Impact of chalk karst on river flow in Normandy : comparison of the behavior of three rivers and quantification of karst flow, France

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In 1758, Jean-Etienne Guettard mentioned in a publication of the French Royal Academy of Sciences the particular behavior of three rivers in Normandy that “gradually disappear and then reappear downstream”. Guettard noticed “holes in the river bed that absorb river flow”. These three rivers are respectfully the Iton, the Avre and the Risle rivers, all flowing on the Upper Cretaceous chalk, and located in the eastern part of Normandy, in northwest France.
The Risle and Avre rivers are both constituted of 3 segments showing changing hydraulic behaviors: a first section upstream where the river and the groundwater (GW) are hydraulically connected and are in equilibrium, a middle portion where the river and the GW are disconnected, with sinkholes forming in the minor bed, progressively decreasing the river flowrate and sometimes leading to complete river dry up, and a third section downstream, representing converging outlets of the karst aquifer system, where river and GW undergo reconnection, starting up with a strong resurgence area. The Iton river is a more complex hydrosystem with two successive karst sections resulting in five segments showing changing hydraulic behaviors (river and WT level being alternatively connected and disconnected).
Several monitoring networks for groundwater level and flowrate do exist in these rivers since the seventies or eighties. A more dense and better located monitoring network was implemented in the Risle river basin as part of the Risle Observatory which operated over a 3 year period (2013-2016).
These monitoring networks allowed for using lumped hydrological modelling with GARDENIA to notably quantify groundwater karstic flowrate as well as the groundwater components of the river flow. Eleven (11) lumped modelling processes were carried out with calibration using both piezometric levels and riverflow : 2 models were generated in the Iton basin, 4 in the Risle basin and 3 in the Avre basin. Two (2) other models were also elaborated in less karstic chalk basins (Austreberthe and Cailly Rivers) for comparison.
Regarding the groundwater component of the river flow, results obtained showed that for less karstic chalk basins, the average net GW input accounts for 74% to 98% of the mean river flow. In karstic basins, the net groundwater component of the mean river flow can decrease to around 30% at the end of the karst sections(i.e; 34 % for the Risle and 29% for the Avre). In the karst sections of the rivers, GW karst flow can be highly significant, up to 36% of the effective rainfall in the second karst segment of the Iton river and 56% in the middle portion of the Risle river).
Acquiring a good understanding of these GW and river flow interaction processes is essential for floodrisk assessment in karstic chalk environments.

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