Biodegradability of Dissolved Organic Carbon in the Río Piedras Watershed, Puerto Rico

Introduction

- Organic matter is classified in groups, and total organic carbon (TOC) is the sum of dissolved organic carbon (DOC) and particulate organic carbon (POC). DOC composes most of the TOC and therefore it is our main focus.
- Puerto Rico has been showing an increase in urbanization, especially in the San Juan Metropolitan Area, which is decreasing the extensions of riparian zones. This in turn reduces the natural inputs of allochthonous organic matter to rivers and are being replaced by organic loads from wastewater and urban runoff.
- The purpose of this project is to characterize the quality of organic carbon in an urban tropical river. Studies have shown that organic carbon originating from sewage discharge is more labile than that of natural sources (Paul & Meyer 2001). We hypothesized that if the main source of organic matter in an urban tropical river is from riparian zones located in the upper parts of the basin, then its biodegradability will decrease downstream as microbial and physical processes decrease its lability.

Study Site

The project took place in the Río Piedras watershed in the San Juan Metropolitan Area of Puerto Rico. This is an example of an urban tropical river with an urban coverage of 63%.

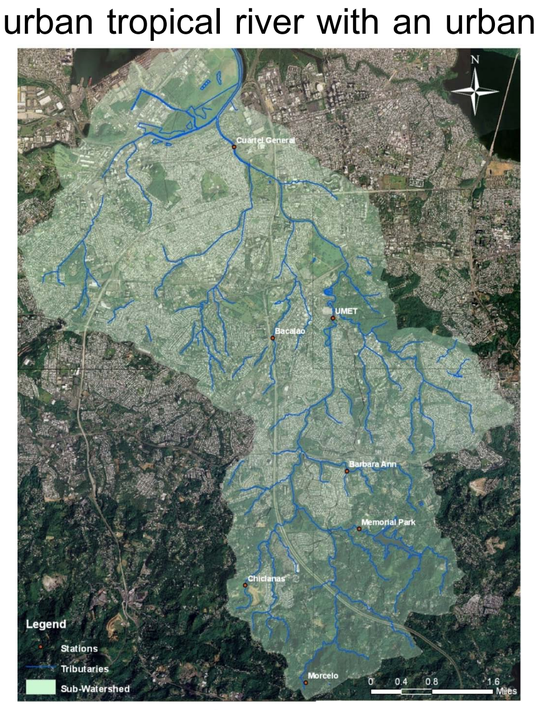

Figure 1. Map of Rio Piedras watershed.

Methodology

A. Field methods:

- Sampling dates: November 2008, January and April 2009
- Location: Five different sites (Figure1)
- Sample collection for analysis of:

BOD (triplicates)
DOC (data not shown)
COD (data not shown)

B. Data analysis

Thomas Graphing Method:

- Subtract daily DO from Day 0;
- This subtraction is used in equation: $(t/BOD_t)^{1/3}$ and plot
- From linear regression use slope (b) and y intercept (a) in equation: k=6(b/a)

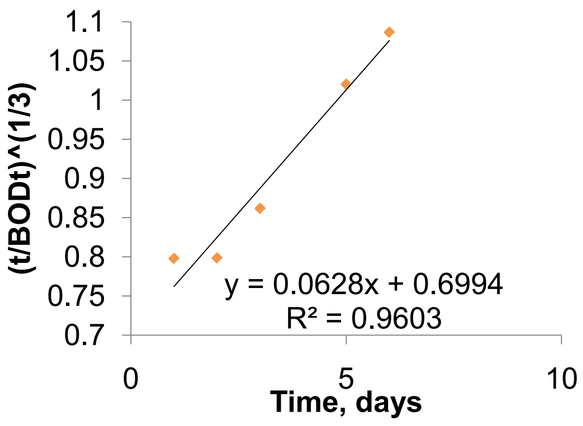

Figure 2. Linear regression to determine k. RPCG Station April 2009.

Results

Table 1. Average biodegradability constants (k, n=3) calculated for each of the sampling sites. Standard deviations for the means are shown in parenthesis.

Site	Order	Elevation, ft amsl	Biodegradability constant, d^{-1}		
			Nov 08	Jan 09	April 09
RP Sector Mocelo	1	719	0.517 (0.036)	0.220 (0.015)	0.270 (.060)
RP Chiclana	1	356	0.564 (0.014)	0.154 (0.013)	0.095 (.049)
RP Barbara Ann	1	166		0.135 (0.003)	1.508 (0.208)
RP UMET	3	46	0.461 (0.014)	0.180 (.004)	0.290 (.005)
RP Cuartel General	4	10	0.266 (0.003)	0.669 (.028)	0.507 (.143)
Stream flow (cfs)*			9.3	52	18

* USGS Gauge at El Señorial Rio Piedras 50048770, daily mean discharge

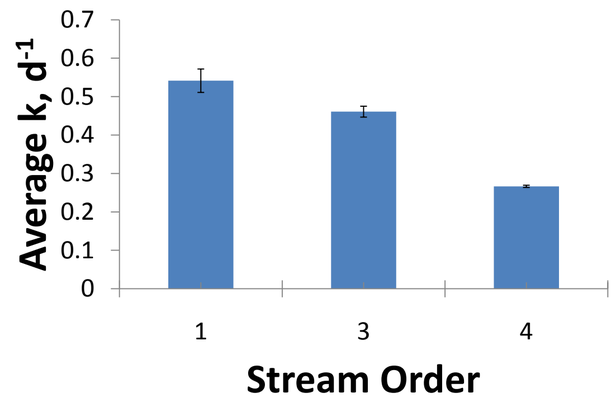

Figure 3. Average of k by stream order for November 24, 2008

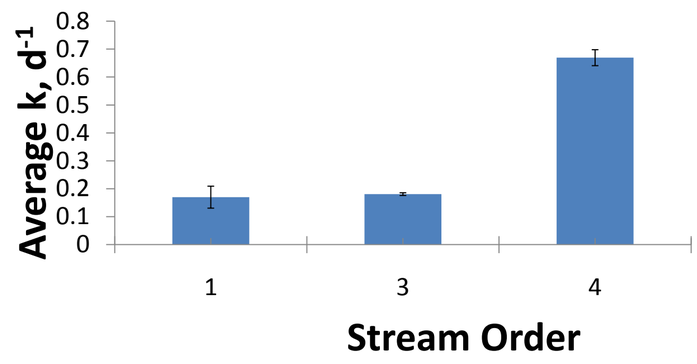

Figure 4. Average by stream order for January 16, 2009

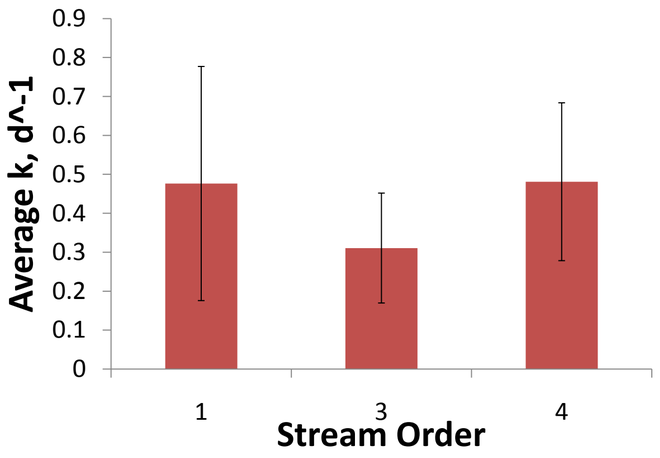

Figure 5. Average of k by stream order with standard deviation

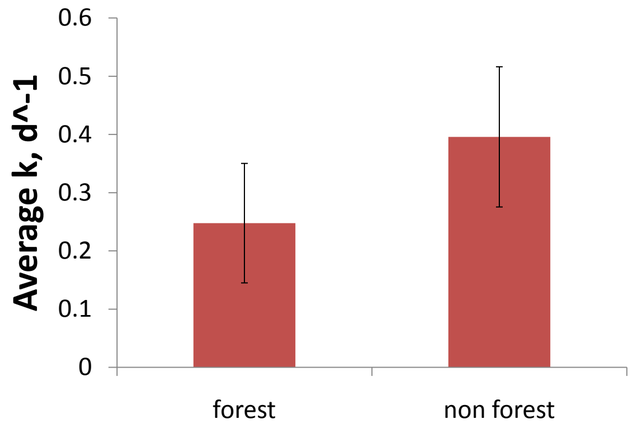

Figure 6. Average of k with riparian vegetation vs. no riparian vegetation with standard deviation

Discussion

During low flows, the biodegradability of organic carbon was significantly higher (Walsh t-test; $P < 0.05$) in the upstream stations than further downstream (Figure 3). During high flows, the biodegradability significantly increased downstream (Walsh t-test; $P < 0.05$) as seen in Figure 4. Regardless of flow, the mean biodegradability constants increased downstream but not significant (Figure 5). Also as riparian vegetation decreases, biodegradability increases as demonstrated in figure 6. The range of the biodegradability constants of organic carbon along the Rio Piedras compares to that of polluted/treated waters and raw sewage (Thomas 1950).

Sample	K (20^0C) (d^{-1})
Raw Sewage	0.35-0.70
Well-treated sewage	0.12-0.23

Table 2. Typical values for the biodegradability constant (k) according to Thomas (1950) .

Conclusions

The observed low biodegradability downstream during low flows could be associated to allochthonous inputs of organic carbon generated upstream which biodegrades as it travels downstream becoming more recalcitrant. During high flows, surface runoff and combined sewer flows discharge organic carbon into the river, increasing the biodegradability downstream. However, in tropical urban watersheds, these patterns can be altered by random and sudden organic carbon (of varying biodegradability) inputs from any point source as occurred in the April sampling (Table 1). Thus, the organic matter fluxes in the urban Rio Piedras are highly dynamic and sensitive to flow conditions. This projects has shown that with some modifications, the Thomas graphing method, which was developed originally to characterize wastewaters, can be useful in characterizing the lability of organic matter in natural bodies of water.

Bianca Rodriguez Cardona and Jorge R. Ortiz-Zayas, University of Puerto Rico, Río Piedras Campus

Funded by National Science Foundation, HRD #0734826 and University of Puerto Rico, Central Administration and Río Piedras Campus