Sedimentation Processes in an Impoundment, Union Lake, New Jersey

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ABSTRACT / A small (3.75 km²) impoundment, Union Lake, on the Maurice River in southern New Jersey contains fine-grained sediment and organic material being transported through the surface water system. Sedimentation is slow, and rates calculated from ^137Cs-dated cores indicate a decrease through time from 2.6 mm/yr to 0.57 mm/yr. Sediment from shallow areas (<3 m) consists of winnowed pre-impoundment fluvial sand, whereas sediment from deeper areas (>3 m) is composed of diatoms, organic matter, and silt- and clay-sized mineral grains. Sediment distribution is controlled by water moving from the river entrance southward toward the outlet and by wind-generated water motion from shallow areas fringing the shore toward deeper portions of the impoundment.

Introduction

Lakes comprise only 1% of the earth's continental surface (Collinson 1978), yet they have long interested man because of their economic, recreational, and aesthetic values. During the past century, increasing urbanization and industrialization have resulted in the pollution and consequent deterioration of many once pristine lacustrine systems. In many cases, human activities have resulted in increased rates of eutrophication, thereby accelerating the natural "life" cycle which most lakes exhibit.

Awareness of the problems created by human activity has sparked research into the impact of industrial, agricultural, and municipal pollutants on lacustrine systems. Lakes act as sinks for the fine-grained sediment, organic matter, and associated pollutants that are transported into the lake in suspension. Pollutants are typically associated with clay minerals, organic complexes, and metal oxides coating detrital grains. Thus, in any given drainage basin, the sediments deposited in lakes will be useful indicators of the pollution history of the basin (Meyers and Takeuchi 1981).

Impoundments (artificially damned lakes) are a product of man's continued encroachment on the environment. Impoundments impede drainage, creating shallow lakes and sluggish rivers fringed by swamps. Sediment load of the river is decreased and the swamps contribute to the organic load. Little is known about the physical processes in impoundments, particularly how the intensity of processes may differ from more commonly studied natural lakes.

This study examines the limnology and sedimentology of a small (3.75 km²) impoundment (Union Lake) located on the Maurice River in southern New Jersey. This system has been under investigation by the New Jersey Department of Environmental Protection in order to assess the extent of arsenic pollution in the drainage basin. The data indicate that arsenic contamination extends from a point source 10 km above Union Lake to Delaware Bay (Fig. 1). Arsenic concentrations measured in the water of the Maurice River and its tributaries ranged from 1 µg/l to 32,000 µg/l, whereas the lake water exhibited arsenic concentrations between 52 and 57 µg/l. River bottom sediments sampled throughout the watershed ranged from 1 ppm to 21,160 ppm, whereas Union Lake sediments revealed total arsenic concentrations from 2 ppm to 166 ppm (J. Charles, unpublished data). Results of the study examining fate and transport of arsenic within the Maurice River system are presently being used in litigation procedures and will be published separately.

The goals of this paper are to describe the physical limnology of an impoundment, Union Lake, to determine processes and pattern of sediment dispersal and to estimate the present sedimentation rate.

Study Area

The Maurice River drains 995 km² (Rooney 1971) of low-relief topography developed on gently dipping unconsolidated sediments of the New Jersey Coastal Plain. The Maurice is a small meandering river (mean annual discharge = 4.64 m³/sec) which is tidal in its lower reaches, from Delaware Bay to Union Lake, a distance of 39 km (Fig. 1). Eleven impoundments block drainage in the tributaries above Union Lake, creating additional sediment sinks and thus reducing total sediment load passing through the system.

Union Lake was created in the late seventeen hundreds when a dam was erected across the Maurice River (Elmer 1869). In 1868, a second dam was built downstream of the first, thereby raising the water level of the lake and increasing the area of the impoundment to its present size (Mulford 1941). Although Union Lake once supported industries and has been a water supply, it is now used primarily for recreational purposes (Fig. 2).

Union Lake occupies an elongate, irregularly shaped basin...
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Figure 1. Location map of Union Lake, a major impoundment on the Maurice River, southern New Jersey.

Figure 2. An aerial photograph of the dam and southern third of the impoundment. Maurice River below dam is tidal.

with an axial orientation of N18.5°W. The Maurice River is the lake's most important inflow, entering at the northern end. The lake is 4.4 km long and its maximum breadth is 1.43 km. Maximum depth is 8 m, located directly behind the present dam (Fig. 3), and the volume [calculated by the method of Cole (1979)] is 0.01 km³ (2.64 × 10⁹ gal). Based on the volume of inflow (calculated from mean annual discharge of the Maurice River) and the capacity of the impoundment, the mean residence time is 28 days.

The configuration of a gradual deepening basin toward one shore (dam) is typical of most impoundments and is in contrast with natural lakes in which the deep areas are centrally located (Horowitz 1980). Water-level fluctuations are minimal because outflow occurs over the spillway as opposed to an outlet located at the base of the dam.

Methods

Field Methods

A bathymetric survey of Union Lake was conducted along closely spaced traverses in August 1980, using a Raytheon Survey Fathometer (DE719B). A bathymetric map was constructed and utilized in calculating morphometric parameters.

A total of 25 bottom sediment samples were collected using a Dietz-LaFond grab sampler. Thirteen cores (diameter = 5.1 cm) of bottom sediments were collected by divers during the summer of 1980. Suspended sediment samples were collected