Abstract

Urbanization results in fluvial systems that contrast sharply with more pristine streams. The cycling and retention of important nutrients like nitrogen and phosphorus as well as biotic variables are expected to be markedly different in urban watercourses. We are investigating how changes due to urbanization in nutrient inputs, hydrology, and geomorphology affect nutrient dynamics in the fluvial systems of the Central Arizona-Phoenix ecosystem. Our work has focussed on two contrasting systems.

Fig. 1. Sycamore Creek, Arizona, a typical Sonoran desert stream. Note the variety of patch types in the stream channel including the cobble bank in the foreground, the sandbar on the far bank and the shrubby vegetation along the stream's edge.

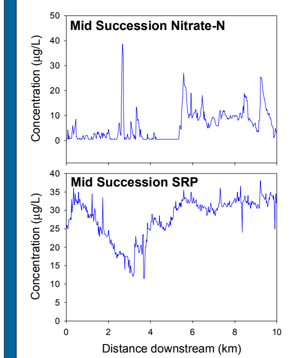

Fig. 2. Spatial variation in nitrate-N and soluble reactive phosphate over a 10-km stretch of Sycamore Creek. Samples were taken every 25 m during middle succession (2 mo post-flood). From Dent and Grimm (1999).

Introduction

Research in Sycamore Creek (Fig. 1) has demonstrated that nutrient concentrations in stream water can be extremely variable in space (Fig. 2) and time (Dent and Grimm 1999). Much of the spatial variation in nitrogen concentrations is produced when nutrient-rich subsurface waters enter the surface stream as a result of fine-scale changes in the stream channel morphology (e.g. water exiting sandbars) or coarse-scale changes in the landscape (e.g. upwellings produced by the narrowing of the valley floor). On the surface, algal uptake of nutrients causes downstream declines in nutrient concentrations (Grimm 1987). This spatial variation in nitrogen concentrations is minimized directly after floods and increases during post-flood succession as biotic activity increases. Because nitrogen is limiting in Sycamore Creek and because phosphorus tends to be controlled by physical factors (Grimm and Fisher 1986), nitrogen shows shows greater spatial variation than SRP.

Urban fluvial systems have often been profoundly modified. They may have channel morphologies that constrain flow paths, limit interactions between surface and subsurface flows, and alter the relative proportion of runs, riffles and pools along a stream. Additionally, they may receive elevated nutrient inputs from the surrounding landscape, especially during storms. We are investigating how these changes affect nutrient dynamics in two contrasting systems: the Tempe-Southern Canal (Fig. 3) and Indian Bend Wash (Fig. 5).

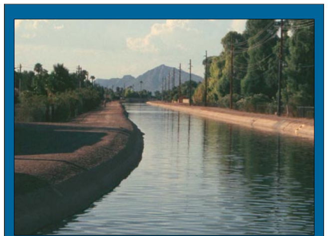

Fig. 3. Tempe-Southern Canal, Tempe, Arizona. Like most water supply canals in the CAP region, this canal is cement lined, limiting the interactions between surface and subsurface waters. Also, the high ratio of water to algae limits the effect of algae on transported materials.

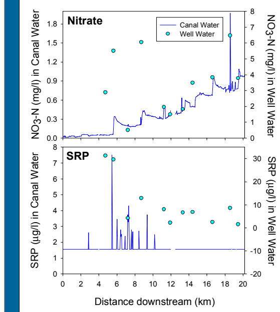

Fig. 4. Spatial variation in nitrate-N and SRP over a 20-km stretch of the Tempe-Southern Canal. Samples were taken every 50 m on June 21, 1999. Inputs from active groundwater wells were also sampled.

Results

The Tempe-Southern Canal (Figs. 3 & 4)

- Nitrate-N concentration increased downstream.
- Spikes in nitrate-N correspond with groundwater inputs.
- Downstream declines in nitrate-N immediately following groundwater wells appear to result from physical mixing, not biotic uptake.
- SRP concentrations were low throughout canal, suggesting potential P-limitation.

Indian Bend Wash (Figs. 5, 6 & 7)

- Nutrient concentrations were extremely variable in space and time.
- During the flood, nutrient concentrations were less spatially variable.
- SRP concentrations at most sampling points were higher during the flood.
- Nitrate-N was more variable both spatially and temporally than SRP.
- Elevated nutrient concentrations were often observed directly below a golf course located at 18.06 km.

Table 1. Summary of the physical characteristics, water sources, and nutrient status of Sycamore Creek, the Tempe - Southern Canal and Indian Bend Wash.

Watercourse	Flowpath	Surface-Subsurface Exchange	Interaction with Uplands/ Floodplain	Water Sources	Nutrient Variability	Potentially Limiting Nutrient	Primary Controls on Nutrient Concentration
Sycamore Creek	Complex	Extensive	Extensive during Floods	Headwaters, Flood Runoff (from uplands)	**NO_3** - high **SRP** - low	Nitrogen	**NO_3** - flowpath, algal uptake (succession), uplands/floodplain iteractions? **SRP** - physical processes (weathering)
Tempe-Southern Canal	Simple	None	Little/ None	Reservoir, CAP canal, Groundwater	**NO_3** - moderate **SRP** - low	Phosphorus	**NO_3** - source water, physical mixing, algal uptake? **SRP** - source water, physical mixing, algae?
Indian Bend Wash	Complex	Limited	Extensive during Floods	Canals, Flood Runoff (from uplands), Groundwater? Other?	**NO_3** - high **SRP** - high	Spatially and temporally variable	**NO_3** - source water, flowpath? algal uptake? uplands/floodplain interactions? **SRP** - source water, flowpath? algal uptake? uplands/floodplain interactions?

Fig. 5. Aerial photo of the lower portion of Indian Bend Wash, a flood control project in Scottsdale, Arizona. Note the width of the floodplain which may be entirely inundated during floods (Fig. 6). Arrows indicate the location and downstream distance of each sampling point.

Fig. 6. Lower Indian Bend Wash during flood on March 7, 2000.

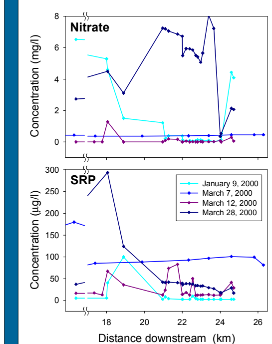

Fig. 7. Nitrate-N and SRP were both highly variable in lower Indian Bend Wash on three of four dates in 2000; variability was much reduced among samples taken during a flood (March 7). Sampling locations as in Fig. 5 except for March 7 samples, collected at road crossings. Intermittent sections above 18 km were not consistently sampled.

Conclusions

The physical structure of urban watercourses often differs dramatically from more pristine systems (Table 1). Thus physical factors, like the mixing of different water sources, may exert more control on surface water chemistry than biotic processes. Additionally, water chemistry may be affected by upstream land use. Although the nature of the hydrologic linkages between upland and aquatic components is complex and poorly understood, the effects of land use should be most important during storms, when the upland, floodplain and surface water components of the landscape are strongly connected.

Literature Cited

Dent, C.L. and N.B. Grimm. 1999. Spatial heterogeneity of stream water nutrient concentrations over successional time. Ecology 80: 2283-2298.

Grimm, N.B. 1987. Nitrogen dynamics during succession in a desert stream. Ecology 68: 1157-1170.

Grimm, N.B. and S.G. Fisher. 1986. Nitrogen limitation in a Sonoran Desert stream. J. N. Am. Benthol. Soc. 5: 2-15.