particulate phosphorus in a lowland, headwater agricultural catchment

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Phosphorus (P) availability controls eutrophication in freshwater ecosystems, since P is generally the limiting nutrient to algal development. The contribution of diffuse P emission to surface waters is significant in intensively livestock farmed catchments as a result of high application rates of P-rich animal waste and subsequent enrichment of soils.

This study investigates the transport dynamics of particulate phosphorus (PP), suspended sediments (SS), and dissolved phosphorus (DP) with the aim of elucidating the relationship between PP and DP transport mechanisms and water dynamics in lowland, headwater catchments. The selected catchment (Kervidy-Naizin catchment, France) is particularly suitable for this purpose as it benefits of a 5 years, high-frequency monitoring of PP and DP concentrations at its outlet, including data recovered both during base flow and storm periods, with the monitoring of more than 50 storm flow events. The data analysis includes interpretation of concentration-discharge relationships at the annual time scale and on an event basis, seasonal analysis of flood characteristics and empirical modeling.

Annual DP and PP concentration-discharge relationships of interflood samples display a hysteretic pattern, with higher concentrations during the autumn and spring periods, and progressive decrease during winter. No hysteretic pattern is visible for interflood SS concentration, which follows a classical C=a*Q̓b relationship. During floods, the dynamic of PP export is similar to that of SS during most of the events: the concentration peak occurs during the rising limb of the hydrogram (clockwise hysteresis), suggesting a source close to or within the stream. The amplitude and the hysteresis' loop size for SS and PP are a function of maximum discharge and rate of change in discharge. On the contrary, there is a strong decoupling between DP and SS (and thus PP) during most of the floods (no significant correlation), with DP concentration peaks occurring several hours after discharge (anticlockwise hysteresis). The dynamic of DP export appears in phase with the water table fluctuations measured at the bottom of the slope domains of the catchment. However, maximum DP concentrations during flood tend to be low during extended periods of soil water saturation, even though these periods corresponded to periods of high flow in the streams.

These results show that the hydraulic energy of the stream controls SS and PP dynamics during floods, whilst DP dynamic is influenced by water table fluctuation. Empirical SS/PP/DP models were built considering these findings. Further investigation is currently being made to test how water table fluctuation and redox conditions could affect P availability in soils.