United States
Environmental Protection
Agency

Environmental Research
Laboratory
Narragansett RI 02882

Research and Development

EPA-600/S3-81-050 Mar. 1982

EPA

Project Summary

Nearshore Marine Trace Metal Geochemistry

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This publication summarizes a number of studies aimed at understanding several aspects of the nearshore geochemistry of trace metals which give information on consequences of trace metal pollution attending nearshore waste disposal.

The studies included the distribution of dissolved and particulate trace metals in the Hudson River Estuary; pore water nutrient, carbon and metal geochemistry in Narragansett Bay; trace metal adsorption in Narragansett Bay sediments; and benthic fluxes of transition metals out of Narragansett Bay sediments.

The key findings are that dissolved Mn, Ni, Cu, Cd and Zn tend to remain dissolved during passage through an estuary; that reducible metals (Mn and Fe) are released at rapid rates from reducing estuarine sediments; and that other divalent cations forming insoluble sulfides are sequestered in reducing nearshore sediment pore waters.

This Project Summary was developed by EPA's Environmental Research Laboratory, Narragansett, RI, 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

The disposal of wastes at a nearshore site may affect the environment by introducing heavy metals (among other pollutants) at subtoxic and toxic levels. Since certain wastes (notably sewage plant effluent, sewage sludge, and dredge spoils) have high metal concentrations, pollution of the affected environment is likely, and it is important to assess the impact of this pollution on the ecosystem. There are three steps to such an assessment: determining the fate of a pollutant metal, determining which metal species (i.e., free ionic, organically bound, particulate, etc.) have deleterious biological effects, and determining the deleterious effects of different metal concentrations.

This study has been concerned with understanding the fate of manganese, iron, nickel, copper, cadmium and zinc in the estuarine and nearshore environment. In particular, three central issues have been addressed: 1) how these metals are partitioned between the dissolved and particulate phases, 2) to what extent they are removed from the water column into sediments, in the nearshore environments, and 3) under what conditions these metals are released from sediments.

A related problem was also addressed. Benthic nutrient regeneration is a major source of nutrients to nearshore waters. The dumping of polluted solids into these waters may, by impacting the benthic community, decrease the benthic fluxes of nutrients and lower the fertility of the overlying waters. The study results give insights into the question of whether nearshore dumping is likely to be a problem in this respect.

Conclusions

Estuarine conditions vary greatly as a function of season, fertility (i.e., bloom vs. non-bloom conditions), and river runoff. There are also major variations from one estuary to another. Hence caution must be used in extrapolating results from this study of two estuaries, concentrating on summer conditions, to other seasons and systems.

The results reveal that about half of the dissolved copper, and more than half of the dissolved nickel, cadmium and zinc, entering the Hudson River at the harbor remain in the dissolved form until removed from the estuary by advection (water flow). Thus it is clear that adsorption, salting out, and other processes do not purify the water of these elements. They remain largely dissolved, presumably the state most toxic to organisms. On the other hand, the mass balance could not be done well enough to rule out the possibility that up to half of the dissolved nickel, cadmium, and zinc entering the Hudson accumulates in sediments. In the case of copper, data show that about this fraction is removed from solution into sediments. Manganese is apparently slowly removed from nearshore waters by oxidation onto particulates. Where estuarine residence times are on the order of a month and temperatures are warm, most of the dissolved manganese will be removed into sediments.

The benthic flux of iron, manganese, nickel, copper and cadmium out of anoxic nearshore sediments is consistent with the relative solubility of these metals in oxic and anoxic environments. Apparently as a result of insoluble sulfide formation, nickel, copper and cadmium have low pore water concentrations and are released at low rates to the overlying waters. Manganese and iron have high concentrations in anoxic pore waters. They are rapidly released, although iron, which is very quickly oxidized in bottom water, shows a low net flux. These results suggest that release of nickel, copper, cadmium and other metals from dumped dredge spoils can be minimized by disposal of spoils under low energy, high productivity waters.

Nutrient benthic fluxes at highly polluted and relatively clean Narragansett Bay sites are similar, indicating that pollution does not inhibit benthic bacterial decomposition and nutrient regeneration.

Recommendations

With regard to preventing toxic metal release, the best type of nearshore environment for dumping dredge spoils and metal rich wastes are low energy environments underlying productive waters. The low energy will obviate sediment dispersal, and the high productivity will supply biogenic debris and insure maintenance of a reducing environment in which most heavy metals are sequestered within sediments. Polluted sediments are likely to be at least as highly reducing as clean sediments at a potential dump site. Thus a site where sediments are currently anoxic very near the interface (certainly within the top centimeter) would appear to be suitable for dumping.

The conclusions are based on very limited sampling and must be tested by more field work on pore water chemistry and metal benthic fluxes.

The effect of pollutants on benthic nutrient regeneration has not been adequately considered. While these results do not indicate that this is a problem, the possibility should be evaluated by more extensive work.

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The complete report, entitled "Nearshore Marine Trace Metal Geochemistry," (Order No. PB 82-109 372; Cost: $11.00, subject to change) will be available only from:
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☆ U S GOVERNMENT PRINTING OFFICE, 1982 — 559-017/0703