Loss of Dissolved Organic Carbon from Watersheds in Northeastern Indiana, USA

D.E. Stott, C. Huang, S.J. Livingston, D.L. Bucholtz
USDA-ARS National Soil Erosion Research Laboratory West Lafayette, IN, USA, 47906-2077
Corresponding author: destott@purdue.edu

Transport of carbon from hillslopes to adjacent ditches, streams, and watersheds can represent a significant loss of C. While carbon associated with eroding sediments is often measured, the concentration of dissolved organic carbon (DOC) is runoff water is rarely measured. As part of a larger project, nine subwatersheds in the St. Joseph River watershed were instrumented to collect runoff into agricultural drainage ditches before water entered creeks and streams. Runoff samples were acidified, frozen, and transported to the lab for analysis. Carbon concentrations were measured in base flows as well as from flows during rainfall events. In one example from the 2004 season, 5-25 g C s^{-1} were lost from the large experimental watersheds in base flow discharge into the ditch receiving drainage from a 4650 ha watershed. Base flow was almost continuous during early April to mid-November during 2004. This translates to 96,768 to 483,840 kg C lost as DOC during the season from the watershed, or 2-10 g C m^2. Data from three years (2003-2005) of DOC measurements from the nine subwatersheds will be presented.

Introduction

In the United States, many cities and towns rely on surface waters for their domestic water supply. In 2003, the US Department of Agriculture initiated the Conservation Effects Assessment Project (CEAP) to determine the effects of government sponsored soil conservation programs. The CEAP effort includes watershed assessment studies to detail the environmental impact of conservation practices on selected watersheds. Among the factors being studied include pesticide and nutrient transport. Transport of carbon from hillslopes to adjacent ditches, streams, and watersheds can represent a significant loss of C. While C associated with eroding sediments is often measured, the concentration of dissolved organic C (DOC) in runoff water is rarely measured.

The St. Joseph River watershed is located in the upper Midwest, USA. The Three Rivers Filtration Plant is located at the southern end of the watershed, which draws water from the St. Joseph River, providing up to 130 million liters of drinking water per day to the over 220,000 citizens of Fort Wayne, New Haven, and Allen County, Indiana. The water used by this plant has a history of excessive atrazine and nitrate levels, and requires extensive treatment to meet the safe drinking water standards set by the US Environmental Protection Agency. Working in partnership with the St. Joseph Watershed Initiative, a local NGO, we have set up sampling stations at nine subwatersheds within this area to study the impact of best management practices (BMPs) on pesticide and nutrient reductions. This paper concentrates on the loss of dissolved organic carbon (DOC) from these watersheds.

Materials and Methods

Site Description

The St. Joseph River watershed is a major watershed of the Great Lakes Western Lake Erie Basin, located in the upper Midwestern USA. The watershed covers over 281,000 ha, with

56% of the area in northeast Indiana, 22% in northwest Ohio, and 22% in south central Michigan (Fig. 1). The land use is comprised of 64% cropland, dominated by corn and soybean, 15% pasture or forage, 10% woodland or wetland, and 11% in urban, farmstead, rural residential, golf courses, airports, commercial, and similar uses. For this study, we concentrated on the area along Cedar Creek, which is the largest tributary to the St. Joseph River. The Cedar Creek sub-watershed covers about 70,800 ha or 25% of the St. Joseph River watershed. Runoff from subsurface tile-drained agricul-tural fields in the area drain into a network of dredged ditches that feed into Cedar Creek. It was along these ditches that a series of watersheds were selected for study, ranging in size from 2.5 to almost 4300 ha. Watersheds were selected to allow comparison of treatments at similar scales, with smaller watersheds nested within larger watersheds. Within one set of three nested watersheds (ALG, AME, AS1, Table 1), farmers were strongly encouraged to adopt BMPs designed to reduce pesticide and nutrient loss from the fields. A second set of three watersheds were designated as controls (BLG, BME AS2), where farmers were encouraged to maintain current practices. When it was discovered that the ditch draining the medium and large control watersheds was scheduled to be dredged, a second set of controls (CLG, CME) were selected to allow a study on the impact of dredging on water quality. The three BMP watersheds were nested within and even larger watershed that had water quality monitoring data from 1996 to present, it was also included in the study (AXL). Watershed characteristics are listed in Table 1.

Figure 1. Map of the St. Joseph River Watershed, covering parts of Indiana, Ohio, and Michigan.

Monitoring and Analyses

The AXL, ALG, AME, BLG, BME watersheds had instrumentation installed in 2002 and the remaining watersheds in 2003. Instrumentation includes automated samplers at each site (ISCO 6712 Portable Samplers), two automatic recording weather stations were installed in 2005, drop box weirs for the small watersheds (AS1, AS2), and water level recorder. Soil data were collected at the start of the experiment to provide baseline data. Air temperature, barometric pressure, wind, precipitation, and relative humidity are recorded every 15 minutes. Water quality and hydrology are monitored at the outlet of each experimental watershed. Water quality samples are collected through Teflon tubing and deposited in glass bottles. For base flow, 50 mL of water was collected every four hours and combined into a single sample for a 24 h period. For flow generated by a rainfall event, 100 mL of water was collected every one-half hour and combined in to a single sample for a 90 min period. During the 2003 sampling season, samples were kept cold in the ISCO samplers by filling the sampler air space with ice. In succeeding field seasons, the ISCO samplers were kept cold using small portable refrigeration units to chill the air within the samplers.

Within four days of collection, water samples were transported from the collection site to a field laboratory where they are divided into subsamples for specific analyses. Subsamples for

the DOC determination were filtered and acidified with H_2SO_4 and frozen in plastic sample bottles. Frozen subsamples were transported from the field laboratory to the USDA-ARS National Soil Erosion Research Laboratory for analysis. After thawing water samples at 4°C, they were analysed for DOC, in duplicate, by UV-persulfate wet oxidation (Shimadzu TOC-V_{ws}, Duisburg, Germany).

Table 1. Experimental watershed characteristics (from Flanagan, et al., 2003).

Watershed	Treatment	Size	Area (ha)	Soil Types	Land Management
AXL	Best Management Practices (BMPs)	Extra Large (XL)	4303	Blount silt loam, Glynwood loam, Pewamo silty clay, Rawson sandy loam, Rensselaer loam, Sebewa sandy loam	78% Agriculture 14% Grass/Pasture 6% Forest
ALG	BMPs	Large (L)	1934	Blount silt loam, Glynwood loam, Morley silty clay loam, Pewamo silty clay, Rawson sandy loam	77% Agriculture 16% Grass/Pasture 6% Forest
BLG	Control – Dredged (CD)	L	1417	Blount silt loam, Glynwood loam, Pewamo silty clay, Rensselaer loam, Sebewa sandy loam	83% Agriculture 12% Grass/Pasture 3% Forest
CLG	Control – Not dredged (C)	L	1380	Blount silt loam, Glynwood loam, Morley silty clay loam, Pewamo silty clay	73% Agriculture 17% Grass/Pasture 5% Forest
AME	BMP	Medium (M)	298	Blount silt loam, Morley silty clay loam, Pewamo silty clay, Rawson sandy loam	79% Agriculture 15% Grass/Pasture 4% Forest
BME	CD	M	311	Blount silt loam, Glynwood loam, Pewamo silty clay	85% Agriculture 8% Grass/Pasture 6% Forest
CME	C	M	921	Blount silt loam, Glynwood loam, Pewamo silty clay	83% Agriculture 10% Grass/Pasture 4% Forest
AS1	BMP	Small (S)	2.2	Glynwood loam, Pewamo silty clay Morley silty clay loam	100% Agriculture
AS2	C	S	2.7	Blount silt loam, Glynwood loam	100% Agriculture

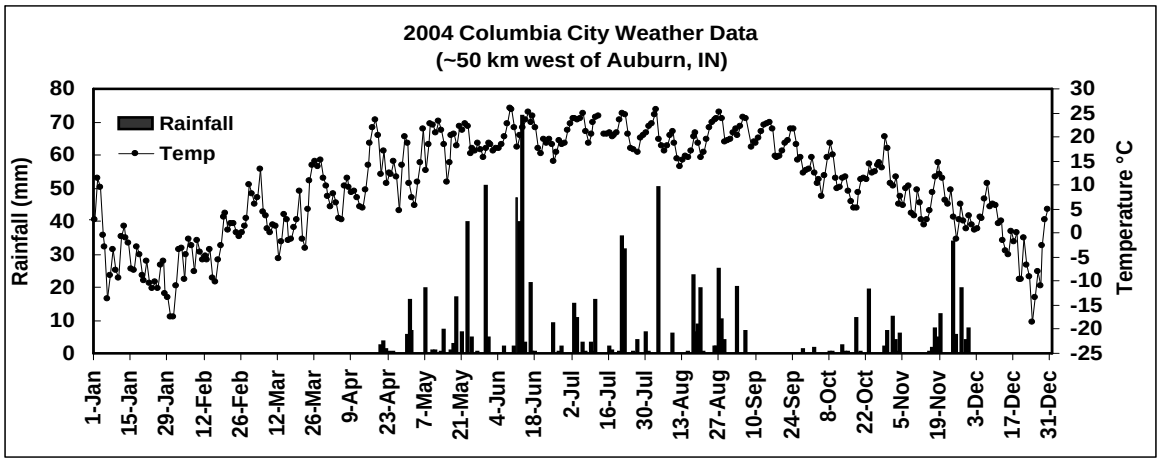

Figure 2. Weather data obtained for Columbia City, which is about 50 km from the sites of the small watershed sampling stations.

Results and Discussion

Baseline data was collected during the 2003-2005 in all watersheds. Weather data (Fig. 1) was obtained from the local official weather station located about 50 km west of the watershed sampling sites. As an example of data gathered from this project, Figures 3 and 4 show DOC lost from the small watersheds during rainfall events of the 2004 season. Event runoff, collected from the installed weirs, were similar for the two watersheds. DOC laden runoff was produced only during the May-June rainfall events, when there is rapid vegetative growth of the crops. Little runoff was generated during the summer months. The largest amount of carbon lost during a rainstorm event was 849 kg DOC from the small AS1 watershed or 386 kg DOC ha^{-1}. Over the course of the summer months, a total of 2,255 kg DOC was lost from this watershed or 1025 kg DOC ha^{-1}. From the AS2 watershed, the greatest amount lost during a rainstorm event was 559 kg DOC or 207 kg DOC ha^{-1}. Over the season, 690 kg DOC ha^{-1} was lost from this watershed. We are still analysing 2005 data for all the watersheds.

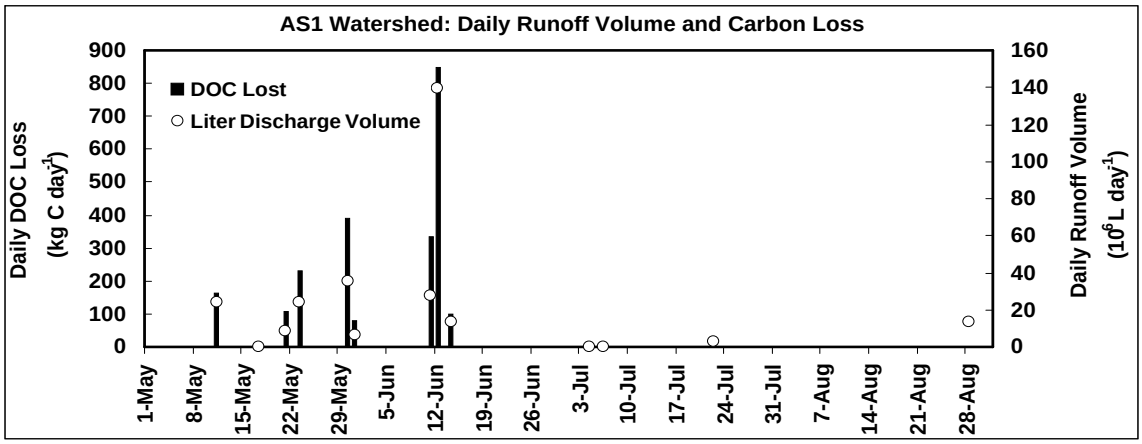

Figure 3. DOC loss from event-based samples for the 2004 season at the watershed designated as AS1. AS1 is 2.2 ha and has a small weir installed for water sample collection. This area was converted to best management practices in 2005.

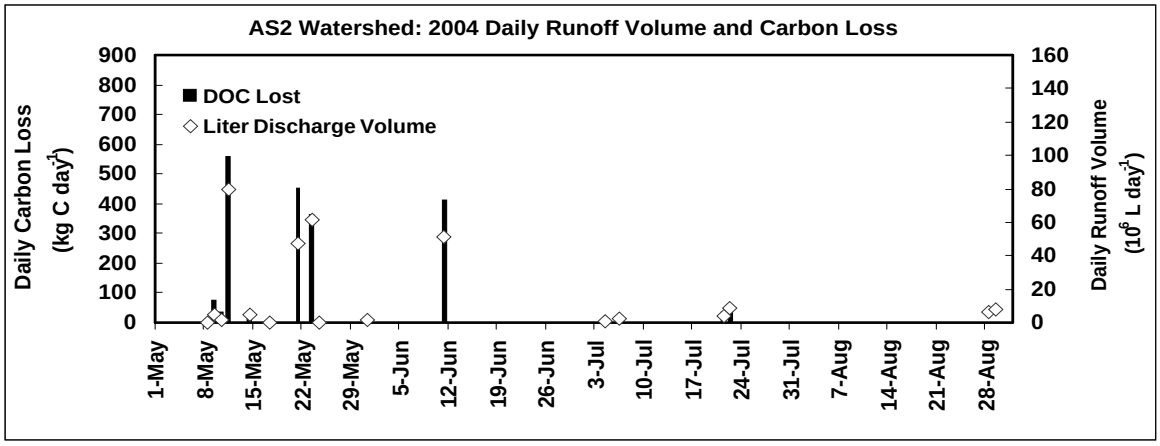

Figure 4. DOC loss from event-based samples for the 2004 season at the watershed designated as AS2. AS2 is 2.7 ha, has a small weir installed for water sample collection, and will continue under the current management practices.

Reference

Flanagan, D.C., Livingston, S.J., Huang, C.H., and Warnemuende, E.A. (2003). Runoff and pesticide discharge from agricultural watersheds in NE Indiana. ASAE meeting paper number 032006. American Society of Agricultural Engineers, St. Joseph, MI (USA).