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Spatio-temporal dynamics of surface water quality in a Portuguese peri-urban catchment

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Urban development poses great pressure on water resources, but the impact of different land-uses on streamwater quality in partly urbanized catchments is not well understood. Focussing on a Portuguese peri-urban catchment, this paper explores the impact of a mosaic of different urban and non-urban land-uses on streamwater quality, and the influence of a seasonal Mediterranean climate on pollutant dynamics. The catchment has a 40% urban cover, dispersed amongst patches of woodland (56%) and agricultural fields (4%). Apart from the catchment outlet, streamwater quality was assessed at three sub-catchment sites: (i) *Porto Bordalo*, encompassing a 39% urban area with a new major road; (ii) *Espírito Santo,* draining a sub-catchment with 49% urban cover, mostly comprising detached houses surrounded by gardens; and (iii) *Quinta*, with a 25% urban cover. The *Porto Bordalo* sub-catchment is underlain by limestone, whereas the *Espírito Santo* and *Quinta* sub-catchments overlie sandstone. Water quality variables (notably nutrients, heavy metals and COD) were assessed for samples collected at different stages in the storm hydrograph responses to ten rainfall events occurring between October 2011 and March 2013.

Urban areas had great impacts on COD, with highest median concentrations in *Espírito Santo* (18.0 mg L^{-1}) and lowest in *Quinta* (9.5 mgL^{-1}). In *Espírito Santo*, the management of gardens triggered greatest median concentrations of N-NO_3 (1.46 mgL^{-1}, $p<0.05$). *Porto Bordalo* exhibited the highest median concentrations of Zn (0.14 mgL^{-1}), possibly derived from the major road, and dissolved phosphorus (0.07 mgL^{-1}). The latter may be linked to human activities, such as terrace and car washing, as overland flow from impervious surfaces was observed to discharge directly into the stream, whereas in other sub-catchments it mostly disperses into pervious soils. Pastoral activities in agricultural fields adjacent to the stream led to highest median concentrations of N-Nk and N-NH_4 recorded at *ESAC* (1.34 $mgL^{-1}$and 0.41 mgL^{-1}, respectively).

Hydrological regime exerted a major influence on water quality dynamics. COD and nutrient variables (N-Nk, N-NH_4, N-NO_3 and P) attained highest concentrations after the summer. Low discharges led to high pollutant concentrations at baseflow of N-NH_4 in *ESAC* and *Porto Bordalo* (up to 1.63 mgL^{-1} and 1.04 mgL^{-1}, respectively). The first storm events after the summer led to flushing of accumulated pollutants to produce serious concentrations of N-Nk in *Porto Bordalo* (2.05 mgL^{-1}) and Zn at *ESAC* and *Porto Bordalo* (up to 0.55 mgL^{-1} and 0.59 mgL^{-1}, respectively), all recorded at peak flows. In wettest periods, greater flow connectivity over the hillslopes led to pollutant concentrations of N-Nk at *ESAC*, *Espírito Santo* and *Quinta* (up to 2.07 mgL^{-1}, 2.54 mgL^{-1} and 2.83 mgL^{-1}, respectively). Also high levels of Cu and Zn occurred at *ESAC* (1.74 $mgL^{-1}$and 0.77 mgL^{-1}) during the falling limb. Baseflow chemistry was influenced by bedrock, with highest median concentrations of Ca and Mg, lowest values of Na, and higher pH recorded in limestone ($p<0.05$).

Information about the spatio-temporal dynamics of pollutants, linked to urban patterns and storm drainage system, should help enable urban planners to minimize adverse impacts of urbanization on water quality.