THE INFLUENCE OF HYDROLOGICAL CONDITIONS ON DISSOLVED AND SUSPENDED CONSTITUENTS IN THE MISSOURI RIVER

JOSEPH J. DELFINO

Laboratory of Hygiene, University of Wisconsin, Madison, Wis., U.S.A.

and

DAVID J. BYRNES

Western Illinois University, Macomb, Ill., U.S.A.

(Received 25 April; in final form 23 June, 1975)

Abstract. Physical and chemical constituents of the Missouri River near Brownville, Neb. U.S.A. were studied during the period May, 1970 through December, 1972. Considerable variation in river discharge was observed. The changing hydrological conditions affected the concentrations of both the dissolved and suspended constituents in the river. Rain and snowmelt runoff increased the river discharge and also contributed to increased turbidity and total suspended solids. A number of parameters including total phosphorus, total organic nitrogen, oxygen demand and certain metals correlated with increased suspended solids. However, most of the major anions and cations measured showed decreased concentrations as a result of increased river discharge.

1. Introduction

The water quality of major rivers of the United States has been a topic of interest to aquatic scientists for some time. Reviews of extensive studies are available which demonstrate correlations of water quality variables with hydrological conditions for various parameters (Wolman, 1971; Livingstone, 1963). Some governmental agencies such as the United States Geological Survey (USGS) maintain river monitoring stations throughout the U.S.A. and provide compendia of data which list the results of composited water analyses along with mean river discharge data (USGS, 1970). In this paper, certain field observations and computed correlations are presented, based on data from a 3 yr period of continuing studies designed to establish the natural characteristics of a stretch of the Missouri River near Brownville, in southeastern Nebraska, U.S.A. The data are provided to illustrate the extreme variability of chemical composition in the Missouri River and to provide further input parameters for those interested in geochemical transport phenomena and water quality modeling in rivers.

2. Background

The Missouri River is over $3.68 \times 10^3$ km long and drains approximately $1.35 \times 10^6$ km$^2$, representing about 16% of the total area of the U.S.A. (Berner, 1951). A large portion of the Missouri River Basin is composed of plains and prairies underlain by sedimentary rock formations consisting of clays, shales, silts, sands and sandstones.
The study area in southeastern Nebraska is basically an agricultural region characterized by principal land uses for crops (70%) and pasture and livestock ranging (16%) (MBIAC, 1971). Annual precipitation ranges between 75 and 100 cm.

The Missouri River exhibits wide variations in seasonal discharge. Melting snow causes a seasonal discharge pulse during the early spring thaw with a secondary rise shortly thereafter due to the appearance of snowmelt runoff that originated in the mountains and high plateaus. Lower discharges occur throughout the remainder of the year except for rapid rises of short duration in summer and autumn brought on by occasional heavy rains and flash floods in the lower basin (MBIAC, 1971). The river has been impounded and channelized throughout almost its entire length to help regulate the river by smoothing maximum and minimum discharges and to stabilize the flow within permanent banks (Morris et al., 1968). The area encompassed by this study has been completely channelized.

3. Methods

Samples were collected on a seasonal basis (May, July and October) in 1970 and 1971 and on a monthly basis (May through December) in 1972. Non-metallic 6 l samplers (Van Dorn or Kemmer design) were employed to collect samples from 1 m below the surface of the water. Sampling sites were established in midchannel between Missouri River Milemarkers 526 and 534 near Brownville, located about 96 km downstream from Omaha, Neb. The USGS operates a river gaging station at Nebraska City which is approximately 48 km upstream from the study area and the river discharge data reproted here were provided by that facility.

Chemical analyses were performed according to standard techniques (APHA et al., 1965, 1971; EPA, 1971). Samples were preserved, placed on ice, transported to the laboratory and analyses initiated within 48 h: temperature, dissolved oxygen, pH and turbidity measurements were completed on site or measured in situ. A quality assurance program was employed to check the applicability of the procedures used and to document the validity of the data acquired (Delfino et al., 1974). The chemical water quality of this 12.8 km stretch of the Missouri River was generally homogeneous on each sampling date so that discrete data from various sampling sites were combined into a mean value for each date. Since there were only three sampling dates in 1970 and 1971 and eight dates in 1972, an annual mean was calculated only for the period May through December 1972. However, the range (minimum and maximum values) for each parameter during the full study period (May, 1970–December, 1972) was identified for reference purposes. The data are listed in Tables I and II. The complete data have been presented in technical reports (Industrial BIO-TEST Laboratories, 1971, 1972, and 1973).

4. Results and Discussion

A. RIVER DISCHARGE

The variable hydrological conditions observed during the study are illustrated in Figure 1. The mean annual discharge was lowest in 1970, increased during 1971 (the