Phosphate Geochemistry and Microbial Activity in Surface Sediments from the Conowingo Reservoir and Susquehanna Flats, MD: Summary of Findings

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The transport of phosphate is directly related to the transport of sediment. As part of preliminary evaluation of the feasibility of dredging Conowingo Reservoir on the Susquehanna River, Pa., a characterization study was initiated that included a description of phosphorus biogeochemistry in the reservoir. Analyses included determination of total phosphorus and interstitial water phosphate concentrations, and phase association of phosphate from sequential extraction data. In addition, an evaluation was made of the antibiotic sensitivity of *in situ* bacteria.

Three box cores were collected in May 2000. To provide data for comparison of the characteristics of sediment that has been transported beyond the dam with the characteristics of sediment retained behind the dam, a fourth box core was collected at the mouth of the Susquehanna River, Md., near Havre de Grace in August 2000. The box corer collects surface material to a depth of 20 cm (8-inches) without compactions of the sediment.

Sampling locations are shown in Figure 1.

Sampling sites and characteristics of samples:
(1) Near the shoreline of the reservoir north of Peach Bottom. The water was approximately 0.5 meter deep. Sediment was very sandy. Centrifugation of sediment did not yield interstitial water.
(2) In the channel of the reservoir across from Broad Creek. Water was approximately 6 meters deep.
(3) North of Conowingo Creek near the shoreline of the reservoir. Water was approximately 6 meters deep.
And in August 2000:
(4) East of Havre de Grace near Furnace Bay, close to the shoreline of the Susquehanna River. Water was approximately 4 meters deep.

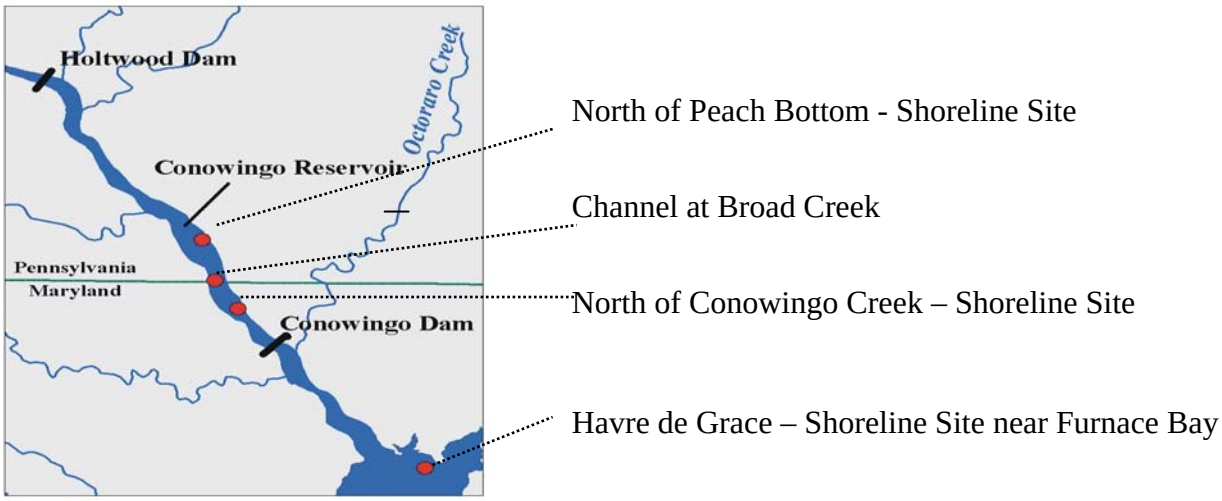


Figure 1. Map of Lower Susquehanna River showing Conowingo Reservoir and Sampling Sites.

Summary of the findings of this study.

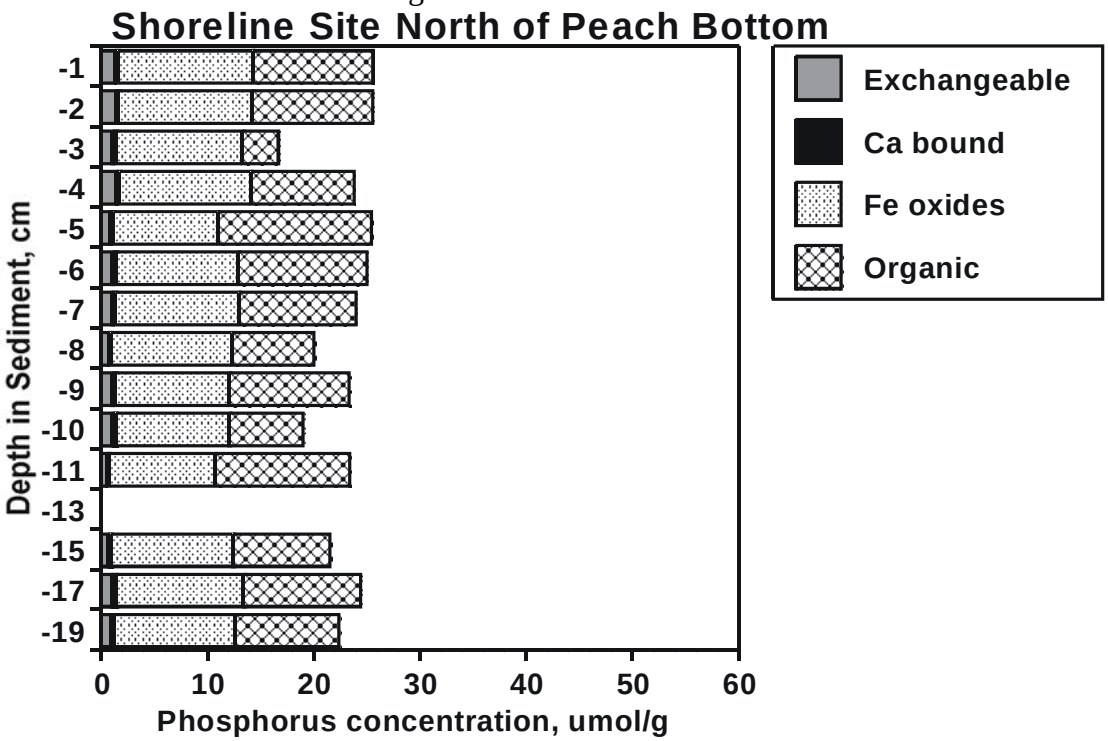
- Geochemical phase associations and total phosphorus concentrations in the bottom sediments of the Conowingo Reservoir vary with location.

Sequential chemical extractions of sediment can determine how much of the total phosphorus is bound in each geochemical phase (component) in the sediment. Different combinations of chemical solutions indicate slightly different distributions of phosphorus, so the sequential extraction data is said to be 'operationally defined'. Table 1 lists the geochemical phases identified in the sediments collected for this study as determined by sequential extraction of sediment using a modified version of the method of Ruttenberg (1992) and shows the ranges of the percent of the total phosphorus found in the four geochemical phases. Table 1 also gives the conditions under which phosphorus could be released to water from these solid phases.

Figures 2 and 3 show the concentrations of phosphorus in four geochemical phases determined in one-to two-centimeter sections of cores collected at each study site. A bar missing from the sequence is the result of a lost sample. The total phosphorus concentrations in the sediment are the sums of phosphorus associated with all geochemical phases in the sediment. Examination of the graphs shows that the concentrations of total phosphorus are smaller in the core collected from the site in the Susquehanna River past the Conowingo Reservoir and Conowingo dam (Havre de Grace near Furnace Bay) than in sediment from the channel site at Broad Creek or in the sediment from the shoreline site south of Conowingo Creek. Granular coal is present in all of the samples and visual inspection indicates that the sediment from the site north of Peach Bottom contains the largest amount. The granular coal obscures the composition of sediment transported into the reservoir.

Table 1. Geochemical Phases of Phosphorus in Sediment Samples Collected in the Conowingo Reservoir, Pa., and Susquehanna Flats, Md.	**Percent of Total Phosphorus**
Exchangeable phosphate (PO_4): Can be released to water if replaced by another anion	2 to 4
Calcium (Ca)-bound phosphate: Slow release of phosphate if mineral is soluble. Can be transported with suspended solids or formed in bottom sediment.	2 to 20
Phosphate sorbed to Iron (Fe) oxides: Iron oxides release phosphate when: (a) oxidized iron is reduced, Fe^{3+} to Fe^{2+} (b) when hydrogen sulfide produced by bacterial sulfate reduction precipitates iron, or, when sediment is exposed to acidic conditions.	30 to 60
Organic Phosphorus (P) Available when microbes degrade organic matter	30 to 70

- Iron oxide associated phosphorus is the principal geochemical phase in the bottom sediments collected at shoreline sites within the Conowingo Reservoir.



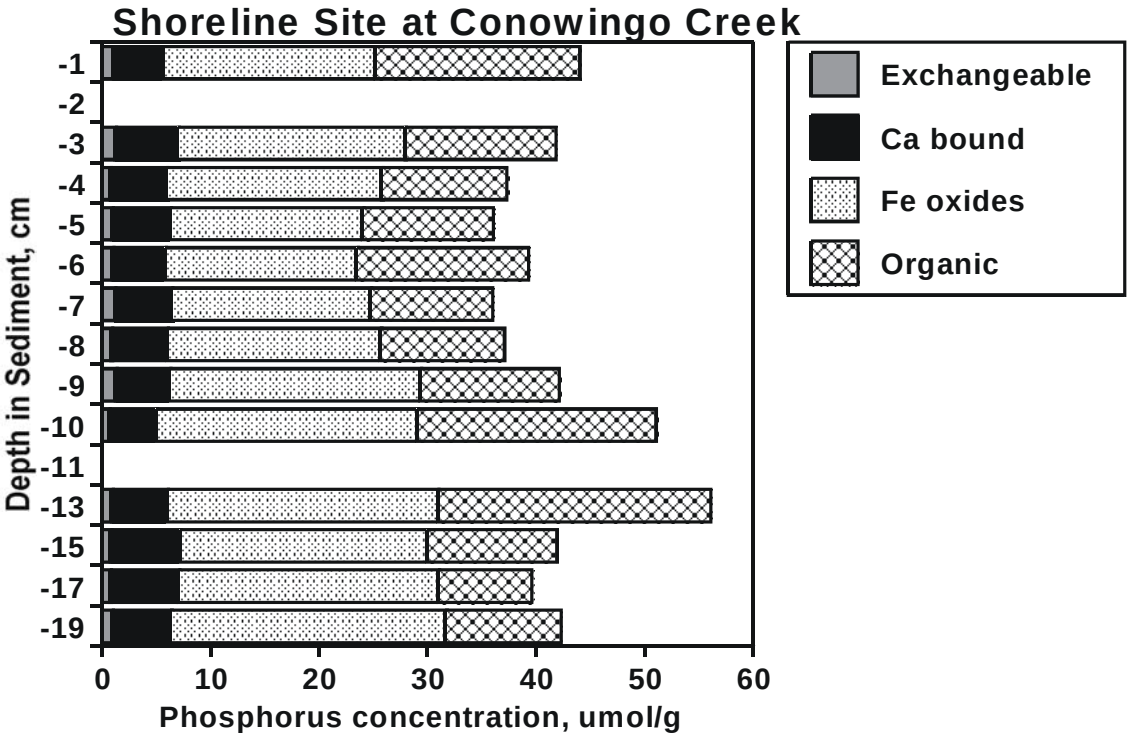


Figure 2. Geochemical Phases of Phosphorus in Sediment Cores Collected north of Peach Bottom and north of Conowingo Creek in the Conowingo Reservoir in May 2000.

- Both iron oxide associated phosphorus and organic phosphorus are important geochemical phases in bottom sediment collected in the channel of Conowingo Reservoir and in bottom sediment collected in the Susquehanna River. Some of the largest concentrations of organic phosphorus found in the samples collected for this study were those in bottom sediments from the channel of the Conowingo Reservoir.

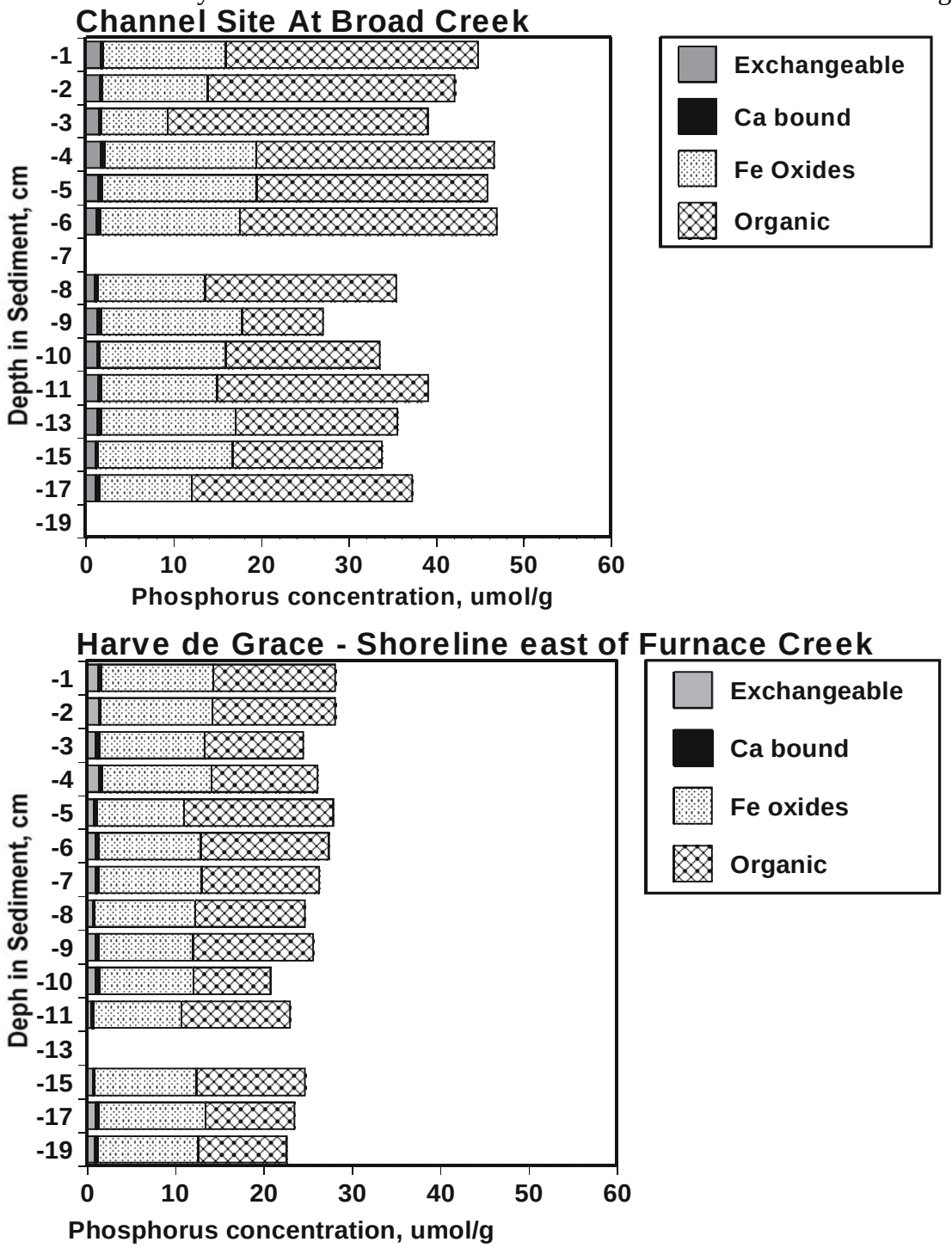


Figure 3. Geochemical Phases of Phosphorus in Sediment Cores collected in the channel of Conowingo Reservoir near Broad Creek and at a shoreline site in the Susquehanna River east of Havre de Grace in May and August 2000.

- The bottom sediments are not a source of dissolved reactive phosphate to the water column of the Conowingo Reservoir.

Water separated from the sediments (interstitial water) collected for this study contains small concentrations of phosphate. There is no increase in phosphate concentration in interstitial water with increase in depth from the sediment-water interface. A concentration gradient with increasing concentrations of phosphate with depth in the sediment indicates movement of dissolved phosphate toward the sediment-water interface and possible release of phosphate to the overlying water. The concentration profiles determined from interstitial water collected from the Conowingo Reservoir and Havre de Grace cores indicates that there is no release of phosphate by diffusive flux from the bottom sediments of Conowingo Reservoir or from the site near Havre de Grace which is in the Susquehanna River beyond the Conowingo Dam. Phosphate concentrations in interstitial water collected from a core taken in Susquehanna Flats approximately 10 kilometers south of Havre de Grace in 1973 are shown in with open circles in Figure 4. The concentrations of phosphate in the interstitial waters of the core collected near Havre de Grace in 2000 are smaller than the concentrations of phosphate in the interstitial waters of the core collected in Susquehanna Flats in 1973.

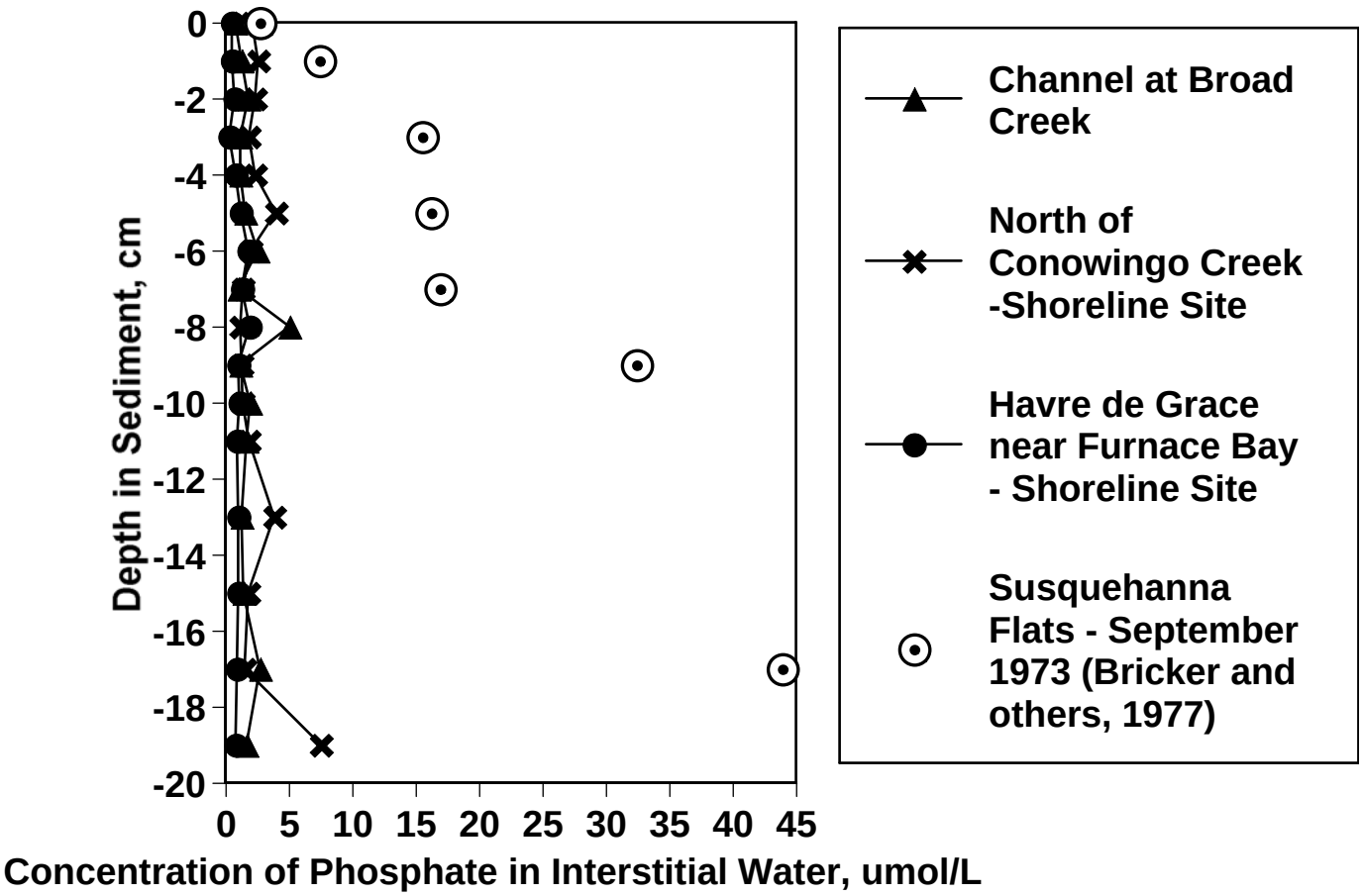


Figure 4. Phosphate concentrations, µmol/L, in sediment interstitial water. Conowingo Reservoir and Havre de Grace samples collected in 2000. Susquehanna Flats samples collected in 1973.

- Bacteria in the sediment that could be cultured in the laboratory were, in general, antibiotic resistant.

Native bacteria from sediment samples collected for this study were tested for sensitivity to five antibiotics. The bacteria in these cultures are mixed populations. Concentrations of antibiotics were the "normal" effective concentrations for inhibition of microbial growth, as well as a significantly higher antibiotic concentration (tetracycline at Havre de Grace – Furnace Bay).

North of Peach Bottom – Shoreline Site

- Amoxicillin (33 μg/mL) R
- Penicillin (10 μg/mL) R
- Ampicillin (33 μg/mL) R
- Tetracycline HCl (10 μg/mL) S
- Sulfadimethoxine (250 μg/mL) I
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Broad Creek - Channel

- Amoxicillin (33 μg/mL) R
- Penicillin (10 μg/mL) R
- Ampicillin (33 μg/mL) R
- Tetracycline HCl (10 μg/mL) S
- Sulfadimethoxine (250 μg/mL) R

North of Conowingo Creek – Shoreline Site

- Amoxicillin (33 μg/mL) I
- Penicillin (10 μg/mL) R
- Ampicillin (33 μg/mL) R
- Tetracycline HCl (10 μg/mL) I
- Sulfadimethoxine (250 μg/mL) R

Havre de Grace – Furnace Bay – Shoreline Site

- Amoxicillin (33 μg/mL) R
- Penicillin (10 μg/mL) R
- Ampicillin (33 μg/mL) R
- Tetracycline HCl (8 -100 μg/mL) R
- Sulfadimethoxine (250 μg/mL) R

R = Resistant. Bacteria populations demonstrate similar growth increases in the presence or absence of antibiotic
S = Sensitive. Bacterial population does not increase in the presence of antibiotic.
I = Inhibited. Bacterial population increase was 2-3 orders of magnitude less than the increase of the bacterial population in the control (no antibiotic added to sample).

Bacteria from all sampling sites were resistant to penicillin and ampicillin at the concentrations used in the experiments. The native populations of bacteria in these sediments were sensitive to tetracycline at two of the reservoir sites (north of Peach Bottom and the channel at Broad Creek). Bacterial growth in the sediment collected north of Peach Bottom was inhibited by sulfadimethoxine. In sediment from the site north of Conowingo Creek, also a reservoir site, bacterial growth was inhibited in the presence of tetracycline and amoxicillin. Bacteria in the sediment from the site near Furnace Bay (in the area of Susquehanna Flats east of Havre de Grace) were resistant to all five of the antibiotics at the concentrations that were tested.

References

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Ruttenberg, K.C. 1992 Development of a sequential extraction method for different forms of phosphorus in marine sediments Limnology and Oceanography 37:1460-1482.