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Project Summary

Fate, Transport, and Transformation of Toxics: Significance of Suspended Sediment and Fluid Mud

Maynard Nichols, Richard Harris, Galen Thompson, and Bruce Nelson

This research sought to determine the distribution of selected metals in suspended material and fluid mud, to identify potential zones of toxic accumulation, and to trace their transport routes.

Between March 1979 and April 1980, observations of flow, salinity, suspended material, pH, and dissolved oxygen were made in Bay-wide longitudinal sections, and at four anchor stations in the Northern Bay. The observations covered a range of conditions, including seasonal high and low river discharges, sediment influx, neap-spring tide range, and oxygenated-anoxic water. Samples of suspended material, fluid mud, and bed sediment were analyzed for particle size, organic matter, and metal content.

Metal concentrations of As, Cu, Mn, Ni, Pb, Sn, and Zn in fluid mud and bed sediment, per gram of material, decrease seaward from a maximum in the Baltimore-Susquehanna River area. The concentrations of metals Mn, Pb, and Zn are four to six times greater than Fe-corrected average shale, indicating major human input, and significant accumulation in this zone.

Metal concentrations of Cd, Cu, Pb, Ni, and Zn are maximal in surfacesuspended material from the central Bay. They are higher than landward near-potential sources, and they exceed concentrations in bed sediment two to 80 times. The enrichment is not natural compared to average shale or plankton; it is most likely created by bio-accumulation.

Transport of particle-associated metals from major sources follows either hydrodynamic pathways leading to particle accumulation by the estuarine circulation or bioecological routes leading to bio-accumulation.

Management and monitoring strategies are provided to reduce potentially toxic metals to acceptable levels and warn management agencies of toxic hazards.

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This Project Summary was developed by EPA's Chesapeake Bay Program, Annapolis, MD, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Each year, a substantial load of trace metals enters Chesapeake Bay, from both natural and human sources. Regional production of toxic metals is increasing with increasing industrial activity and sewage discharge. At least half of all cadmium (Cd), lead (Pb), copper (Cu), and chromium (Cr) reaching the Bay results from sewage and industrial waste. Although low concentrations of metals are important to environmental quality of the Bay, there is cause for concern if concentrations are excessive. Toxic effects have not been demonstrated, but disturbing changes in the Bay environment have been observed: a decrease in oyster and striped bass populations, a lack of shad runs in the upper bay, and declining clam catches. Knowledge of contamination levels, transport routes, and reservoirs of potential contaminants is necessary because toxicants may alter the quality of the Bay over periods of time.

This study investigates the role of suspended sediment and fluid mud in the fate of toxic metals in the Chesapeake Bay system. Fluid mud, an intermediate stage between mobile suspended material and mud, is chemically important because it is a reservoir for potentially toxic metals and a medium for chemical transfer.

Procedure/Methodology

A series of field observations defined the Bay-wide distribution of metal contaminants in the following way: suspended material was collected for analysis of toxic metals; water in which the metals occur was characterized; and sediments with which metals associate were analyzed for particle size and physical properties. Temporal variations of sediment and metal loading were established, and potential zones of metal accumulation and their transport routes were identified. Field observations included contrasting conditions such as seasonal high-low river discharges and sediment influx, neap-spring tide range, and oxygenated-anoxic water differences. A survey of 122 stations, identifying these variables, and recording the parameters of temperature, salinity, dissolved oxygen, pH, and total amounts of suspended material, resulted in 5576 measurements, including analyses of six to 11 metals.

Bed sediment and fluid mud were obtained with a stainless steel Smith-MacIntyre* grab or Bouma box core. Suspended materials collected on Nuclepore filters were analyzed by flame atomic absorption for iron (Fe), manganese (Mn), and zinc (Zn). Flameless atomic absorption was used to obtain concentrations of arsenic (As), cadmium (Cd), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and tin (Sn).

Results and Conclusions

The maximum turbidity zone (stations 12 to 18) contains high suspended loads, fine particle size, and low organic carbon percentages. Low suspended loads, coarse particle size, and high organic percentages are common to the central Bay zone (stations eight to 11); stations one to seven, representing the near-entrance reaches, have intermediate suspended loads, moderate particle size, and moderate organic percentages. Conditions in the deeper portions of the central Bay region favor accumulation of metals and fluid mud because of fine-grained, moderately organic sediments which deposit rapidly.

Metal distributions in suspended material are vertically stratified, with mean-surface and mid-depth concentrations greater than near-bottom depths. Cd, Cu, and Pb of surface and mid-depth waters are three to 12 times higher in summer than in spring. Concentrations of Cd, Cu, Pb, Ni, and Zn are maximal in surface suspended matter from the central Bay, suggesting bio-accumulation of metals from distant sources.

Bay water is well-buffered against pH change and is oxygenated, except in summer when near-bottom water of the central Bay (below 10 m depth) is anoxic. Also, time, depth, and distance seaward are conditions which affect physical, chemical, and sedimentologic rates of transport and accumulation of toxics.

Recommendations

By dealing with Chesapeake Bay as an entity, the state of the Bay can be improved by reducing input of such potentially toxic metals as Cd, Cu, Ni, Pb, and Zn from wastewater and industrial discharges. Nutrients which stimulate organic production should be reduced to alleviate the suspended solids load, of which some 40 to 60 percent is composed of organic material. Entrapment of river-borne sediment can be deterred by regulating inflows during periods of high sediment influx.

Potentially toxic metals should be managed by controlling them at their sources, by learning the long-term changes and "far-field" effects in zones of accumulation, by recognizing *amounts of toxicants in the system* which are above natural levels, as well as the associations between metals and sediment. A monitoring system of the Bay and its tributaries, with a scientific data base, should be established to warn Bay managers of toxic hazards. Research should consider such factors as bio-accumulation of toxics in plankton, the significance of repetitive sediment resuspensions, and the role of tributaries as sinks or sources of metals and sediments.

*Mention of tradenames or commercial products does not constitute endorsement or recommendation for use by the U S Environmental Protection Agency.

Maynard Nichols, Richard Harris, Galen Thompson, and Bruce Nelson are with the Virginia Institute of Marine Science, Gloucester Point, VA 23062.
***Duane Wilding** was the EPA Project Officer (see below for present contact).*
The complete report, entitled "Fate, Transport, and Transformation of Toxics: Significance of Suspended Sediment and Fluid Mud," (Order No. PB 83-116 426; Cost: $13.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
*For information contact **David Flemer** at:*
Chesapeake Bay Program
2083 West Street, Suite 5G
Annapolis, MD 21403

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