Stormflow Nutrient Concentrations in Coastal Streams Tributary to the Santa Barbara Channel, California: A Common Urban Response

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We have been sampling nutrient concentrations in coastal streams as part of the Santa Barbara Coastal LTER. The ultimate goal is to determine nutrient export to the Santa Barbara Channel and to model how export varies with land use. We are using two approaches: (1) sampling, at their outflow, streams that represent different dominant land uses, and (2) sampling at land use transects in a subset of selected streams. (From comments by Al Leydecker, Santa Barbara Channel LTER, Santa Barbara, February 2001.)

The catchments vary in area, topography, vegetation, soils, geology and land use, and display a wide range of base- and storm-flow nutrient concentrations. Arroyo Hondo is relatively pristine, Mission densely urban along the coastal plain, and Franklin highly impacted by “green house” agriculture. (Photo: winter 2001)

The relative export associated with urban streams was consistent: phosphate export at least 5-times that of ammonium, nitrate at least 5-times that of phosphate. Export on the rising hydrograph limb was most important for ammonium (where 30 to 50 % of the ammonium is lost), somewhat important for phosphate (~25 % of total export) and relatively unimportant for nitrate (10 to 15 %). (McKee et al., 2004:10).

This winter we are sampling storms “along the line of flow” to determine how nutrient concentrations change with land use in selected streams. During the first storm of the year, nitrate concentrations from early surface runoff increased downstream in Mission Creek, coincident with increasing residential densities (MC07 to MC06 to MC01). The greatest increase in nitrate occurred below a series of urban parks between MC06 and MC01. Interestingly, the lowest section of the stream, which flows through downtown Santa Barbara, produced a decrease in nitrate concentrations (MC00); “lawns and dogs” may contribute more nitrate than the flushing of impervious surfaces. For this small storm, where urban runoff predominated, only MC00 produced the characteristic urban nitrate signature shown previously.

The stormflow response of “non-urban” streams varies, but streams with appreciable urban sub-catchments in their lower basins exhibit a common pattern: (a) ammonium declines exponentially after a peak at the beginning of storms, (b) the rise and fall of nitrate concentrations are 180 degrees out of phase with the hydrograph, and (c) variations in phosphate concentrations are in parallel with the hydrograph. Concentration-discharge relationships for the urban streams show hysteresis and fit a 3-compartment baseflow/stormflow/solifluction model. The pattern for each species is different in shape and temporal variation, indicating the lack of a common source or hydrologic response. The inference is that high ammonium concentrations are produced by early surface flow flushing of urban surfaces, high solifluction concentrations produce the highest nitrate concentrations late in the receding storm hydrograph, and phosphate is characterized by a “flamy” urban effect (note how phosphate leads the rising hydrograph limb and lags the falling limb) superimposed on an overall catchment response. (Photos: Winter 2001: (a) Mission Creek, (b) Arroyo Hondo, (c) Franklin Cr.; Mission Cr. in flood).