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Project Summary

Assessment of Nitrogen Loads to Aquatic Systems

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Estimates of the contributions of atmospheric nitrogen deposition to Chesapeake Bay, Galveston Bay, and Tampa Bay are reported. The estimates are based on a refinement of a methodology developed by the Environmental Defense Fund (EDF) in a 1988 study of Chesapeake Bay. The three-embayment study employed a spreadsheet methodology that produced estimates of nitrogen loadings from the various nitrogen sources found in each of the study areas. Sensitivity analysis showed that atmospheric deposition has a significant effect on the nitrogen loadings delivered to the aquatic systems. More than 40% of the total nitrogen loads to the three systems resulted from atmospheric deposition.

This Project Summary was developed by EPA's National Exposure Research Laboratory's Ecosystems Research Division, Athens, GA, 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

Nitrogen, released by many mobile and stationary sources, is ubiquitous in the environment where it can have both beneficial and deleterious effects. Nitrogen improves soil fertility and plant nutrition, but also produces water and air pollution through acidification and eutrophication of surface waters, contamination of ground water contribution to greenhouse gas emissions, and effects on ozone distribution.

As part of a study of sources of nitrogen to the Chesapeake Bay in 1988, the EDF developed modeling systems that included mass balance modeling of nitrogen on various land categories to explore and quantify both the sources of nitrogen and potential reduction alternatives. Subsequently, the U.S. Environmental Protection Agency (EPA) through its Ecosystems Research Division in Athens, GA, directed a research project to refine the EDF methodology that resulted in the development of a spreadsheet format that incorporates commonly available data sources, e.g., EPA/state waste discharges, emission inventories, soils and meteorologic data bases. The refined procedures were then applied to the Chesapeake Bay, Galveston Bay, and Tampa Bay watersheds. Results of the EDF and EPA studies were compared.

The spreadsheet procedure estimates the contribution of atmospheric nitrogen deposition to the three study sites with respect to nitrogen contributions from nonpoint and point sources. The land use categories from which nonpoint source loadings were calculated consist of forest, cropland, pasture, and urban area. The point source loadings consist of contributions of nitrogen from industrial and sewage treatment plant discharges. The annual wet atmospheric deposition data were obtained from the National Atmospheric Deposition program.

Percentage contributions from various nitrogen sources in the three watersheds are presented in Table 1. The Chesapeake Bay was divided into 14 subbasins for the spreadsheet analysis; the EDF procedure considered the watershed to be a single basin. The two procedures produced results that were in close agreement with

respect to the contribution of atmospheric deposition to the total load to the Chesapeake Bay. The total nitrogen loads of 140 million kg/yr from the EDF study were similar to, but slightly higher than, the 115 million kg/yr from the spreadsheet analysis.

The spreadsheet methodology estimated slightly higher contributions of nitrogen from point sources as compared to the EDF analysis. The higher percentage could reflect the data used to calculate point source loads. The spreadsheet procedure used average point source loadings as estimated by EPA's Chesapeake Bay Program Office for 1984-1987, whereas the EDF procedure used point source data for 1985 only. The spreadsheet estimate for the percentage contribution from manure was 3.2% higher than the EDF estimate. In the EDF analysis, manure was applied only to pastures and a retention factor of 97.5% was used, which resulted in very low nitrogen loadings to the Bay as a result of manure application. In the spreadsheet analysis, manure was applied to both cropland and pastures, and as cropland has lower retention of nitrogen than pastures, a slightly higher percentage nitrogen load was estimated.

The percentage nitrogen loadings to Chesapeake Bay from fertilizer applications as estimated by the two procedures did not agree. In the EDF analysis, county fertilizer sales data were used to estimate the total amount of fertilizer applied to the entire watershed, and a single constant retention factor was used for all the agricultural cropland in the Chesapeake watershed. For the spreadsheet analysis, fertilizer application data estimated by state and county extension officials were used. The total fertilizer application was 13 million kg greater for the spreadsheet analysis than for the EDF study. As variable retention parameters (computed from unit area loads) for all 14 subbasins were used in the spreadsheet method, however, fertilizer loads were lower than for the EDF method.

For Galveston Bay, the nonpoint nitrogen loadings information used in the spreadsheet study indicated that more than 50% of the total nonpoint load is due to the land use area occupied by urban dwellings. The total nitrogen load to Galveston Bay was estimated to be 36 million kg. Of the total 49% atmospheric deposition load to Galveston Bay (Table 1), direct atmospheric deposition to the Bay's surface water accounted for 39%, with the watershed contributing the remaining 10%. Fertilizer loadings to the Bay were quite low as only 22% of the watershed was under crop production.

For Tampa Bay, a total nitrogen load of 4.5 million kg was estimated. Direct atmospheric deposition onto Tampa Bay surface water accounted for 40% of the total 67% (Table 1) atmospheric deposition load, with the watershed contributing 27%. The relatively large contribution of atmospheric deposition may reflect the considerably lower total nitrogen load for Tampa Bay as compared to the loads in the other two embayments. The relatively small watershed area and large water surface area of Tampa Bay also magnified the relative contributions from atmospheric sources.

In summary, the study results indicate that atmospheric deposition of nitrogen over portions of the U.S. may be a significant contributor of nitrogen to aquatic systems. Application of the spreadsheet methodology developed in this project to Chesapeake Bay, Galveston Bay, and Tampa Bay supports this conclusion; more than 40% of the total nitrogen load that is delivered to these water bodies is estimated to be the result of atmospheric nitrogen deposition. Although not confirmed in this study, increased emissions of nitrous oxides to the atmosphere may be a source of the increased nitrogen inputs to aquatic systems through the deposition pathway.

Users of the estimates reported here should be aware of the assumptions on which the spreadsheet methodology was based. These assumptions are that (1) dry atmospheric deposition is equal to wet atmospheric deposition, (2) nitrogen inputs to the land use categories of pastures, urban areas, and wetlands are only from atmospheric deposition, (3) the riverine nitrogen loss parameter is constant for all steams in all three study sites, (4) biological fixation is ignored for crops and forests, and (5) the retention parameter is assumed to be the same for fertilizer application and atmospheric deposition on cropland. Further investigations may be needed to support these assumptions.

Table 1. *Nitrogen Contributions (Percent) from Various Sources to Chesapeake Bay, Galveston Bay, and Tampa Bay*

	EDF Analysis	*Spreadsheet Analysis*		
Nitrogen Source	*Chesapeake Bay*	*Chesapeake Bay*	*Galveston Bay*	*Tampa Bay*
Point Source	*23*	*30*	*48*	*19*
Atmospheric Deposition	*39*	*43*	*49*	*67*
Fertilizer	*34*	*20*	*3*	*14*
Manure	*4*	*7*	*--*	*--*

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The complete report, entitled "Assessment of Nitrogen Loads to Aquatic Systems," (Order No. PB97-125 421; Cost: $25.00, subject to change) will be available only from:
National Technical Information Service
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