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Hydrology, Erosion, and Water Quality of the Saucon Creek Watershed

Introduction:

The Saucon Creek watershed, a major tributary of the Lehigh River, is undergoing changes in land-use practices from the expansion of residential and urban development within the area. Monitoring the effects of these land-use practices is important for protecting the surrounding ecosystem and recreational areas within the Saucon Creek watershed. Urbanization has shown to increase erosion rates within watersheds and subsequently sediment yields in streams draining watersheds (Nelson and Booth, 2002). Soil erosion has recently been given greater emphasis as a contributing source of nonpoint pollution. As eroded sediments enter fluvial systems, they can carry nutrients and pollutants from the surrounding environment, changing the chemistry of stream water by introducing dissolved solids (*DS*) and lowering surface water quality (Elliot and Ward, 1995). Studies have shown that the majority of sediment is transported within streams during single hydrologic events, such as flooding from heavy precipitation and snowmelt (Lenzi and Marchi, 2000). The relation between suspended solid concentration (SS) and discharge (*Q*) during storm events is often variable, exhibiting time lags and hysteretic relationships (Lenzi and Marchi, 2000). Thus, the development of a long-term record of flow rates and sediment flux on the Saucon Creek is imperative to understanding the effects of changing land use practices on erosion and the subsequent water quality of the Saucon Creek watershed. The present paper aims to summarize the progress that thus far has been made in establishing a protocol for the study of Saucon Creek and the preliminary findings of the investigation.

Study Area and Measuring Station:

Saucon Creek at Friedensville, Pa drains 26.6 square miles of the Lehigh basin and can be characterized as an armored alluvial channel with alternating pool and riffle sequences. The course of the stream brings it in contact with forested lands, urbanized areas, residential property, and major roadways. The measuring station is located on the property of the Bethlehem City Sewage Treatment Plant, near the confluence of the Saucon Creek with the Lehigh River, as shown by Fig. 1 by the red crosshair. Measurements of stream flow and water samples are preformed by an ISCO automated water sampler. Stream flow is calculated from the stream stage determined by the ISCO's pressure sensor. The monitoring location has been carefully surveyed to ensure the accurate measurement of stage height (Appendix A).

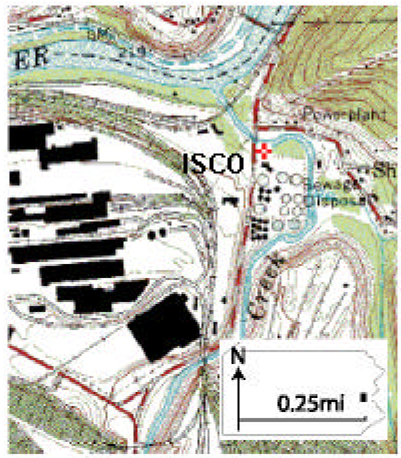


Fig. 1. Monitoring Location

Discharge measurements were made in a prior investigation to produce a rating curve (Appendix B) allowing discharge to be calculated from the measured stage height (Pazzaglia, 2002). Flow data is downloaded from the ISCO approximately every 5th day when the ISCO batteries are replaced. The ISCO can sample up to twenty-four times after one or more enabling conditions are met and a sampling program has begun. For an outline of the ISCO sampling programs used see Appendix C.

250ml samples were first collected on a uniform two hour time interval once base flow had surpassed a stage height of 0.4m, thus enabling the program to begin. The sampling program was later changed to sample at a non-uniform interval or "event-paced". Event-paced samples were taken only when the enabling event, a 0.03m change in stage height per hour, was met. Stage height was continuously measured on a 15min time interval and recorded with an internal data logger.

Suspended Sediment Laboratory Procedures:

The development of a standardized method to measure and record suspended solid concentration is necessary to ensure that data can be accurately added to a long-term record regardless of changes in who is collecting the data. Due to this concern, initial laboratory tests were conducted to rate the accuracy, precision, and efficiency of calculating suspended solid concentrations with different techniques and materials. Appendix D is a summarization of these initial tests.

A vacuum filtration method for collecting the suspended solids was developed and a list of procedures was written for repeatability;

1. Label filter paper (2 sheets/sample) consecutively,
2. Label drying tins,
3. Weigh filter paper, and tins, record initial weight,
4. Record date/time each sample was collected,
5. Secure filter (labeled side down) to surface of vacuum apparatus by screwing down container,
6. Shake ISCO sample bottle vigorously,
7. Pour contents into graduated cylinder and record volume,
8. Pour contents into filtration container,
9. Ensure complete removal of all solids from sample bottle and cylinder, if necessary use de-ionized water to wash out all solids,

10. Remove filter paper with suspended solids,
11. Place second piece of filter paper over first (to secure sediments captured),
12. Take a 20ml aliquot of filtered water sample, place in weighed drying tin,
13. Put both filter paper and tins containing samples into oven to be dried,
14. After a 24hr period remove samples, weigh and record data,
15. Input data into Excel spreadsheet to determine suspended solids concentration (*SS*) and dissolved solids concentration (*DS*).

Appendix E provides a blank example of the data sheet that should be used when following these laboratory procedures.

Downloaded data from the ISCO Rapid Data Transfer device is connected to the appropriate computer terminal and the program Flowlink 4 is run. Selecting “RTF transfer” under the File menu transfers the data to the Flowlink 4 program. If samples were taken, a record of sample date and times is available when the “View last report” option is chosen, any errors in collection will be noted in the report as well as a description of the sampling program parameters. After opening a graphical display of the flow record from the navigational bar, flow data is exported by selecting “Export” under the file menu. Flow data is saved as a comma-delimitated Excel file in the appropriate folder; new flow data is copied into the existing Excel spreadsheet to determine discharges.

Preliminary Results:

The ISCO water sampler was installed at the monitoring site on April 4th, 2002. Data collection was initiated the following afternoon, April 5th. Unfortunately flow was measured erroneously high, which initiated the sampling program and the collection of six water samples before power failed. These six samples were processed using the standard procedure to determine a background suspended and dissolved solid concentration during "normal" or non-storm flow. Accurate discharge measurements were not recorded for these samples, though it is assumed that the discharge was approximately 2.7 m^3/s as recorded when data collection was initiated. From Table 1, the SS for this base flow is 0.0215 ± 0.104 (g/L) and a DS of 0.3015 ± 0.260 (g/L).

Sample #	SS (g/L)	TS (g/L)	SS variance	TS variance
02_01	0.0061	0.3500	0.0155	0.0350
02_02	0.0129	0.2750	0.0087	0.0400
02_03	0.0267	0.3050	0.0051	0.0100
02_04	0.0309	0.3000	0.0094	0.0150
02_05	0.0330	0.3250	0.0114	0.0100
02_06	0.0196	0.3350	0.0019	0.0200
Avg.	**0.0215**	**0.3150**	**0.0104**	**0.0260**

Table 1. "Normal" Suspended and Dissolved Solid Concentration

Accurate flow measurements began mid-day April 10th and a record of discharge was produced until erroneously high measurements were again recorded mid-day of April

13th. The erroneous measurements initiated the sampling program on April 14th @ 0:30 and twenty-four samples were taken at two-hour intervals. Though no record of discharge was recorded the samples were processed since they had spanned a rainfall event beginning April 14th @ 19:30 and ending April 15th @ 3:30, with a total rainfall of 13.3mm. The Packer Campus Weather Station located on the roof of Williams Hall, Lehigh University, approximately five miles from the Saucon Creek monitoring site, records rainfall measurements in fifteen-minute intervals. Fig. 2 and 3 are the recorded SS and DS concentrations during this two-day sampling period, respectively.

Fig. 2

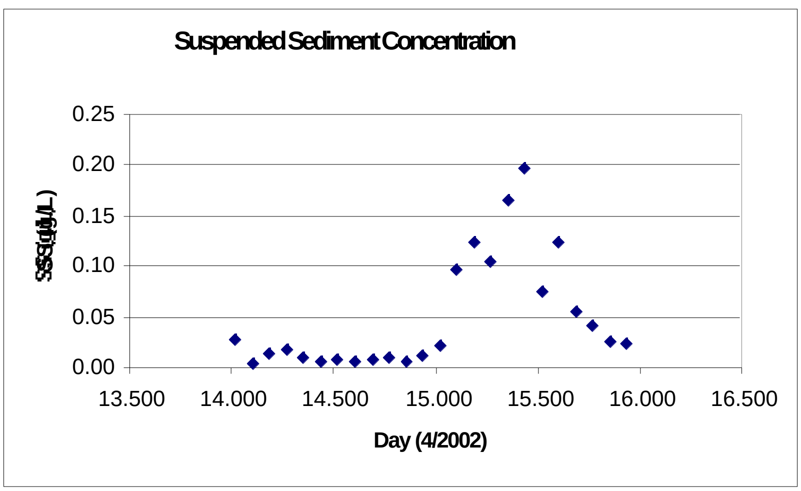
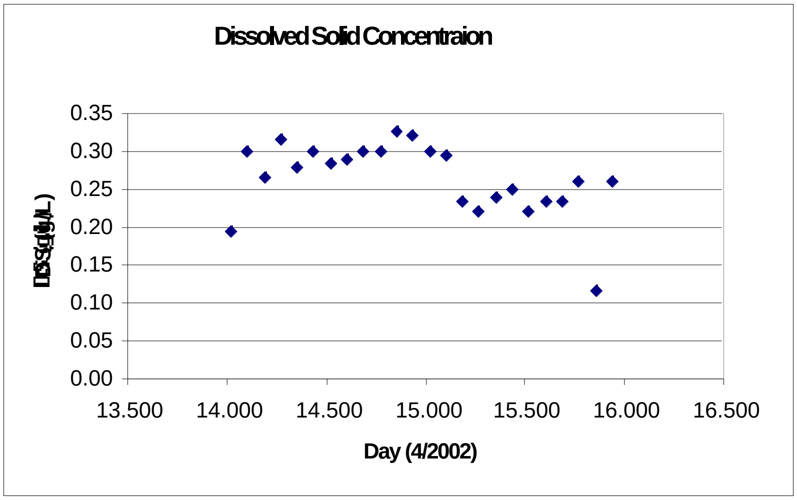


Fig. 3



Accurate measurement of flow height was established again during the early afternoon of April 17th without any further errors to the end of the investigation period May 6th @ 10:00. Figure 4 shows the discharge record of Saucon Creek, the times that water samples were taken, as well as the rainfall record that spanned the investigation period. Eight distinct rainfall events of varying magnitude and durations occurred that produced noticeable response in the Saucon Creek hydrograph during the investigation period.

The largest rainfall event, beginning on April 27th @ 23:15 and ending April 28th @ 12:15 brought 20.9mm of rainfall, and was closely followed by an additional two hour event at 19:00 that added 9.0mm of rainfall with one 15 minute interval bringing 3.3mm, the greatest intensity of rainfall during the investigation. This rain event produced a striking hydrograph with multiple peaks corresponding with subsequent intervals of rainfall. Sampling was initiated during the initial increase in discharge with a non-uniform, event-paced program, sampling eleven times over an approximate thirty-six hour period. Since sampling was initiated dependent on increases in discharge and not time, fig. 5 and 6 express the SS and DS concentrations as they are related to the changes in discharge recorded during this period. The arrows indicate time progression. The majority of the samples were taken during the rising limb of the first peak, though the last two samples, taken ninety minutes apart, sample the second dominant peak of this storm hydrograph and show a dramatic decrease in SS concentration from 3.727 (g/L) to 0.648 (g/L). A small peak in discharge is visible rising from the falling limb of the second dominant curve and a third dominant peak on the hydrograph is apparent. Two rain events delivering 5.4mm and 19.9mm, respectively, are noticeable during this time period as well.