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Application of iron-based nanoparticles in French wetland ecosystems: reactivity, iron transformation and pharmaceutical removal

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In last few decades, surface modification of advanced nanomaterials has been focused on enhancing their utilization in water and soil remediation. Nevertheless, their applicability in the environment subjected to redox oscillations remains still poorly known. This study is conducted to support the most recent progress in nanomaterials development and their roles in the field of environmentally friendly utilization even in redox challenging conditions. We focused on behavior and efficiency of nanoscale zerovalent iron (nZVI) particles and iron nitrides nanoparticles (nIN) towards emerging organic contaminants in the organic matter-rich and redox-variable environment.

Initial, laboratory batch experiments were performed with a well know humic acid (Leonardite, IHSS). The interaction was investigated between nZVI, nIN (1 g/L) and dissolved organic carbon (DOC from 1 to 50 mg/L). Preliminary results confirmed that nanoparticles can effectively interact with DOC, when it is present at concentrations higher than 10 mg/L, leading to an increase of the negative surface charge and a faster stabilization of the size of aggregates to cca 3 μm (mainly for nIN).

Subsequently, we applied nZVI and nIN to organic-rich environments for a period of three weeks, to study the Fe speciation changes and capacity of nanoparticles to remove organic contaminants. The research was conducted in a natural peatbog weakly influenced by anthropogenic activities [1] and a pond, in a peri-urban watershed strongly affected by urban activities, rich in pharmaceuticals [2]. The application of nZVI and nIN in the streams and piezometers (in peatbog) have been done through dialysis bag system acting as a passive sampler. X-ray diffraction results proved the instability of nZVI and nIN by the formation of two main secondary phases, lepidocrocite and magnetite. These final corrosion products do not change with aging time, redox conditions or type of organic matter and could further contribute to the reduction of pharmaceuticals. Therefore, our results demonstrate the relevance of iron-based nanoparticles for remediating emerging contaminants and shed light on the understudied interaction between these nanomaterials and organic matter in the environment.

[1] Gogo, S. et al. (2021), *Hydrological Processes* 35, e14244.
[2] Ledieu, L. et al. (2021), *Chemosphere* 279, 130385.