NUTRIENT CRITERIA

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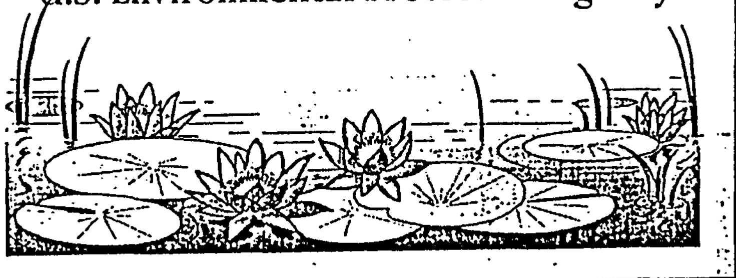

NUTRIENT CRITERIA

- What is EPA Up to This Time?
  - Creation of the Nutrient Task Force

EUTROPHICATION MODELING FOR WATER QUALITY MANAGEMENT: AN UPDATE OF THE VOLLENWEIDER-OECD MODEL

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INTRODUCTION

During the mid-1970s, the Organization for Economic Cooperation and Development (OECD) sponsored a 5-year study of the relationships between nutrient loading and eutrophication-related water quality response in waterbodies in the US, Canada, Australia, Japan, and 14 countries in Western Europe. One of the primary purposes for the OECD eutrophication study was to try to quantify, for a broad range of types of waterbodies, the relationships between the loading of nutrients, especially phosphorus, and the eutrophication-related water quality responses. About 35 waterbodies or parts of waterbodies in the US which had in the past been intensively studied for nutrient loading and response characteristics were included in this study, along with Canadian waterbodies which had previously been investigated. New studies were initiated on the waterbodies in the other participating countries. Previous editions of the Water Quality Bulletin (July and October, 1981) have provided discussions of the problems of eutrophication and the results of parts of the OECD eutrophication modeling study effort.

Because of the availability of data on the US waterbodies, this group was the first to be evaluated (Rast and Lee, 1978; Lee *et al.*, 1978) following the theoretical approaches developed by Vollenweider. Vollenweider (1968, 1975, 1976) had begun to quantify relationships between nutrient loading and general conceptualizations of *eutrophication-related water quality* as assessed by "eutrophic", "mesotrophic", and "oligotrophic" designations, based on about 20 primarily European waterbodies. Vollenweider found that one of the relating factors was the mean depth of the waterbody; the greater the mean depth, the greater the phosphorus loading could be before "eutrophic" conditions would be found. It reflects the greater dilution capacity of deeper waterbodies and proportionately smaller photic zones, allowing the deeper waterbodies to have a higher P load without stimulating greater amounts of algae. Vollenweider corrected for the effects of fast or slow flushing rates of water through a waterbody on the utilization of nutrients by planktonic algae, and for the impact of the surface area of the waterbody receiving light by including hydraulic residence time and waterbody surface area as normalizing factors in his load-response relationships.

The focus on P loading in the Vollenweider-OECD eutrophication modeling approach was based on several considerations. It is phosphorus which most frequently controls algal growth in waterbodies; P control is more readily effected and is less costly than nitrogen control; and phosphorus can be more readily controlled at point sources than nitrogen. Furthermore, Schindler (1977, 1985) has shown that even in lakes exhibiting nitrogen limitation, algal growth responds to decreases in phosphorus load. The possibility of nitrogen fixation by algae also interferes with the use of nitrogen load in estimating or predicting waterbody algal responses.

Vollenweider (1976) developed a regression relationship for average planktonic algal chlorophyll concentration as a function of the annual P load, normalized by waterbody area (L(P)), mean depth (z), and hydraulic residence time (T_w) for a group of European waterbodies. Following the same approach, Rast and Lee (1978) developed a line of best fit for the US OECD waterbodies; they found the regression to be essentially the same as that which had been developed by Vollenweider for his separate set of waterbodies. Jones and Lee (1982) updated the Rast and Lee line of best fit by including an additional approximately 40 US waterbodies on which data were available or on which they had worked; their line of best fit was essentially the same as that of Rast and Lee (1978). The focus on average chlorophyll concentration as the response parameter is justified for a number of reasons. As a measure of waterbody "greenness", it integrates the quantification of various types of planktonic algae. Furthermore, chlorophyll concentration can be related to many of the impairments of water use that result from algal growth.

Rast and Lee (1978) had also expanded the scope of the original normalized P loading/chlorophyll relationship concept by developing analogous relationships between normalized P loading and Secchi depth (water clarity) for waterbodies in which water clarity is controlled primarily by planktonic algae, and between normalized P loading and hypolimnetic oxygen depletion rate based on US OECD data and the literature. These relationships were also updated by Jones and Lee (1982); their three normalized P loading/eutrophication-related water

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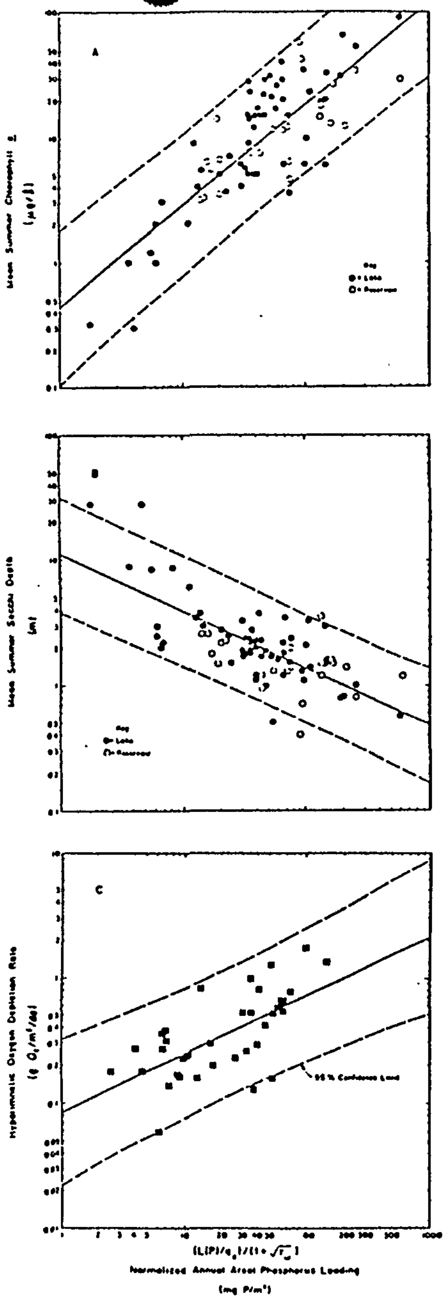


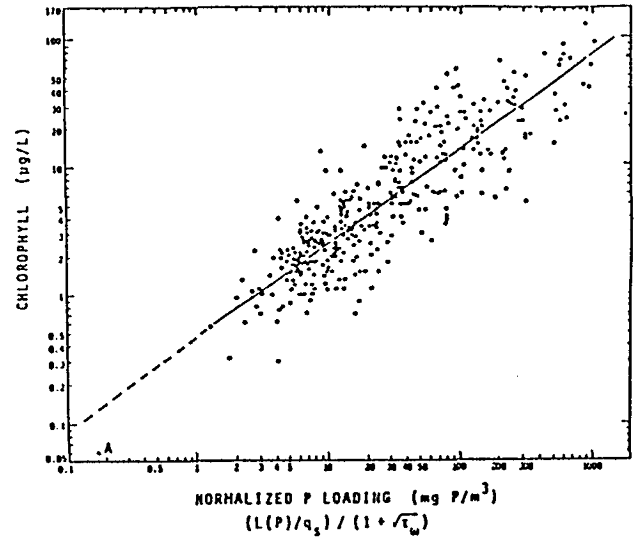
KEY

L(P) = Areal Annual Phosphorus Load (mg P/m²/yr)

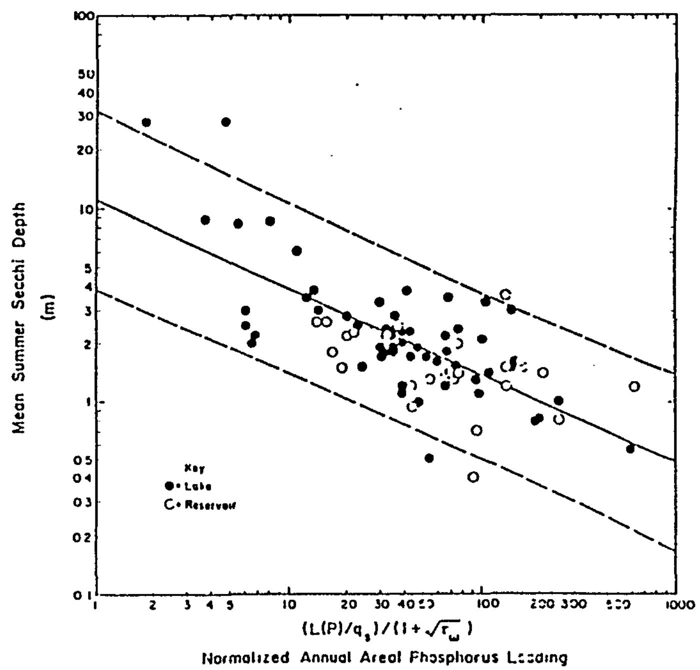
q_s = Mean Depth ÷ Hydraulic Residence Time = $\bar{z}/\tau_\omega$ (m/yr)

τ_ω = Hydraulic Residence Time (yr)

Relationship between Normalized P Loading and Chlorophyll in Lakes & Reservoirs Worldwide



Relationship between Normalized P Loading and Water Clarity (Secchi Depth)



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