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Spatio-temporal variability of streamwater chemistry within a Peri-urban Mediterranean catchment

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The complex landscape of peri-urban areas, characterized by a mosaic of land-uses and urban fabric, provides different sources of runoff and pollutants which affect stream ecosystems. This study investigates the impact of land-uses and their location within catchments on streamwater quality in a peri-urban Mediterranean catchment, including temporal variations driven by antecedent weather and rainstorm characteristics.

The study is based in Ribeira dos Covões, a small (6 km2) catchment in the city of Coimbra, central Portugal. Land-use is dominated by woodland (56%) and urban cover (40%), with a small agriculture area (4%). Streamwater was monitored at the catchment outlet (ESAC) and three upstream locations: Espírito Santo and Porto Bordalo, with similar urban cover (42% and 49%) but different imperviousness (27% and 15%) and lithologies (sandstone versus limestone), and Quinta with lower urban extent (25%) but including a construction site covering 10% of the area. Samples collected throughout ten rainfall events between October 2011 and March 2013 were analysed for natural water chemistry and major pollutants (notably ammonium, nitrates, total phosphorus, COD and metals). In the paper, temporal variations in water quality are explored via hysteresis loop and correlation analysis.

Hydrological regime exerted a major influence on water quality. Major nutrients declined within and after the dry summer than in winter events, because of limited dilution by the low stream baseflow. Through the wet season, increasing baseflow led to increased concentrations of major cations (Na, Mg and Ca) because of reduced dilution by solute-poor stormflow.

Espírito Santo, the most urbanized sub-catchment, displayed higher concentrations of COD and NO_3 (tended to peak with stormflow), but the latter was thought to result from agricultural fields located adjacent the tributary. At the catchment outlet (ESAC), the high Nk and NH4 concentrations exceeded water quality standards (2 mg/l and 1 mg/l) at summer baseflow and at peak flow during late winter storms. Zn, Cu and Cd also attained pollutant levels in late winter storms.

When clear-felled areas were located close to tributary watercourses they supplied high suspended sediment concentrations into streamflow, whereas when they were located upslope the impact was minor, due to enhanced opportunities for overland flow retention and infiltration. Artificial drainage systems, however, increase the connectivity between the sources and the stream channel; this explained the greatest turbidity in the Quinta sub-catchment, where sediment was derived from an upslope construction site.

Specific loads of water quality parameters (except for suspended sediment) increased with percentage impervious area, but linear relationships were only significant for NO_3 and major cations (Na, Mg, Ca and K), possibly due to cement chemical composition. Sources of contaminants include bare surfaces (turbidity), untreated sewage (COD, TP, NH4, Fe and Zn), manure (NH4), industrial pollution (Fe and Zn) and vehicles (metals). The identification of pollutant sources and knowledge about seasonal and within-storm variations are important to establish spatially- and temporally-explicit water management strategies to improve local water quality. Moreover, a better understanding of the potential sources and sinks of pollutants should guide stakeholders to design more sustainable peri-urban areas.