DOES THE CHICKASAWHATCHEE SWAMP INFLUENCE WATER QUALITY?

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Abstract. As watersheds become dominated by human land use, water quality is often altered or degraded. Since 1994, water-quality constituents have been measured monthly in three adjacent Coastal Plain watersheds in southwest Georgia. Row-crop agriculture and managed forestlands are the dominant land use within each watershed; however, one watershed (Chickasawhatchee Creek) had 10-13% less agriculture and greater wetland area than the others. Much of the wetland area was within the Chickasawhatchee Swamp, a substantial wetland complex adjacent to the lower portion of the creek. Riparian areas had less forest, greater agriculture, and greater wetland area compared to the other watersheds. Chickasawhatchee Creek had significantly lower suspended sediment and NO_3-N concentrations than the other sites. Organic and inorganic carbon concentrations were significantly greater than the other sites. These results suggest that the Chickasawhatchee Swamp may be an important buffer preserving water quality in southwest Georgia. However, these results should be considered preliminary because water quality was not quantified in tributaries entering the swamp. An expansion of the current sampling effort to include upstream tributaries of the swamp is addressing this information need.

INTRODUCTION

The Chickasawhatchee Swamp is an extensive palustrine wetland located in southwest Georgia. It is the second largest swamp and wetland complex in the state. The swamp is an important component of the groundwater/surface water systems of the region, although its role in regional hydrology has not been quantified. Wetlands and streamside forests have also been shown to absorb nutrient and sediment runoff from managed lands (Mitsch and Gosselink 1993). Thus, the Chickasawhatchee Swamp may be important in maintaining regional water quality.

In southwest Georgia, row-crop agriculture has expanded with the development of center-pivot-irrigation technology in the 1970's (Hicks et al. 1987). As a result, land use is dominated by irrigated agriculture. Patterns of agricultural development in southwest Georgia are unique. Most agricultural operations are in the uplands away from stream and river corridors. This has left extensive unfarmed riparian areas, primarily mature second growth bottomland forest. However, systematic river corridor conservation strategies are lacking in the southeast (Benke 1990) and a cycle of streamside forest harvest is reoccurring (personal observation).

As watersheds become dominated by human land use, water quality is often altered or degraded. Elevated export of nitrogen, phosphorus, and suspended sediment is associated with runoff from fertilized agricultural lands or land application of animal waste (Johnson et al. 1997, Heathwaite et al. 2000). While there have been intensive studies of water quality in agricultural or human dominated watersheds in other parts of North America, less is known about water quality in southwest Georgia.

Since 1993, we have been monitoring water quality in three adjacent watersheds on the Gulf Coastal Plain. Specific objectives of the study were to: (1) characterize watershed and riparian land use within each watershed, and (2) to compare water quality in Chickasawhatchee watershed with adjacent watersheds that have intact streamside forest but lack extensive swamp and wetland complexes.

STUDY SITE

We studied three adjacent watersheds (Pachitla Creek, upper Ichawaynochaway Creek, and Chickasawhatchee Creek) in the Ichawaynochaway Creek drainage, which is a major tributary of the lower Flint River. The watersheds lie within the recharge zone for the Upper Floridan aquifer, a regionally important water resource. Low topographic relief in combination with porous sandy soils results in a low stream drainage density and a dominance of subsurface water flow in regional hydrology. The channels of major streams are incised within the aquifer and tend to be perennial; smaller streams with channels above the aquifer tend to be intermittent (Hicks et al. 1987).

The three study streams originate in swamp forests. Intact riparian forests occur along most of the streams and are composed of flood tolerant hardwoods, bald cypress (*Taxodium distichum* L.), and red cedar *(Juniperus silicicola* L.). Winter is the primary season when most groundwater recharge occurs in the region. During typical winters both the regional water-table level and streamflow increase in response to extended storms (Hicks et al. 1987) and inundation of riparian areas occurs. The streams tend to be highly stained, particularly during high flows when streamflow is dominated by discharge from swamps and wetlands. During summer, most precipitation is lost through evapotranspiration, groundwater recharge is minimal, and the water table declines. As a result, riparian areas dry and streams are at seasonal low flow.

METHODS

Since 1994, surface-water samples have been taken monthly during stable flow periods at the base of the three watersheds. Generally, storm pulses were avoided, but samples were taken during many high-flow periods. Surface grab samples were collected in well-mixed areas with measurable flow, samples were collected in clean plastic bottles at each site on each date, stored on ice, and transported to the laboratory for processing. Samples were analyzed for particulate organic matter (POM), particulate inorganic matter (PIM), dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), NO_3-N, NH_4-N, and soluble reactive phosphorus (SRP) following standard analytical methods and using accepted QA/QC procedures (Anonymous 1999).

Study-wide and seasonal median values were compared to examine variation in each water-quality constituent between streams and under differing flow conditions. Comparisons were performed using an ANOVA on ranks followed by a Tukey's Studentized Range test (Helsel and Hirsch 1992, Spahr and Wynn 1997). Seasonal medians were based on two "hydrologic" seasons derived from long-term climatic and hydrologic conditions (e.g. Golladay et al. 2000). The period of January-June tends to have moisture surpluses with streams often at high flow and the floodplain inundated; and the period of July-December tends have moisture deficits with the floodplain typically dry. Seasonal values for typical years were contrasted with a period of above average flows (July 1994 – May 1995).

RESULTS

Land use

The watersheds range in size from 65,800 to 86,800 ha (Table 1). Row-crop agriculture and managed forestlands were the dominant land use within each watershed. Pachitla Creek and upper Ichawaynochaway Creek watersheds had very similar land use (~50% agriculture, ~30% forest). Chickasawhatchee Creek watershed had 10-13% less agriculture and greater wetland area than the other sites. Much of the wetland area within the Chickasawhatchee watershed is the Chickasawhatchee Swamp. Urban development was minimal in each of the three watersheds. Upper Ichawaynochaway Creek and Pachitla Creek had very similar riparian landcover being dominated by forest (~48%) with substantial agriculture (~23%) and wetlands (~22%). In riparian areas, Chickasawhatchee Creek had less forest (~30%), greater agriculture (~25%), and greater wetlands (~30%) compared to the other streams.

Table 1. Land use within watersheds and riparian zones. Estimates were derived from 1990 Landsat Thematic Mapper imagery. The riparian zone was delimited using a 500m buffer on each site of a stream. Buffer widths were selected using field measurements of the floodplain and by examination of digital elevation maps.

	Pachitla Creek	Upper Ichawaynochaway Creek	Chickasawhatchee Creek
Watershed			
Agriculture (%)	51.9	54.9	42.0
Forested (%)	31.8	30.4	32.2
Clearcut (%)	7.5	7.0	9.7
Wetlands (%)	8.4	7.5	15.8
Urban (%)	0.4	0.2	0.3
Riparian (500m)			
Agriculture (%)	23.5	22.6	24.7
Forested (%)	47.2	48.4	29.4
Clearcut (%)	7.2	6.8	14.7
Wetlands (%)	22.0	22.0	30.7
Urban (%)	0.1	0.2	0.5
Riparian area (ha)	10,470	12,092	11,874
Catchment area (ha)	65,800	78,500	86,800

Water Quality

Study-wide median concentrations of several water quality constituents were different among streams. Chickasawhatchee Creek had significantly lower PIM and NO_3-N than either of the other sites (Table 2). DOC and DIC concentrations in Chickasawhatchee Creek were significantly greater than the other streams. POM concentrations and possibly NH_4-N concentrations (Tukey's Test was inconclusive) were lower in Chickasawhatchee Creek than at least one of the other streams. There was no difference in SRP concentration between streams.

Hydroperiod had a strong influence on some water-quality constituents. POM, PIM, and NH_4-N concentrations were significantly greater during wet and flood periods compared to dry periods for each stream (data not shown). While there was a general trend of higher concentration with increasing degree of flooding i.e., flood > wet > dry, a broad overlap of ranges in concentration occurred and differences were only significant for NH_4-N in Pachitla Creek and Ichawaynochaway Creek and for PIM in Chickasawhatchee Creek. A weaker influence of hydroperiod was observed for DOC, which was significantly greater during flood and wet periods compared to dry periods in Pachitla and

Ichawaynochaway Creeks. Hydroperiod had little impact on NO_3-N, SRP, or DIC concentrations in the streams.

Table 2. Study-wide median concentration of water quality constituents. For each water quality constituent concentrations with different letters are significantly different (ANOVA on Ranks, followed by Tukey's Studentized Range Test, $p < 0.05$). Values in parentheses represent the interquartile range.

	Pachitla Creek	Upper Ichawaynochaway Creek	Chickasawhatchee Creek
POM (mg/L)	1.853ab (1.353-2.332)	2.063b (1.410-2.783)	1.465a (0.905-2.175)
PIM (mg/L)	5.247b (2.254-6.762)	4.458b (2.772-6.595)	2.728a (1.660-5.015)
DOC (mg/L)	3.627a (2.753-4.608)	4.825b (3.708-6.274)	7.862c (5.791-10.901)
NO_3-N (ug/L)	376.1b (278.9-459.1)	538.0c (412.1-738.5)	171.1a (98.2-287.9)
SRP (ug/L)	3.704a (2.813-4.553)	3.439a (2.417-4.281)	4.003a (3.320-4.635)
NH_4-N (ug/L)	26.98a (17.08-41.21)	28.78a (16.87-45.66)	18.39a (12.47-31.04)
DIC (ug/L)	4.939b (4.029-5.606)	2.959a (2.230-3.289)	16.392c (12.702-21.853)

DISCUSSION

Land use/land cover influences

Alterations in stream water quality are often associated with human land use within watersheds. In particular, conversion of natural vegetation to agriculture, silviculture or other uses increases inorganic nitrogen, phosphorus and suspended sediment (PIM) concentration (Johnson et al. 1997, Heathwaite et al. 2000). Elevated concentrations can result from increased erosion, reduced plant uptake, increased transport, and fertilizer application (e.g. Arheimer and Liden 2000). By acting as filters, floodplain wetlands and swamp forests can partially offset runoff from human dominated uplands and are important in preserving water quality (Mitsch and Gosselink 1993).

While lower than the other sites, the Chickasawhatchee watershed had considerable human land use. The Chickasawhatchee riparian zone had greater development than the other stream corridors, with most concentrated in headwater reaches upstream from the swamp. Yet, inorganic nitrogen concentrations and suspended sediment concentrations in Chickasawhatchee Creek downstream from the Chickasawhatchee Swamp were lower than the other sites. This suggests that the swamp may be an important buffer preserving water quality in southwest Georgia. However, these results should be considered preliminary because water quality was not quantified in tributaries entering the swamp. An expansion of the current sampling effort to include the major tributaries was initiated during fall 2000.

Chickasawhatchee Creek also had consistently higher DOC concentrations than the other sstreams. DOC generally originates in wetland soils and concentrations in streams are often proportional to wetland area within watersheds (Dosskey and Bertsch 1994, Gergel et al. 1999). Higher DOC concentrations reflect the greater wetland area in the lower Chickasawhatchee watershed and suggest substantial DOC export from the Chickasawhatchee Swamp is occurring.

Finally, greater DIC concentration in Chickasawhatchee Creek indicates a stronger hydrologic connection to the Upper Floridan aquifer than the other streams (Hicks et al. 1987). At present, the degree of connection to the aquifer and the role of the swamp in regional hydrology have been largely uninvestigated. However, considering regional concerns about human use of the Upper Floridan aquifer, this is clearly a critical information need.

Hydrologic Influences

POM, PIM, DOC, and NH_4-N were under strong hydrologic control, with higher concentrations generally observed during 'wet' or 'flooded' conditions. Hydrologic control reflects the strong linkage between low-gradient streams and their floodplains. In low-gradient streams, POM originates on floodplains and greatest concentrations occur when particles are floated from soils during floods (Golladay et al. 2000). PIM originates from disturbed areas adjacent to streams; and greatest concentrations occur during high flows when surface erosion transports soil particles into streams (Arheimer and Liden 2000). High PIM concentrations can also result from resuspension of sediments deposited during previous floods. In Coastal Plain streams DOC originates from floodplain soils. Higher concentrations are generally observed during floods when leaching of soil occurs (Dosskey and Bertsch 1994). While not generally considered a mobile form of nitrogen, NH_4-N is a common form in waterlogged wetland soils (Mitsch and

Gosselink 1993). Higher concentrations during floods also reflect leaching from floodplain soils. Concentrations of POM, PIM, DOC, and NH_4-N decline during low-flow periods when streams are largely disconnected from floodplains.

Ecological Benefits

In addition to its role in preserving water quality, the Chickasawhatchee Swamp may also provide important ecological functions within the region. Swamp forests are noted for their high productivity (reviewed by Watt and Golladay 1999). A portion of this productivity, litterfall, is seasonally deposited on floodplain soils. Litterfall is then partially degraded by microbial activity and a portion is exported during seasonal flood pulses. Exported organic carbon is an important food resource for aquatic communities downstream (Dosskey and Bertsch 1994). Aquatic productivity in Chickasawhatchee Creek, lower Ichawaynochaway Creek and Flint River may be dependent on swamp derived carbon export.

Significance

Even though substantial human land use has occurred within the Ichawaynochaway Creek watershed, water quality is good within the major streams. The parameters we measured never approached water quality guidelines. We attribute the maintenance of water quality to several factors. The streams we sampled generally had intact riparian forests and associated wetlands along most of their length. Streamside forests have been shown to be effective buffers protecting water quality (Mitsch and Gosselink 1993). Deep, sandy soils characteristic of the region encourages water infiltration resulting in a dominance of subsurface flow paths. The movement of water through soils permits water purification to occur through physical and microbial processes.

While current conditions appear to protect water quality, several issues should be of concern in the development of watershed management plans. Presently, most riparian forests in southwest Georgia are in private ownership. Forests along streams are maturing and a cycle of forest harvest is beginning. Loss of streamside forests may result in a loss in water quality buffer capacity. If conservation of streamside forests was encouraged, their value in water quality protection might exceed their commodity value. An excellent example is the recent purchase of portions of the Chickasawhatchee Swamp for conservation; this not only provides substantial recreational opportunities but also appears to provide water quality benefits.

At present, there is no evidence for widespread deterioration of water quality within the Upper Floridan aquifer, however localized examples of degradation have been documented (Frick et al. 1996). Clearly, more research is needed on the sustainability of water purification by soils in southwest Georgia. If nutrient saturation of soils and groundwater is imminent, a significant regional water resource is threatened.

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