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Passive sampling reveals continuous pesticide pollution in a tropical catchment with intensive agriculture

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Tropical agricultural areas are prone to be highly polluted by pesticides. There, a broad range of pesticides is used intensively all-over the year to protect crops from pest infestation. After application these pesticides can be washed-off from crops and transported through the soils after heavy raining events. Through surface run-off they enter rivers and impair aquatic organisms or they end up in groundwater reservoirs via infiltration where they deteriorate drinking water quality.

Comprehensive information about the degree of pesticide pollution, continuous pesticide monitoring strategies, and knowledge about the environmental fate of pesticides are often absent in tropical regions. There is a need for feasible and continuous sampling strategies to improve the environmental pesticide monitoring; and to gain more long-term data to better understand the environmental behavior of pesticides in tropical countries. To that end, we used three different passive sampling approaches (polydimethylsiloxane (PDMS) sheets, styrene-divinylbenzene (SDB) discs, and a water level proportional (WLP) sampler) in the tropical Rio Tapezco (RTZ) catchment in Costa Rica. Subsequently, a large number of pesticides was analyzed by an advanced targeted screening via GC MS/MS and LC-HR-MS. The RTZ catchment is located in central Costa Rica and is mainly used as pasture and horticultural farming for the national market. The catchment, comprising 5287 ha, is characterized by its agricultural areas with steep slopes and its high pesticide application rates.

In 2015, 5 sampling points were sampled for 2 months during the more dry El Niño rainy season with an average precipitation of 36 mm/week – in 2016, 8 sampling points were sampled for 6 months during a more regular rainy season with an average precipitation of 60 mm/week. During both years, time-integrated, biweekly samples were collected.

The PDMS sheets, used to detect apolar organophosphates and pyrethroids, revealed elevated concentrations of: chlorpyrifos, alpha-cypermethrin, permethrin and lambda-cyhalothrin in both years. Concentrations varied between pg/L and hundreds of ng/L for chlorpyrifos. The data suggest that rainfall had a clear effect on the concentration levels. During the more dry first sampling weeks in 2015, the values were lower or below detection limits and increased later on, the compounds were found in most of the sampling points all the time during the 2016 rainy season.

The semi-polar and polar compounds were measured with the SDB discs and the WLP sampler. In 2015, the five pesticides/pesticide metabolites with the highest concentrations were carbendazim, propamocarb, dimethoate, fipronil-desulfinyl and, and imidacloprid ranging from 14 μg/L (above calibration range of 2 μg/L) to 0.4 μg/L. In total, 70 different pesticides were detected. In 2016, the top five pesticides/pesticide metabolites were fipronil-desulfinyl, carbendazim, linuron, acephate, dimethomorph and propamocarb ranging from 7.5 to 1.4 μg/L. In total, 110 compounds were detected.

The passive sampling data revealed that our approaches were very useful for a continuous and time-integrated environmental monitoring. Further data analysis will show the dependency of the pesticide transfer into rivers through precipitation. However, first data indicates already that in more wet periods more different pesticides with higher concentrations are released into the streams.