The effect of commercial and recreational traffic on the resuspension of sediment in Navigation Pool 9 of the Upper Mississippi River

Miles M. Smart13, Ronald G. Rada1, Dennis N. Nielsen[2] & Thomas O. Claflin1
River Studies Center, Department of Biology, Cowley Ha 11, University of Wisconsin-La Crosse, La Crosse,
WI 54601, U.S.A.
[2] Department of Geology, Winona State University, Winona, Minnesota, U.S.A.
[3]*Present* address. Carolina Power and Light, Co., Harris Energy and Environmental Center, Rt. 1, Box 327,
New Hill, NC 27562, U.S.A.

Abstract

This study was conducted to determine some effects of commercial and recreational traffic on the resuspension of sediment in Navigation Pool No. 9 of the Upper Mississippi River. Fifty commercial vessel passages were examined at five different main channel locations and at side channels that were adjacent to each of the main channel locations. Sixteen recreational vessel passages were examined at one main channel location and its adjacent side channel and at a channel located in the backwaters. The backwater channel was not directly influenced by navigation in the main channel. Changes in total non-filterable residue (TNFR) and average particle size of suspended silts were used to assess some effects of navigation. Seventy-eight percent of the commercial vessel passages resulted in significant increases of TNFR and/or average particle size in the water column. In the main channel, TNFR increased from 3.4% to 15% above ambient levels; in the side channels, increases ranged from 2.5% to 2 1.7%. The average diameter of the resuspended silts increased by 0.21 to 2.34 µm. In the main channel, 50% of the recreational vessel passages caused increased TNFR and all passages increased average particle size. In the backwater channel, all of the recreational passages caused increases in TNFR and average particle size. Total resuspended sediment transported downstream ranged from an estimated 0.82 to 1015.7 mTons/passage in the main channel for commercial vessels, 0.39 to 0.64 mTons/passage in the main channel for recreational vessels, 0.22 to 28.12 mTons/passage in side channels due to commercial vessels in the main channel, and *0.54* to 2.08 mTons/ passage in the backwater channel for recreational vessels. Bed-sediment composition, location of the vessels in the channel, channel geometry, the number of successive passages, and vessel speed were identified as factors that affected the magnitude of the resuspension.

Introduction

The Upper Mississippi River has been impounded into a series of navigation pools that are essentially controlled by reservoir dynamics under normal conditions rather than by open-channel flow. The upper reaches of each pool are typified by free-flowing channels with associated backwater consisting of active, braided channels. The middle reaches are dominated in offchannel areas by wetlands, while lower portions are characterized by shallow, open waters contiguous with the main channel.

Non-channel areas of the river are supplied to various degrees with water and sediment from the main channel. The supply of water and sediments is generally a function of total river discharge, upstream sediment loadings, slope of the pool and the geometrical configurations of the side channels within a pool. There is an active interchange between the main channel and backwater areas as a result of the flow patterns. A balanced supply of Sixteen recreational passages were also examined. Sampling transects were at Ml and SI in the main channel and at a channel located in the backwaters (hereafter termed a backwater channel). The backwater channel was not directly influenced by navigation in the main channel.

Vessel speed was established by measuring the time of passage for each vessel for a specific distance through a 30° angle that was measured from the observation point. The distances were determined with a 0.5-in rangefinder, and the distance travelled by the tow through the angle was determined using the law of cosines.

Four sampling boats were used to obtain the data. Three boats were aligned on a perpendicular transect across the main channel and the fourth boat was centered in a side channel immediately downstream from the main channel transect. After each vessel passage, a boat was positioned directly in the sailing line of the vessel, and two boats were positioned on either side of the center boat and inside of the main channel navigation buoys.

Prior to sampling, current velocity measurements were made with a current meter at several locations along each main channel and side channel transect by the standard three-point method (0.2, 0.6 and 0.8 of the total depth; USGS 1969a).

The sampling regime included the collection of triplicate background samples by each of the four sample boats at the beginning of each day. If background samples were not collected prior to vessel passage, they were collected at least four hours after the passage of any commercial vessels i.e. after TNFR had returned to ambient levels. The sampling period for each passage event was initiated simultaneously by all boats when the leading edge of the vessel crossed the transect line. Radio communication was used to coordinate sampling, and stopwatches were used to ensure synchronous sampling times. After commercial vessel passage (time 0), samples were collected at the following times: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 35, 40, 45*,* 50, 55*,* 60, 70, 80 and 90 min. Sample collection after recreational vessel passages followed the same protocol as above. However, sampling ceased after 35 mm. because the river returned to ambient conditions more quickly. Depth-integrated suspended sediment samplers (Model DH76, US Army Corps of Engineers) were used to collect samples for all passages.

Total non-filterable residue (TNFR) was determined according to APHA (1980). Triplicate analyses were conducted on at least 10% of the samples. The average percent coefficient of variation for TNFR was 5.3%. TNFR was chosen as the primary variable to assess the effects of vessel passage on the resuspension of sediments. The advantages of TNFR over other methods of evaluating resuspension (e.g. turbidity) are that TNFR quantities measure mass of suspended solids. TNFR provides an accurate, direct estimate of the total weight of the suspended sediments and can be used more reliably than turbidity to calculate mass transport (Allen, 1979).

Mass transport was estimated by multiplying the average TNFR concentration by the average discharge for each time interval and then summing over the duration of the event. The volume occupied by the resuspended sediments was calculated by assuming that the sediment had an average density similar to quartz.

Particle size analyses were conducted for each passage. Traditionally, particle size analyses of suspended sediment required the use of pipette techniques for silt- and clay-size grains, and sieving or visual accumulation tubes for sand-size grains (USGS, 1969b). The pipette method requires the use of large amounts of sediment (1.0 to 5.0 g of silt and clay) below which accuracy decreases appreciably (USGS, 1969b). Visual accumulation tubes can be utilized only for sand-sized grains and require a minimum of 0.5 g. These techniques work reasonably well when suspended sediment concentrations are great enough to provide the minimum amounts of sediment necessary for particle size analyses. In Pool No. 9 and most of the Upper Mississippi River, however, a composite of ten or more 1-liter samples would have been required from each sampling boat to provide enough silt and clay for one particle size analysis using conventional pipette techniques. Instead, a laser particle counter was used (Model ILI 1000 Prototron Particle Counter; Spectrex Corporation, Redwood City, California). This instrument is capable of in-situ counting and measuring of suspended particles that range in size from I to 100 m m. Because of the non-spherical shape of clays (particles <4 m m), we used the laser technique to count and size only silt particles (4—64 m m). Therefore, all data on sediment particle size refer only to silt.