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Editorial

Insights into Organic Carbon, Iron, Metals and Phosphorus Dynamics in Freshwaters

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Organic carbon (OC), iron (Fe), metal, and phosphorus (P) are key aquatic components that largely determine the biotic and abiotic functioning of freshwater systems, including groundwater, soil water, lakes, rivers, and their estuaries. Over the past decade, there has been increasing interest regarding the elevation in organic carbon and iron concentrations in freshwaters in relation to the so-called "browning" effect, caused by climate warming and changes in anthropogenic pressure. As for phosphorus, it is a vital element for all aquatic ecosystems and its aquatic biogeochemical cycle is now undergoing sizable changes linked to eutrophication, invasive species development, and transformations between organic and inorganic forms. This Special Issue combines the articles dedicated to various aspects of the behavior of organic carbon, phosphorus, iron (and other related metals) in a broad range of freshwater environments, from soil solutions and groundwaters to ponds, lakes, rivers, and their riparian zones and estuaries.

Savenko and Savenko [1] presented a review on the geochemistry of phosphorus in continental runoff in the form of both dissolved and solid substances, with a separate consideration for the processes of runoff transformation in river mouth areas. The authors could draw a conclusion about the non-conservative distribution of phosphorus in the estuaries, in most cases associated with biological production and destruction processes. They further argue that conservative behavior of phosphorus was observed only in heavily polluted river mouths with abnormally high concentrations of this element.

Pokrovsky et al. [2] reported a new assessment of riverine fluxes of carbon, nutrients, and metals in the surface waters of permafrost-affected regions; their study is crucially important for constraining adequate models of ecosystem functioning under various climate change scenarios. As a case study, they used the largest permafrost peatland territory on the Earth, the Western Siberian Lowland (WSL). By applying a "substituting space for time" scenario, the WSL south–north gradient was used as a model for future changes due to the permafrost boundary shift and climate warming. The authors demonstrated that, contrary to common expectations, the climate warming and permafrost thaw in the WSL will likely decrease the riverine export of organic C and many other elements; they conclude that modeling of C and element cycles in the Arctic and sub-Arctic should be region-specific, and that neglecting huge areas of permafrost peatlands might produce sizeable bias in our predictions of climate change impact.

In the same territory, Manasypov et al. [3] studied the biogeochemistry of thermokarst lakes and demonstrated that thermokarst lakes and ponds that are formed due to thawing of frozen peat in high-latitude lowlands are very dynamic and environmentally important aquatic systems. They showed that these thermokarst lakes and ponds play a key role in controlling C emission to the atmosphere and organic carbon (OC), nutrient, and metal lateral exports to rivers and streams. Analyses of lake water chemical composition across the permafrost gradient allowed them a first-order empirical prediction of lake hydrochemical changes in the case of climate warming and permafrost thaw, employing a scenario where space is substituted for time. The main conclusion of this study was that the exact magnitude of this response will be strongly seasonally dependent, with the largest effects observable during baseflow seasons.

Extending the knowledge of river water chemical composition in Siberia, Tashiro et al. [4] studied watershed-scale iron dynamics, and coupled the seasonal changes in Fe and dissolved organic carbon (DOC) concentrations in the tributaries of the Amur River basin. They demonstrated that permafrost wetlands in valley areas act as hotspots of dissolved Fe production and greatly contribute to Fe and DOC discharge to rivers, especially during snowmelt and rainy seasons.

Additionally, in Eastern Siberia, Vorobyev et al. [5] described a snapshot study of major and trace element concentration in the Lena River basin during the peak of spring flooding, which revealed a specific group of solutes according to their spatial pattern across the river main stem and tributaries and allowed the establishment of a link to certain landscape parameters. The authors demonstrate that future changes in the river water chemistry linked to climate warming and permafrost thaw at the scale of the whole river basin are likely to stem from changes in the spatial pattern of dominant vegetation as well as the permafrost regime. They further argue that comparable studies of large, permafrost-affected rivers during contrasting seasons, including winter baseflow, should allow efficient prediction of future changes in riverine "inorganic" hydrochemistry induced by permafrost thaw.

Two studies of river water hydrochemical composition in Western Siberia—those of Ivanova et al. [6] and Kolesnichenko et al. [7]—provided new insights on landscape, soil, lithology, climate, and permafrost control of dissolved carbon and other major and trace elements in the Ob River, its tributaries, and other small- and medium-sized rivers of the region. These works demonstrated strong environmental factor control on major and trace element concentrations in Western Siberian rivers and predicted a future increase in the concentration of DIC and labile major and trace elements and a decrease in the transport of DOC and low soluble trace metals in the form of colloids in the main stem of the Ob River. They assert that large-scale, seasonally resolved transect studies of large riverine systems of Western Siberia are needed to assess the hydrochemical response of this environmentally important territory to ongoing climate change. An example of using such an approach for two contrasting rivers of the region—permafrost-affected Taz River and permafrost-free Ket River—is provided by Pokrovsky et al. [8], who showed that climate warming in northern rivers may double or triple the concentration of DIC, Ca, Sr, U, but also increase the concentration of DOC, POC, and nutrients. The study applied a substituting-space-for-time approach for the south–north gradient of the studied river basins.

Further insights on the factors shaping the chemical composition of rivers were provided by Krickov et al. [9] who measured chemical composition of dissolved (<0.22 µm) fractions of snow across a 2800 km south–north gradient in Western Siberia. Based on mass balance calculation, these authors demonstrate that the wintertime atmospheric input represents a sizable contribution to the riverine export fluxes of dissolved (<0.45 µm) Mn, Co, Zn, Cd, Pb, and Sb during springtime and can appreciably shape the hydrochemical composition of the Ob River main stem and tributaries.

The role of river water hydrochemistry in freshwater organism ecology and chemical composition is presented in work of Lyubas et al. [10]. The authors used new data on trace elements accumulation by freshwater mussels in the Severnaya Dvina and the Onega River Basin—the two largest subarctic river basins in the Northeastern Europe. The study revealed that iron and phosphorous accumulation in shells have a strong relationship with their distance from the mouth of the river; additionally, they demonstrated that the accumulation of elements in the shell depends on the environment of the biotope.

Finally, Venelinov and Tsakovski [11] presented a case study of surface waters where they implemented the metal bioavailability concept in the Water Framework Directive (WFD) compliance assessment. Based on comprehensive database including DOC and metals, they used three substitution approaches and demonstrated that BIO-MET can be used as the most appropriate tool for the bioavailability assessment of Cu, Zn, and Pb in Bulgarian surface water bodies.

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