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Contribution of stable isotopes and age dating tools to the understanding of pesticide transfer into surface and ground-waters in Martinique (French West Indies)

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In Martinique, chlordecone, a synthetic chlorinated organic compound has mainly been used as an insecticide for banana farming up to 1993. The intrinsic characteristic of this contaminant makes it still quite abundant in soil, surface and groundwater. Since 2004 and the implementation of the Water Framework Directive the concentration of chlordecone in groundwater has been monitored regularly (two to four times / year) at different points of the island by the ODE (Office de l'Eau). Previous study (Gourcy et al. 2009, Arnaud et al. 2012) showed that variations of pesticides concentrations in groundwater are temporally strong and not always easy to correlate to climate, geological or hydrogeological context. The objective of the present study was to explore new investigation ways to identify, in a specific site and for high sampling frequency possible pathways of chlordecone into surface and ground-waters.

A major sampling campaign was carried out in December 2011 including 12 surface and groundwater points located in Chalvet and Chez Lélène wells watersheds. Besides, monthly or weekly samples were taken at these two groundwater monitoring wells and the Falaise river up to August 2012. Major dissolved ions, $\delta^{18}\text{O}$, $\delta^2\text{H}$, chlordecone concentrations were determined for all samples. CFC-11, CFC-12, CFC-113 and SF₆ analyses were performed for groundwater for apparent age estimation. Punctual or cumulative rainfalls were sampled at Chalvet (30 m NGM) and Aileron (800 m NGM) for stable isotopes determination.

The isotope data are indicating a deuterium excess higher for surface water, groundwater and rainfall collected at high altitude vs. samples corresponding to lowest altitudes. This data can therefore be used to estimate the average altitude of recharge area of groundwater. This altitude of recharge, between 30 and 350m corresponds to the altitude of banana growing ; it is therefore in accordance with the presence of chlordecone in soils. This information is also giving necessary data for apparent age estimation using dissolved gases tracers (CFCs). Apparent age (or CFC and SF₆ concentrations) and $\delta^{18}\text{O}$ and $\delta^2\text{H}$ (and calculated d-excess) of groundwater are very stable with time even during intensive rainfall episodes and high water stage. Limited variability of chemistry and isotopes in surface water allow demonstrating that the Falaise River is highly sustained by groundwater. As a consequence, regarding chlordecone, the quality of surface water is governed by groundwater quality. Besides, during the dry season when the contribution of groundwater to the flow is the highest, chlordecone concentrations fluctuations are similar for both surface and ground-waters. During the period December 2011 - August 2012, chlordecone concentration varies from 0.25 to 0.45 $\mu\text{g/L}$ at Chez Lélène borehole and 0.02 to 0.1 $\mu\text{g/L}$ at Falaise River. In this area, groundwater contributes to the degradation of surface water quality.