



IAHS2022-534

IAHS-AISH Scientific Assembly 2022

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Veterinary pharmaceutical and fecal contamination in mixed-land use watersheds: from agricultural headwater watersheds to water-monitoring watersheds.

Anne Jaffrezic¹, Lise Charuaud², Marine Liotaud³, Fabien Mercier², Barbara Le Bot², and Emilie Jardé³

¹UMR SAS, Institut Agro, AGROCAMPUS OUEST, INRAE 35000 Rennes, France

²Univ Rennes, Inserm, EHESP, Irset -UMR_S 1085, F-35000 Rennes, France

³Univ Rennes, CNRS, Géosciences Rennes, UMR6118, 35000 Rennes, France

Veterinary pharmaceuticals, widely used in intensive livestock production, may contaminate surface waters. Identifying their sources and pathways in watersheds is difficult because i) most veterinary pharmaceuticals are used in human medicine as well and ii) septic or sewer wastewater treatment plants (WWTP) can release pharmaceuticals into surface water, even in agricultural headwater watersheds. This study aimed to analyze the spatiotemporal variability of animal-specific, mixed-use, and human-specific pharmaceuticals, from agricultural headwaters with intensive livestock production and a WWTP to a watershed used for Water Framework Directive monitoring. Grab sampling was performed during three hydrological year in seven nested watersheds in intensive husbandry area upstream and downstream from a WWTP with areas of 1.9-84.1 km². Twenty pharmaceuticals were analyzed. Microbial fecal indicator *E. coli* and fecal stanols were determined. Fecal stanols are microbial source tracking tool allowing to identify the origin of the fecal contamination (porcine, bovine or human). Animal-specific pharmaceuticals were detected at all sampling dates upstream and downstream from the WWTP and at concentrations higher than those of human-specific pharmaceuticals. Animal-specific pharmaceuticals were detected mainly during runoff events associated with bovine or porcine fecal contamination. A large percentage of mixed-use pharmaceuticals was assigned to animal sources. Mixed-use and human-specific pharmaceuticals predominated in the largest watersheds when runoff decreased. In areas of intensive livestock production, mitigation actions should focus on agricultural headwater watersheds to decrease the number of pathways and the transfer volume of veterinary pharmaceuticals, which can be the main contaminants.