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Modelling triazines in the valley of the River Cauca, Colombia, using the annualized agricultural non-point source pollution model

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ABSTRACT

The annualized agricultural non-point source pollution model (AnnAGNPS) was applied to simulate losses of triazine herbicides to the River Cauca following application to sugarcane, maize and sorghum in the Cauca Valley of Colombia. Surface runoff was found to be the main driver of triazine losses to surface water in the catchment. Satisfactory simulation and validation of the hydrology was achieved after little calibration (Nash-Sutcliffe model efficiency = 0.70 and $r^2 = 0.73$). A fairly good simulation of pesticides was generally achieved, but some patterns in the measured data could not be simulated. Uncertainty analyses of sensitive input parameters were carried out which explained most of the concentrations that were not captured by the initial simulation; however, evidence of point source pollution was observed for some large concentrations measured upstream. Replacing triazine herbicides with mesotrione was predicted to result in an 87% reduction in pesticide losses expressed as a proportion of the total pesticide applied.

1. Introduction

The geographical valley of the River Cauca in the Valle del Cauca department, Colombia, is characterised by intensive agriculture where sugarcane is the main crop covering about 200,000 ha (approximately 50% of the arable land in the area) for the production of sugar and bioethanol. A monitoring study in 2010 and 2011 showed high levels of pesticides in the river (Sarria, 2015). In particular, the herbicides atrazine and simazine were found in most of the samples collected. Atrazine and simazine are used in Colombia for pre-emergence and early post-emergence weed control in sugarcane, maize and sorghum crops.

Despite the high potential risk for contamination of water by pesticides due to intensive agriculture in the proximity of the River Cauca and its tributaries, no catchment management or monitoring programmes are currently put in place by the government to investigate and reduce emissions. The main reasons for not tackling pesticide contamination in the area (and in general for the whole country) are that these programmes are especially expensive and require large investment from the government. An alternative to refine and reduce costs of water monitoring is to use mathematical modelling of pesticide fate as a tool to understand the dynamics of these substances in the catchment (Holvoet et al., 2007). The aim of this paper is to study the dynamics of the herbicides atrazine and simazine along with their routes of entry to the River Cauca by conducting catchment pesticide fate modelling for the first time for this area using a spatially distributed model of the geographical valley of the river.

1.1. Catchment description

The River Cauca is located between the west and the central Andean ranges in Colombia and is one of the two main rivers of the country. The river flows from its source in the Colombian Massif in the Cauca department for approximately 1350 km, draining a watershed of 63,300 km^2 to its confluence with the River Magdalena in the Bolivar department and finally flowing out into the Caribbean Sea (Fig. 1a). The river flows through 183 municipalities where about 16 million people live (about 38% of the population of Colombia). The watershed of the River Cauca in the Valle del Cauca department is particularly important to the economy of the country; most of the sugarcane industry and part of the coffee plantations are located in this area (CVC and Univalle, 2001). The River Cauca in the Valle del Cauca receives domestic and industrial discharges from 33 municipalities; the main ones are Cali, Jamundí, Yumbo, Palmira, Buga, Zarzal, Florida, Tuluá and Cartago.

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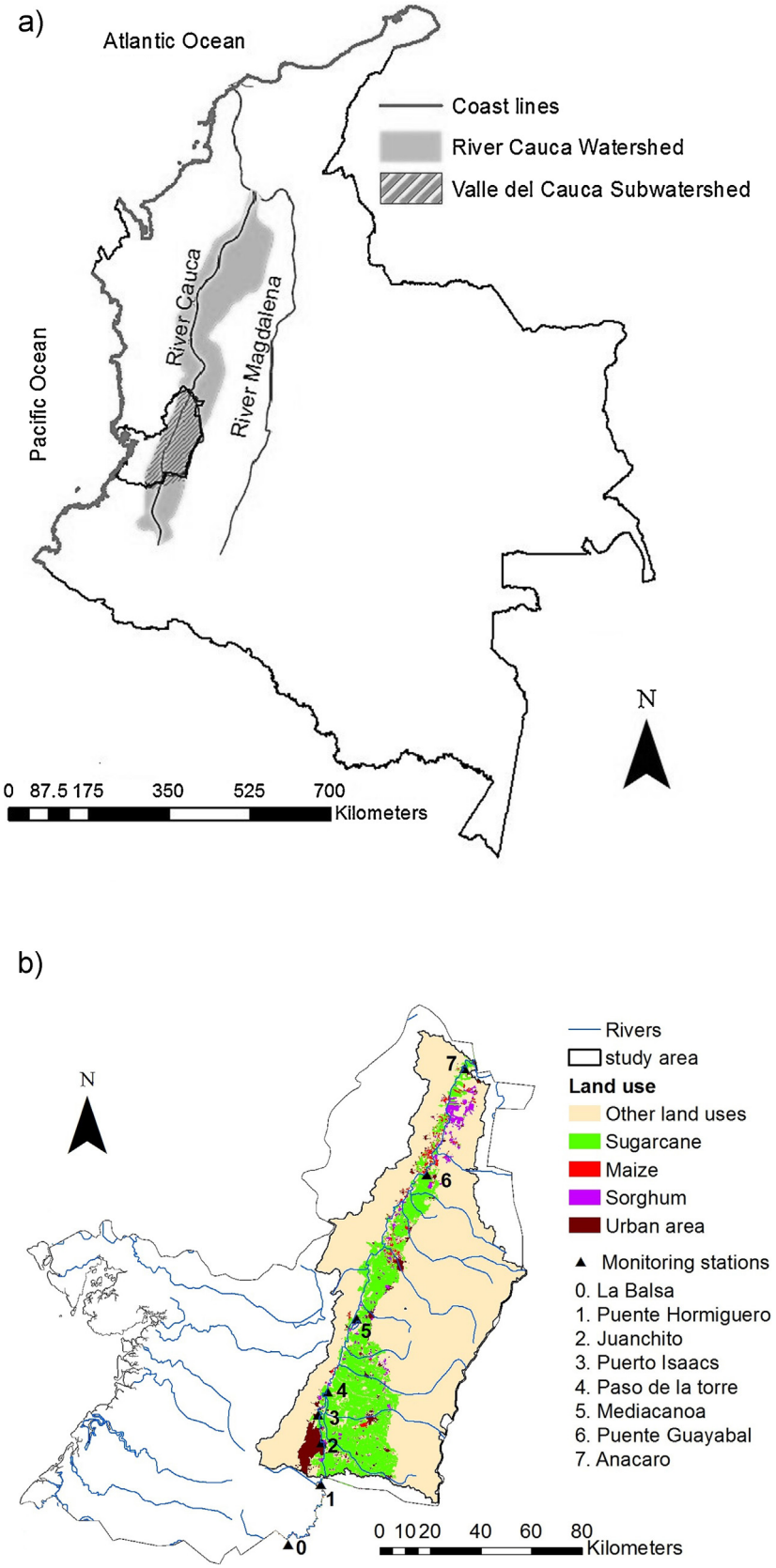

Fig. 1. a) Location of the River Cauca catchment in Colombia and its watershed in the Valle del Cauca (Adapted from CVC and Univalle (2001)) and b) Map of the studied watershed of the River Cauca in the Valle del Cauca (study area), crops where triazines could have been used and the CVC monitoring stations. The administrative boundary area of the Valle del Cauca department is included.