

CHARACTERISTICS OF SUSPENDED PARTICULATE MATTER IN ICHAWAYNOCHAWAY CREEK, A BROWN-WATER COASTAL PLAIN STREAM

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Abstract. Water samples were collected at 7 sites along Ichawaynochaway Creek, a Gulf Coastal Plain brown-water stream, from July 1993 - October 1994, including an extended dry period (July - November 1993) and a record flood period (June - August 1994). Particulate organic concentrations in Ichawaynochaway Creek were very consistent (1-3 mg/L) during extended stable flow periods characteristic of the region. Large floods resulted in elevated organic concentrations (4-5 mg/L). The results of this study, although preliminary, suggest that headwater swamps and areas with extensive riparian forest are sources of particulate organic matter in transport.

In the development of regional conservation programs, riparian swamp forests may merit special consideration to protect the trophic base of stream communities. The significance of seasonal and catastrophic flooding to stream biota is unknown at present, but merits future study.

INTRODUCTION

Background

Quantifying energy flow and determining sources of organic matter is a critical step in understanding ecosystem structure and function. Because of the linear nature of stream drainages, applying the ecosystem concept to and subsequently defining functional attributes has proved difficult. As ecosystems, streams have several unique characteristics (Vannote et al. 1980, Minshall et al. 1983). The linear nature of streams promotes maximum interaction with the adjacent landscape, and organic matter and other materials from terrestrial sources are important resources for stream communities. In addition, stream communities are longitudinally linked by the flow of water so that material exported from upstream areas may be important resources downstream.

The contributions of organic matter to streams by riparian vegetation is well recognized (i.e. Fisher and Likens 1973). In many drainages, headwaters represent a majority of channel length (e.g. Meyer and Edwards 1990) and have been viewed as collecting zones for materials entering stream

ecosystems. The importance of riparian contributions was assumed to be limited to the headwaters of most stream drainages (Vannote et al. 1980, Minshall et al. 1983).

Coastal plain streams are unusual because extensive riparian swamp forests often extend laterally from stream margins. Seasonally, during floods, these forests may contribute substantial quantities of organic matter to streams (e.g. Cuffney 1988, Meyer and Edwards 1990). Since a major food resource in coastal plain streams is transported organic matter (e.g. Wallace et al. 1987), predictable pulses of organic matter from floodplain forests may be extremely important in maintaining aquatic productivity.

Research Objectives

To date, most studies on riparian control of organic matter in streams have focused on headwaters or stream segments (e.g. Cuffney 1988, Dosskey and Bertsch 1994). The influence of riparian geomorphology on organic matter concentration and particle size distribution has been little explored from a whole stream perspective. The purpose of this research was to examine organic transport in Ichawaynochaway Creek, a Gulf Coastal stream, during extended low and high flow periods. Ichawaynochaway Creek has upstream segments with extensive riparian floodplain swamps and downstream segments with minimal riparian development. Thus, it was ideally suited to examining the influence of riparian geomorphology on organic matter concentrations. We hypothesized that segments of the stream with well developed floodplains would act as sources of organic matter to the larger stream system.

Significance to Conservation Issues

As human populations have increased, the geomorphology, hydrology, and water quality of most stream systems has been altered through municipal development, agriculture, silviculture, and channel modification. As a result, very few unaltered stream drainages remain in North America (Benke 1990, Dewberry and Pringle 1994). Efforts at river protection and conservation have lagged behind development and, to date, have largely focused on water quality and protection of

"pristine" reaches or river segments (Palmer 1993, Dewberry and Pringle 1994). Little progress has been made in protecting stream ecosystem structure and function.

The lack of whole basin perspective in river conservation can also be attributed to a lack of information. Until recently few studies of structure and function of whole stream ecosystems existed (e.g. Dewberry and Pringle 1994). Since stream segments are linked both longitudinally (headwaters to large rivers) and laterally (to uplands and riparian zones) the strategy of protecting segments is destined to be unsuccessful. Implementing conservation programs on a basin perspective is essential to preserving and protecting streams as ecosystems. Studies of origins of organic matter and relation to riparian geomorphology are essential in developing this broad basin-oriented view of stream ecosystems.

SITE DESCRIPTION

Ichawaynochaway Creek is a major stream crossing the Dougherty Plain, on the Gulf coastal plain of southwest Georgia. Geologically this region is classified as mantled karst topography. A surface layer of sands and clays 1-40 meters in depth covers the area (Hayes et al. 1983). Beneath is the Ocala limestone, an extensively fractured and porous rock layer characterized by high hydraulic transmissivity. The Ocala limestone is the principle water bearing strata for the Floridan Aquifer. The low topographic relief in combination with porous surface geology results in low stream drainage density and a dominance of subsurface water flow in regional hydrology.

Ichawaynochaway Creek is a brown water stream originating in an extensive swamp and wetland system. It flows southward approximately 100 km crossing an agricultural and forested landscape before discharging into the Flint River. An intact riparian zone occurs along most of the stream and is composed of flood tolerant hardwoods, bald cypress (*Taxodium distichum*), and red cedar (*Juniperus silicicola*). However, channel geomorphology changes downstream. Headwaters are characterized by a broad floodplain which increases in width through the midreaches. Downstream the channel becomes incised and riparian forests narrow, often limited to a narrow band along the stream margin. Outcrops of Ocala limestone occur near the confluence with the Flint River. Average annual discharge at a gaging station approximately 69 km downstream from the headwaters is 22 m/s. Average discharges range from a low of 11.7 m/s in September to a peak 37.6 m/s in March (USGS -- based on 50 years of records).

METHODS

Baseflow seston samples were collected monthly (July 1993-October 1994) at 7 sites ranging 10-96 km downstream from the headwaters. Sampling included an extended dry period (July-December 1993), a typical spring runoff period (February-June 1994), a record flood period (July - August 1994), and subsequent recovery (September-October 1994). Sampling frequency was increased during the summer flooding in 1994.

In the field, 20-30 L of water were poured through nested sieves (250 μ m, 43 μ m). Material collected was rinsed into plastic bottles, stored on ice and transported to the laboratory for analysis. Water passing through sieves was also collected. In the laboratory, each fraction was filtered onto preweighed glass fiber filters, dried, weighed, ashed, and reweighed to determine organic and inorganic content. This procedure quantified particle concentrations in three fractions: large (>250 μ m), medium (43-250 μ m), and small (<43 μ m).

RESULTS

Total particulate organic matter (POM) concentrations ranged from 0.47-4.79 mg/L. When averaged over the study, concentrations declined significantly downstream (Figure 1). Lowest concentrations were observed during the extended dry period (July -December 1993). Highest concentrations were observed during the record flooding of summer 1994. The general trend of decreasing concentrations downstream was observed during the dry period, spring runoff, and flood recovery period. Downstream stations appeared to be sensitive to record flooding; unusually high concentrations of POM were measured during the summer of 1994.

Total particulate inorganic matter (PIM) concentrations ranged from 1.00 -15.14 mg/L. When averaged over the study, concentrations were greatest and most variable in the mid-reaches of the stream (Figure 2), which flow through the areas of most intensive agriculture. Seasonally, lowest concentrations were observed during the extended dry period. Highest concentrations of PIM were observed during and following record flooding. PIM concentrations at downstream stations remained elevated for several months following the summer 1994 flood, suggesting that significant sediment transport occurred in response to flooding.

Prior to flooding, POM transport was dominated by the small fraction which accounted for ~75% of organic matter in transport (Table 1). Following flooding, the small fraction contributed ~80-83% of total POM in transport. Increases in the proportion of small POM were attributable to concentrations of small organic particles remaining elevated above pre-flood levels. PIM transport was also dominated by the small fraction (Table 1). No changes in proportions of PIM were observed in response to flooding.

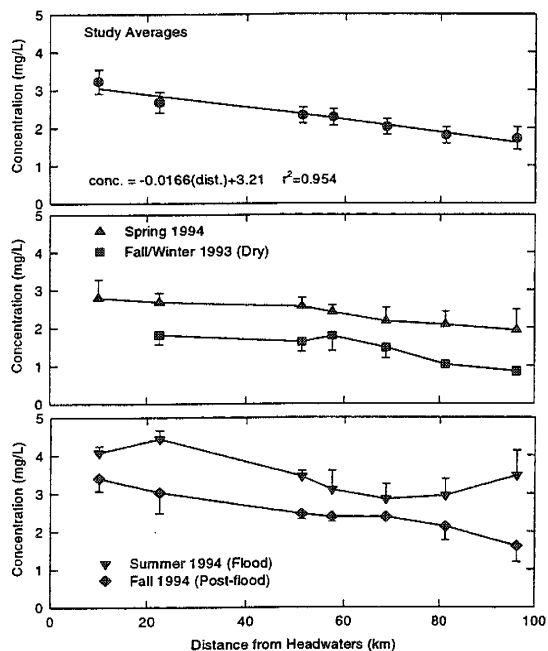


Figure 1. Concentrations of particulate organic matter in Ichawaynochaway Creek. Values are means \pm standard errors.

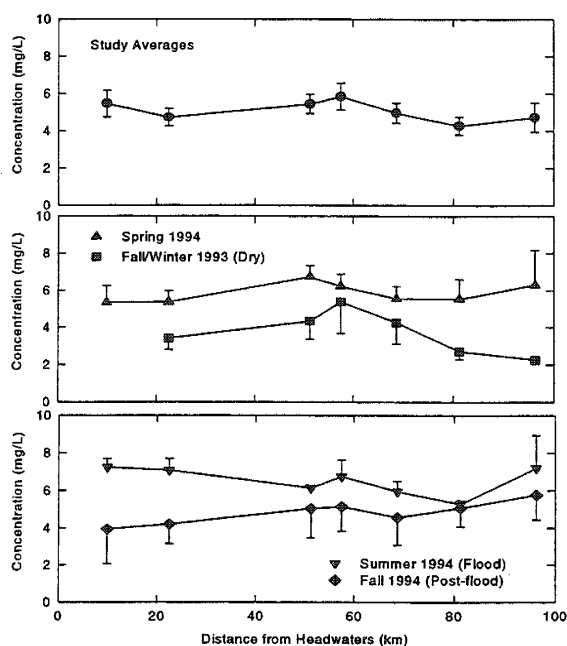


Figure 2. Concentrations of particulate inorganic matter in Ichawaynochaway Creek. Values are means \pm standard errors.

Table 1. Percent Contributions of Organic and Inorganic Particle Size Categories to Total Concentration. Values are Means and in Parentheses Standard Errors and Sample Sizes

		Small	Medium	Large
		<43 μ m	43-250 μ m	>250 μ m
Fall/Wtr 93	POM	76.4 (1.8,6)	20.5 (1.4,6)	3.1 (0.7,6)
	PIM	76.2 (3.0,6)	22.4 (2.9,6)	1.3 (0.2,6)
Spring 94	POM	74.5 (2.2,7)	22.1 (1.8,7)	3.4 (0.5,7)
	PIM	77.2 (1.4,7)	21.8 (1.4,7)	1.0 (0.1,7)
Summer 94	POM	82.8 (1.8,7)	14.3 (1.7,7)	2.9 (0.3,7)
	PIM	78.0 (2.6,7)	20.9 (2.5,7)	1.1 (0.1,7)
Fall 94	POM	80.7 (2.7,7)	17.0 (2.3,7)	2.3 (0.5,7)
	PIM	74.3 (1.6,7)	25.0 (1.5,7)	0.7 (0.2,7)

DISCUSSION

Stable Patterns. Most studies of stream ecosystems have not shown consistent longitudinal patterns of organic matter concentration like those observed in this study (e.g. Sedell et al. 1978, Wallace et al. 1982). The lack of pattern, particularly in high gradient streams, has been attributed to local variation in geomorphology and frequent floods (e.g.

Sedell et al. 1978, Wallace et al. 1982). The low gradient of Ichawaynochaway Creek and other coastal plain streams results in gradual changes in stream morphology. In addition, on the Dougherty Plain, the porous surface geology promotes subsurface runoff with consequent extended stable flow periods and broad flood hydrographs. These factors combine to promote stable patterns of organic matter concentration.

Organic Transport. Consistently higher concentrations in upstream areas indicate that headwater swamps and riparian areas with broad flood plains are important source areas for organic matter in transport. Declines downstream suggest that organic matter is being metabolized or retained in upstream areas and not replaced by instream or riparian sources. Regional hydrology also appears to be an important factor controlling organic matter transport. As the stream channel changes during extended wet and dry periods, organic matter concentrations respond accordingly. During dry periods as the channel shrinks, concentrations decline. During wet periods concentrations increase as the channel expands and organic matter is scavenged from inundated riparian areas. It has been proposed that alternate drying and flooding stimulate nutrient release and organic matter decomposition (Junk et al 1989). Partial decomposition of stored organic matter on floodplains during dry periods may promote organic export during subsequent flood cycles, enhancing aquatic productivity (Junk et al. 1989).

Flood Effects. Downstream stations, those with narrow floodplains, appeared to be particularly sensitive to record flooding. Concentrations of organic matter were substantially elevated above pre-flood levels. Large increases can be attributed to increased particle travel distance (e.g. Meyer and Edwards 1990) or export of organic matter from uplands as streamside terraces were flooded. The significance of catastrophic floods to stream biota is, at present, unknown but merits future study.

Small Particles. The dominance of small particles (< about 50µm) observed in this study appears to be a universal feature of streams. Similar patterns have been reported in boreal (Naiman 1982), northern temperate (Sedell et al. 1978), southern prairie (Hill et al. 1992), southern Appalachian (Wallace et al. 1982), and Atlantic coastal plain streams (Cudney and Wallace 1980).

Summary. Despite agricultural and municipal development on its catchment, Ichawaynochaway Creek remains a relatively undisturbed stream. Both headwater swamps and riparian forests along the Creek and its major tributaries remain largely intact. The results of this research, although preliminary, suggest that headwater swamps and areas with extensive riparian forests are an important source of organic matter to coastal plain streams. The role of swamps and riparian forests in flood water storage, in reducing non-point source pollution, and as wildlife habitat has long been appreciated. However, this research also suggests that export of organic matter from riparian areas is critical in maintaining organic matter concentrations downstream, the probable trophic base of aquatic communities. In the development of regional conservation programs, floodplain swamps and forests deserve special consideration and protection. Such protection may be critical for the maintenance of instream biological community structure and productivity.

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