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Short-term versus long-term effects of summer flooding on floodplain biogeochemistry; interacting role of soil use and water quality

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Wetlands may be both sinks and sources of nutrients. Soil cultivation and drainage affects natural biogeochemical cycling of elements, fertilization may cause high accumulation of nutrients in soils (Lamers et al., 2006; Loeb et al., 2007).

Inundation of soils may lead to severe eutrophication due to fast and huge mobilization of phosphate as a result of redox-related reduction of Mn and Fe minerals (Lamers et al., 2006, Smolders et al., 2006). Accumulation of reduced products (e.g. ammonium, sulphide) could affect both element cycling and biodiversity. The quality of floodwater and time of flooding also play a crucial role in nutrient mobilization. Observed effects vary due to way of land use, timing and the period of a year (Zak et al., 2006; Loeb et al., 2007; Swarzenski et al., 2008).

In Poland there have been increasing tendency in both frequency and severity of flood events during last 20 years (Kundzewicz et al., 2005) and there is a need to study the consequences of these events for both water- and nature managers. Presented work compares the effects of summer inundation of different timing (5 and 41 weeks) on biogeochemistry of soils with various way of use (cultivated and non cultivated). The samples originated from former floodplain of the tributary of the Vistula River in Poland (51°13'N; 21°51' E). The material was inundated with water of different quality (enriched with both sulphate and nitrate, nitrate only, sulphate only, no enrichment). Several parameters were analyzed including redox potential and concentrations of P, N, S, Mn and Fe both in soil- and surface water.

One-month inundation led to severe P mobilization up to 200-300 μmol l^{-1} and 25-30 μmol l^{-1} in soil- and surface water, respectively. It was much stronger in cultivated soil due to higher Olsen P pool (3818 and 1863 μmol l^{-1} of bulk soil, for cultivated and non cultivated soil, respectively) indicating a key role of land use in the soil response to flooding. Observed process was linked with nitrate reduction which buffered redox potential (Eh) hampering P mobilization (Eh$>$300 mV). After nitrate depletion P mobilization continued due to Fe reduction. We found the increase in Fe concentration (up to 450 μmol l^{-1} in soil water) and a positive relationship between Fe and P (R^2=0.69) what means what P mobilization was redox-related process (Eh=150 mV) only because there was no P added into floodwater. The composition of floodwater, however, did not play a significant role due to high Fe content in soils immobilizing of sulphide which could not interfere with Fe bound P fraction. It can be also explained by low infiltration of water into soil.

Long period of submergence showed the strongest eutrophication of cultivated soil (150-250 μmol l^{-1} in soil- and 60-120 μmol l^{-1} in surface water) which was related to Fe. However, longer period of inundation revealed also a role of water composition. Sulphate enrichment led to significantly higher concentrations of phosphate both in soil- and surface water in comparison to sulphate-free treatments (p <0.001) due to Fe reduction by produced sulphide and stimulation of mineralization by produced bicarbonate. The presence of nitrate did not prevent eutrophication due to fast depletion under water stagnant conditions.

The results showed that summer inundation strongly impact biogeochemical processes in floodplain soils both cultivated and non cultivated even on short-term. The main drivers are way of soil use and water quality. The longer inundation causes stronger changes in the system. That knowledge can be used in prediction the possible consequences of different management strategies for riverine systems and to define optimal choices.