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Spatial hydrochemical and isotopic variations within the alluvial aquifer of the Allier River (Massif Central, France)

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Hydrodynamic, hydrochemical (major ions, traces, pharmaceuticals and pesticides), isotopic (oxygen, hydrogen and carbon stable isotopes) and biological investigations were conducted every two weeks, since December 2010, to assess groundwater quality in the unconfined shallow alluvial aquifer of the Allier River (main tributary of the Loire River). The aquifer is mainly composed of unconsolidated alluvial deposits produced by the erosion of local crystalline rocks, the aquifer overlies impervious Oligocene marls; the surrounding hills are constituted with Quaternary deposits (early and old alluvial deposits on both sides of river), Oligocene limestones, marls and sandstones and Miocene volcano-sedimentary formations (Peperites). The study area is located in the east of the city of Clermont-Ferrand (France) where groundwater resources are used mainly for water supplies and then play an important socio-economic role as it is the major source of drinking water for about 100 000 inhabitants. This study aims at determining the factors and processes controlling shallow groundwater quality and groundwater origin by using the hydrochemical and hydrodynamical data collected on 87 water samples (71 boreholes, 13 piezometers and 4 surface waters) during a first field campaign carried out from the 9th to the 14th of December 2010. The Cournon Meteoric Water Line was determined according to 30 weekly rainfall samples. The results of this study show that spatial variations of physico-chemical parameters do exist in the study area, and the groundwater chemical composition is characterized by different water types with the predominance of the Ca-HCO_3 type. Ionic concentration increases in boreholes far from the Allier River due to the increase of residence time or by a mixing with groundwater coming from the hills. The ð2H and ð18O signature of groundwater and surface water indicate that most of the boreholes close to the river are recharged by the Allier River, while boreholes far from the river exhibit isotopic contents close to the values of sampled springs of the hills, recharged by local precipitation. Nevertheless, some boreholes do not follow this simple scheme of functioning and present values attesting of a secondary process related to evaporation and/or mixing with deep groundwater from geothermal origin.