Nanosulphur for winegrowing: laboratory assessment of its transport in the subsoil

The increasing frequency of extreme events such as draughts, heat waves and floods, linked to climate change, will put a lot of pressure on agricultural systems, that will become more vulnerable to the attack of infesting species and parasites. Consequently, the use of substances such as pesticides and fungicides will significantly increase within the primary sector, with the aim of mitigating the spread of possible fungal diseases. Recently, nanostructured sulphur-made materials have been proven to be effective antibacterial and antifungal agents, avoiding the spread of diseases related to these types of pathogens. However, their fate and dynamics in the soil still need to be understood.

The aim of this project is the investigation of the behaviour of five sulphur nanoparticles (SNPs), used as fungicides in viticulture, in soil environments. More in detail, the study focuses on understanding the transport, retention, and release mechanisms of SNPs in sand through column transport tests in both saturated and unsaturated conditions. Initially, the five SNPs were characterized to have information about size, morphology, and colloidal stability. In the second part, particle transport tests were performed, by injecting the SNPs suspensions into sand-packed columns, to obtain the breakthrough curves of the five contaminants and to determine the profiles of retained concentration. In the third part, the breakthrough curves of the contaminants were modelled using the HYDRUS-1D numerical software, to estimate the coefficients that describe the deposition and release kinetics. The results showed that non-commercial SNPs exhibited greater retention, especially close to the column inlet, in both saturated and unsaturated sandy soils compared to commercial ones. Even though the retention was slightly higher in saturated soils, the difference was not significant. Finally, modelling revealed that first-order detachment coefficients were generally higher than the attachment coefficients, suggesting an easier release of the SNPs from the sand grains.