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Graphene oxide nanoparticles for aquifer remediation: transport experiments and reactivity batch tests.

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Graphene oxide nanoparticles (GONPs) proved effective in the adsorption of a broad set of environmentally relevant contaminants, such as organic aromatic compounds, heavy metals, dye molecules, pharmaceuticals (Iqbal and Abdala, 2013; Zhou et al., 2016). Moreover, thanks to their small size, GONPs could be injected in the subsurface for the in-situ treatment of contaminated aquifer systems. A key step in the development of such remediation technology is the study of the injectability and mobility of GONP suspensions in porous media, as well as of their reactivity against contaminants.

In this study, three GONP sources were considered (two commercial, one synthesized in the laboratory). A systematic study was carried out exploring the influence of GO type, size (300 –1200 nm), concentration (10 – 50 mg/L), and sand size (coarse to fine) on its transport in sand-packed columns (15 cm long, 1.6 cm diameter) at a Darcy velocity of 8.11×10 5 m/s. The main aims were (i) to evaluate which parameters mostly influence GONP transport, (ii) to identify the main mechanisms of GONP interaction with the porous medium, (iii) to verify if the advection-dispersion-deposition model, developed for round-shaped colloids, is quantitatively reliable also for GONPs, characterized by a clearly different structure. Particles were stably dispersed in water and showed a good mobility in the porous medium in all conditions: after injection of 5 pore volumes and flushing, the highest recovery was around 90%, the lowest around 30% (only for large particles in fine sand). This suggested that injection and distribution in groundwater should not be challenging. The particle size was by far the most impacting parameter, even if sand size and particle concentration were also relevant. The numerical model MNMs 2021 (Bianco et al., 2016) (www.polito.it/groudnwater/software) proved adequate to describe GONP transport in the porous medium, both from a qualitative and quantitative point of view: transport was correctly described by a two-site deposition (reversible blocking and irreversible straining) (Beryani et. al., 2020).

As a second part of this study, the capability of GONPs to remove organic contaminants was characterized through batch adsorption tests. Methylene blue (MB) was opted as a model molecule representative of these contaminants of concern, which could be absorbed by GONPs in aquatic environments. MB is a common aromatic, water soluble, cationic dye which has been reported as a major pollutant of water resources because of its carcinogenicity and other health adverse effects on aquatic organisms and humans. Additionally, MB removal processes can be representative of other contaminants removal procedures since electrostatic interactions, π-π stacking and hydrogen bonds are the most effective phenomena governing all adsorption processes. The adsorption experiments demonstrated that GO is highly effective in the rapid adsorption of MB, hereby chosen as a model molecule representative of cationic contaminants. However, it shows a maximum capacity to attract MB on its surface. In this study, the estimated adsorption capacity of GOs was observed at a mass ratio of MB/GO equal to 1.

Time Block Preference

Time Block B (14:00-17:00 CET)

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