Minnesota Pollution Control Agency

Identifying sediment sources in the Minnesota River Basin

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Many of the streams and rivers in the Minnesota River Basin show high levels of turbidity, which impairs the ecosystem of the river, as well as the Mississippi River and Lake Pepin. Considerable research flows into understanding the sources and fate of sediment, the primary cause of turbidity in the basin's streams and rivers.

Researchers from the Minnesota Pollution Control Agency and affiliates have issued a report summarizing the current research, "Identifying sediment sources in the Minnesota River Basin." It describes the context and different sediment sources, and summarizes current understanding; yet, more research is necessary. Much evidence indicates that most of the sediment entering Lake Pepin comes from the Minnesota River Basin, and that the rate of sediment supply has increased ten-fold over the past 150 years. The basin's geological history, climate, and land use are primary factors.

Geology, land use

The geological history of the Minnesota River valley leaves it primed to produce large amounts of sediment. About 12,000 years ago, floods from glacial meltwater lowered the Minnesota River valley bottom by as much as 70 meters. The tributaries draining into the mainstem have been adjusting to this downcutting by carving their own valleys ever since. The incised zone, although relatively small in area, can supply large amounts of sediment from erodible glacial deposits in a setting of steep slopes and incising river channels. Research has focused in the Blue Earth and Le Sueur watersheds, which together may contribute as much as half of the sediment

to the Minnesota River, even though they account for only one-fifth of its drainage area.

In the low relief upland zone, erosion rates are generally smaller, but the area is very large and rates of soil erosion have increased many times over since European settlement due to the development of row-crop agriculture throughout the watershed (Mulla and Sekely, 2009). The challenge in determining sediment sources in the Minnesota River Basin is to evaluate sediment yield from upland field sources in the context of other sources driven by incision of the stream network.

Sediment sources

The major sources of sediment can be grouped into four broad categories:

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fields, ravines, bluffs, and stream banks.

Fields
More than 90 percent of the land in the Minnesota River Basin is used for annual row cropping (primarily corn and soybeans). Sediment sources include erosion from sheet and rill flow, gully development, and enlargement of drainage ditches. Intakes to drainage tiles create a sediment pathway, and the increased runoff rates promoted by artificial drainage can increase erosion from flow surging through the watershed network.

Bluffs
Bluff erosion is driven by river erosion at the toe, which triggers slope failure by grain fall, slumping, gullying, and block fall. In developing a sediment budget to estimate the overall contribution from bluffs, the challenges are to determine the rates of bluff erosion and their controls, to identify all actively eroding bluffs, and to develop a reliable means of assigning erosion rates to all bluffs in the watershed.

Ravines
Unlike bluffs, ravines erode by a combination of hillslope and river processes. Although net erosional, ravines can store as well as erode sediment. Although the ultimate cause of ravines is the drop in elevation between the uplands and the incised mainstem channel, the immediate driver of erosion is the volume and rate of water discharged to the ravine, which can be increased by discharge from upland drainage systems.

Stream banks
Stream bank erosion supplies sediment directly into the river, although the *net* contribution of sediment from stream banks and the floodplains behind them is not easily apparent. In developing an estimate of the net contribution from stream banks, the challenges are to determine rates of channel migration, channel enlargement, and floodplain deposition along the river valley channels in order to determine the net contribution of sediment from stream erosion and deposition.

Measuring erosion

To develop reliability in our estimates of erosion, we depend on multiple methods and work to corroborate different, independent lines of evidence. Stream gauging provides the most direct and reliable evidence of erosion rates from a watershed. Methods include measurements of the rate of water flow, or discharge, and the river water level, and the sampling of suspended solids. Erosion at local sites can be measured through direct surveys or by changes measured on aerial photographs taken at different times. Comparison of air photos taken at different times allows erosion to be measured over longer time periods, but generally with less precision than local measurements in the field. In recent decades, "radiometric fingerprints" and other geochemical tracers associated with sediment have been used to separate overland (field) erosion from non-field erosion (stream banks, bluffs, ravines, gullies). A sediment budget is a mass balance – not unlike a checkbook – in which the difference between inputs and outputs must equal any changes in storage.

Findings

1. Most of the sediment delivered to Lake Pepin is delivered from the Minnesota River Basin, and the rate of this supply has increased ten-fold over the past 150 years.
2. Some subwatersheds contribute most of the sediment to the Minnesota River.
3. Sediment sources within tributaries, including those with large sediment yield, are not evenly distributed.
4. In order to direct restoration efforts, it is necessary to determine not only the regions that contribute the most sediment to the Minnesota River network, but also the specific location and mechanism by which sediment is introduced.
5. Changes in sediment storage along the Minnesota River influence sediment delivery at the mouth.

Ongoing research

More research is necessary to better understand sediment sources in the Minnesota River Basin: Monitoring of Total Suspended Solids loads, gauging upstream and downstream of incised portions, sediment budget for LeSueur River watershed, inventory of ravines and bluffs, use mass balance to reconcile erosion estimates from different methods, develop sediment budget for mainstem, research roles of climate versus land use changes, explore role of artificial drainage impact on hydrology.

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