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DEPOSITION OF INORGANIC AND ORGANIC PHOSPHORUS IN MARYLAND IN MARYLAND TIDAL MARSHES: A PRELIMINARY ANALYSIS

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INTRODUCTION

The environmental degradation of Chesapeake Bay is thought to be the result of excess nutrient inputs, primarily'nitrogen and phosphorus. The major sources of these nutrients include diffuse and point-source inputs from the watershed, atmospheric deposition, and phosphorus inputs from the coastal ocean (Boynton et al. 1994). The long-term burial of phosphorus in subtidal sediments is the ultimate fate of virtually all of the phosphorus inputs, and fluxes to subtidal sediments have received considerable attention. Chesapeake Bay tidal marsh sediments also retain phosphorus, although the form and burial rate of phosphorus have not been examined prior to this study. This study seeks to determine the relative importance of tidal marsh sediments in nutrient retention by examining deposition in three National Estuarine Research Reserve sites included in northern Chesapeake Bay. If tidal marsh sediments are an important sink for nutrients, their proper management in the Chesapeake Bay area is critical to the Bay's ecology.

Our approach to determining the rate of nutrient burial in northern Chesapeake marshes involves the dating of cores using ^{210}Pb techniques to estimate sedimentation rates and the measurement of nutrient concentrations in vertical core profiles. While we have determined the concentrations of phosphorus in numerous cores, the quantification of burial rates awaits completion of ^{210}Pb dating. In this paper, we show the concentrations and forms of phosphorus buried in several different marsh sites, including Patuxent River, Monie Bay, and the Choptank River. The importance of tidal marshes to phosphorus retention examined relative to the total inputs of phosphorus to the system. An earlier study of Choptank River marshes lead to the rough estimate that 5 - 10% of phosphorus loading from atmospheric and watershed inputs was retained in marsh sediments (Stevenson 1991).

This study of phosphorus deposition in Chesapeake Bay marshes includes all three National Estuarine Research Reserve System (NERRS) sites. The Monie Bay site is located on Maryland's Eastern Shore, in Somerset County (figure 1). The marsh system consists of three main tidal creeks draining agricultural and undisturbed watersheds. The salinity ranges from 0-17 ppt (Cornwell et al. 1990, 1994) with vegetation dominated by *Spartina alterniflora*. Much of the nutrient input to this system is the result of drainage from surrounding agricultural fields. Ward et al. (1988) have shown that this marsh system experiences marsh loss from a rise in sea level .

Jug Bay is located on the Patuxent River in Anne Arundel County, Maryland. The research reserve is predominantly freshwater, with maximum salinities reaching only 0.5 ppt in late summer (Swarth and Peters 1993). Vegetation at our sampling sites included *Nuphar* spp. (spatterdock) and *Peltandra Virginica* (arrow arum). As in other tidal fresh marshes, the vegetation at this site is lost from the marsh surface in the winter months, potentially promoting nutrient loss from the system by erosion.

Otter Creek is located just north of Baltimore, Maryland on the Bush River. The watershed surrounding the marsh is heavily developed. Plant

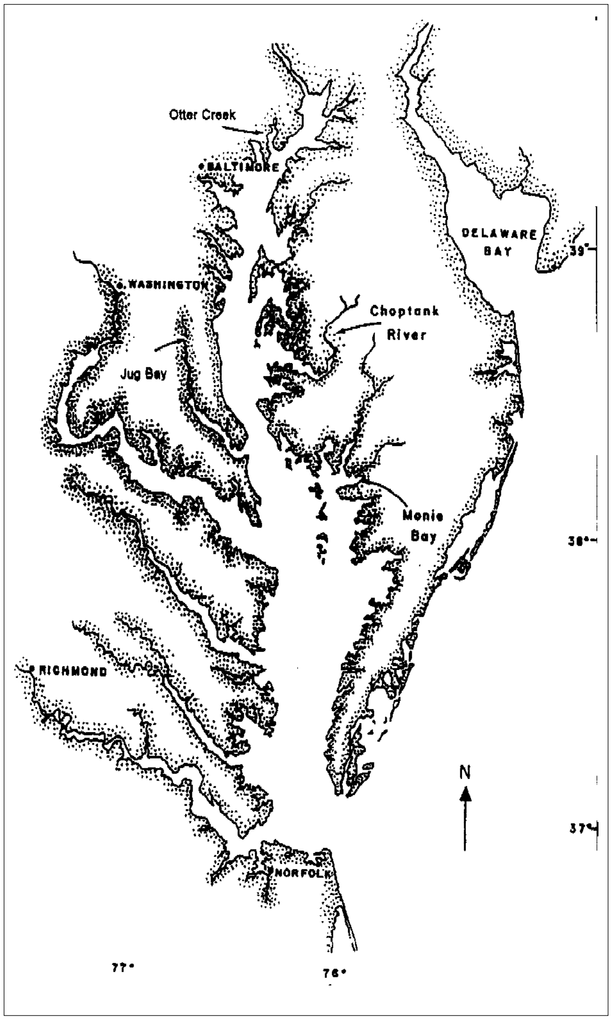

Figure 1. Study site locations on Chesapeake Bay.

communities here show little sign of physical disturbance and include *Typha* spp., P. virginica, *Nuphar* spp. and *Pontederia cordate* (pickerel weed). Salinities at this site range reach a maximum of 3 ppt. Sampling of this site commenced during the summer of 1994.

The Choptank River is the largest tributary on the Eastern Shore and drains mostly agricultural and forested watersheds and was sampled in 1991 for marsh nutrient concentrations. Cores were collected from three sites in the upper Choptank River and three sites in a marsh at the Horn Point Environmental Laboratory. This system has experienced elevated inputs of nitrogen and phosphorus from nonpoint sources, primarily agriculture (Stevenson et al. 1993). Salinities at the sites range from 0 to 15 ppt, depending on location.

METHODS

A McAuley corer was used to sample the sediments (Bricker et al. 1989). Cores were extracted and immediately divided into 3 or 5 cm samples to a depth of 1 meter. Samples were placed on ice and returned to the laboratory where they were dried at 65°C and ground with a ceramic mortar and pestle.

Total phosphorus was determined by ashing the sediments at 550°C and extracting phosphorus with HCI (Aspila et al. 1976). Inorganic phosphorus was measured in the same manner, using an unashed sample. Organic phosphorus was estimated as the difference between these two measurements. Inorganic phosphorus was determined in the extracts by colorimetry. Sediment burial mtes (g m^{-1} yr^{-1}) for six Monie Bay sites were taken from Ward et al. (1988) and P deposition rates were calculated as the product of the burial rate and the phosphorus concentration (mg P g/l) to detemine the overall retention rate of phosphorus on an areal basis. Future calculations will be based on ^{210}Pb.

RESULTS

All phosphorus profiles in this study show surface enrichment of organic and inorganic phosphorus (figure 2). Monie Bay organic phosphorus concentrations remain fairly constant with depth, and inorganic phosphorus concentrations

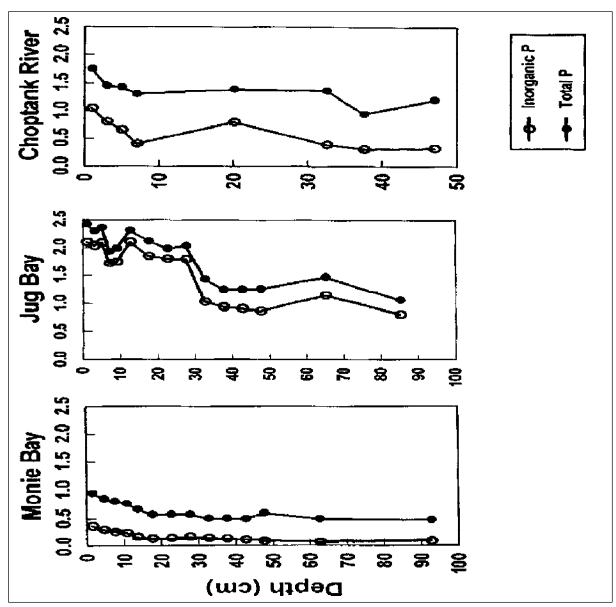

Figure 2. Depth profiles of total and inorganic phosphorus (mg g^{-1}). The Choptank River site is located at Windy Hill, an area of maximum turbidity on the river.

decrease with increasing depth of burial. Oranic phosphorus is the main phosphorus form at the Monie Bay site; the marsh appears to match sea-level rise by plant growth, rather than trapping of inorganic particulates. Cores from Jug Bay are similar to others from Patuxent River marshes (Zelenke unpublished data); these cores show a constant but small fraction of organic phosphorus. The source of phosphorus in these marshes is suspended inorganic matter from the Patuxent River drainage, The phosphorus concentrations in these sediments is strongly dominated by inorganic phosphorus, which decreases with depth. Sites along the Choptank River show relatively even distributions of organic and inorganic phosphorus throughout, with only small decreases in total phosphorus with increasing depth.

DISCUSSION

Controls on Phosphorus Distribution in Tidal Marsh Sediments

In all cores, we found a surface enrichment of phosphorus similar to that found in studies by Chambers and Odum (1990). This enrichment is most likely the result of postdepositional mobility of phosphorus as it moves with iron to the oxidized layer and precipitates with the iron oxides ($FeOOH\text{-}PO_4$). Phosphorus must be in a dissolved inorganic state (PO) to be absorbed by marsh primary producers. This would seem to indicate that organic forms of phosphorus would be more stable, and more strongly retained in sediments than would inorganic forms. However, inorganic phosphorus in the oxidized cap of sediments is strongly bound by iron, greattly reducing rates of transformation to biologically available dissolved forms. Organic storage of phosphorus depends on the growth of primary producers and the subsequent organic matter degradation, which can be limited by any number of factors (ie, nitrogen availability, solar radiation). If the overall storage capacities of tidal marsh sediments are to be determined, the difference between these two mechanisms of storage must be more clearly understood.

High variability in phosphorus forms has been observed in different marshes. Jug Bay sediments store mostly inorganic phosphorus. This is attributable to a combination of factors, including the high particulate load in the Patuxent River, and the export of much of the plant biomass during the winter months. Monie Bay phosphorus storage is mostly in an organic form, resulting from the low particulate inputs and the year-round presence of *Spartina alternifora*.

Fluxes of Phosphorus to Marsh Sediments

Early estimates of phosphorus burial in Monie Bay show that it does not play a significant role in the retention of phosphorus. Preliminary calculations show that only 0.27 g P m^{-1} y^{-1}, is buried, whereas a typical subtidal sediment of the Chesapeake Bay may retain 1.0 g P m^{-1} y^{-1} (Boynton et al. 1994). However, a study of marshes along the Choptank River found that the marshes retained more phosphorus than did the subtidal sediments, as shown in (figure 3) (Stevenson 1991). This contradiction exemplifies how little is known about the retention of phosphorus by marsh sediments. Early analyses of Jug Bay sediments indicate that accretion rates may be as high as several centimeters per year. Jug Bay marsh sediments are likely to provide important nutrient buffering in the Patuxent River. Management of tidal marsh ecosystems is becoming increasingly critical to their maintenance in Chesapeake Bay. Increasing our understanding of the relative importance of these systems will help ensure their proper management, Studies such as this one hope

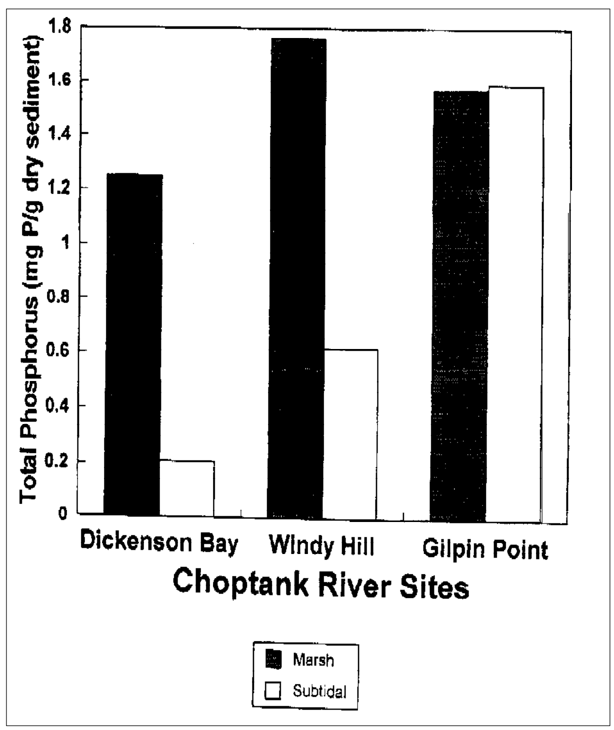

Figure 3. Choptank River phosphorus burial. Dickinson Bay is located

to clarify and quantify the role of tidal marsh ecosystems such as Jug Bay, Monie Bay, and Otter Creek in the phosphorus budget of the Chesapeake Bay.

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