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Influence of lithology on tracer movement in the vadose zone of the Calcaire de Beauce aquifer (France).

Emélie Viel (1,2,3), Yves Coquet (1,2,3), Myriam Dedewanou (2), and Stéphane Binet (4)

(1) Université d'Orléans, ISTO, UMR 7327, 45071 Orléans, France , (2) CNRS, ISTO, UMR 7327, 45071 Orléans, France, (3) BRGM, ISTO, UMR 7327, BP 36009, 45060 Orléans, France, (4) CNRS, UPS, INPT, EcoLab, UMR5245, ENSAT 31326 Castanet Tolosan, France

The "Calcaire de Beauce" aquifer is contaminated by nitrate and pesticides mostly coming from agricultural activities. In this region the saturated part of the aquifer is relatively well known compared to the unsaturated (vadose) zone. This unsaturated zone can extend to more than 20 m in depth, and may play a significant role in the retention and/or release of pollutants or in the rate of nitrate transfer to wells.
In order to improve knowledge on the dispersion of contaminants in the vadose zone, a tracer experiment took place at the Lycée de la Saussaye near Chartres. A pit, 4 meter in width, 1.60 meter deep and 1 meter large was excavated in a Beauce limestone, giving access to the vadose zone. The surface organic soil layer (40 cm) was excavated. Thirty Liters of brilliant blue (FCF) at a concentration of 6 g/L have been applied to the surface at a rate of 0.14 L/h/m^2 with automatic sprinklers during 66 h. The pit has then cut successively in four vertical profiles at 0, 33, 66, 100 cm from the edge.
A RGB-photo and a lithological description was taken for each vertical profile. Image processing (ratio red canal /green canal) was applied to picture the plume of brilliant blue (BB). Areas filled with BB were converted into polygons using ArcGIS and compared with the lithological description. The proportion of tracer filled area at a given depth was used to evaluate the dispersion of the tracer with depth.
The lithology present within the 4 profiles was very heterogeneous from fine ocher limestone to clay. Some profils are structured with tilt around 120° to the right in the (x,z) plane.
Dye maps showed irregular plume dispersion with fast flows. A "fingered" front of BB was observed and was oriented according a tilt of 110-120° in the (x,z) plane. This distribution appears to be controlled by the lithology, with tracer moving around the low permeable lithologies. Fast flow distribution and lithological observation showed the same tilt, indicating a link between the orientation of the macro-structure and fast flow.
Plume dispersion had different forms, when tilled lithological structure is clearly visible plume dispersion is located at low depth whereas when no clear lithological structure geometry is visible plume dispersion is located deeper and its spreading is more homogeneous. Presence of structure generates heterogeneous macroscopic dispersion, the lack of structure generates vertical flux faster to depth.
A better physical description of the various lithologies (in terms of water retention and hydraulic conductivity) will be helpful to understand the role of the geometrical arrangements of lithologies (e.g. tilt) on the observed macroscopic BB dispersion.