AN EVALUATION OF NEW YORK STATE LAKE LIMING DATA AND THE APPLICATION OF MODELS FROM SCANDINAVIAN LAKES TO ADIRONDACK LAKES

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ABSTRACT

Limestone dissolution efficiencies and reacidification rates observed in ten small Adirondack Mountain lakes, treated in 1983 to 1984 as part of the Extensive Liming Study (ELS), were compared with Scandinavian model predictions of dissolution (Sverdrup and Bjerle, 1983), and reacidification (Wright, 1985). The standard deviation of predicted initial dissolution was 15.4% of the observed fraction of limestone dissolved. Model predictions of dissolution for the Scandinavian lakes were similarly within 8 to 14% of observed values. Further analysis of the ELS data indicated that of the dissolution model parameters, dose rate alone was the best predictor of initial dissolution efficiency. Dissolution rates declined exponentially with time to undetectable levels within 2 to 3 yr following treatment. Total limestone dissolution efficiencies were in the range of 17 to 59% for the ELS lakes, which are comparable to levels observed in Scandinavian treatments with similar limestone materials (26 to 64%). Analysis of data from other Adirondack lakes limed by private groups and the New York State Department of Environmental Conservation for fisheries management programs, yielded similar estimates of dissolution efficiency for calcite based materials (average 36%). However, some of these lakes which were treated with slaked lime [Ca(OH)$_2$], exhibited initial dissolution efficiencies approaching 100%. The simple two box dilution model of reacidification, satisfactorily predicted Ca loss rates in the ELS lakes, indicating the importance of hydrology (water retention time) as a factor controlling reacidification rates in these small, limed lakes. For the ELS lakes, the ratio of watershed area/lake volume satisfactorily predicted Ca loss rates ($R^2 = 0.96$) and this simplified empirical model was applied to other Adirondack lakes where inadequate water chemistry and hydrologic data were available to utilize the dilution model. Limed Adirondack lakes with mean water retention times less than 4 mo reacidified within 1 yr after treatment. Given the preponderance of acidified lakes in the Adirondack region with retention times less than this threshold value of 4 mo (approximately 80% of lakes <10 ha surface area), simple whole lake liming practices would not be adequate for maintaining water quality suitable for the support of viable fish populations in these lakes.
1. INTRODUCTION

The principal mitigation measure applied to acidified surface waters has been base addition (e.g., stream and lake liming). Numerous basic materials have been utilized to neutralize acidic lakes although major operational and research programs in Scandinavia, Canada, and the United States use CaCO$_3$. This calcite is frequently referred to as agricultural limestone in the United States although CaCO$_3$ materials are available in varying degrees of purity and particle size.

Sweden currently has the world's largest operational liming program, involving the application of approximately 800,000 t of calcite yr$^{-1}$ (Sverdrup, 1984). Programs in Norway, Canada, and the United States tend to be more research oriented and involve fewer lakes and less material (Fraser and Britt, 1982). Within the United States it is generally recognized that the Adirondack Mountains region of New York is the area most severely impacted by acid deposition. Estimates from the late 1970's suggested that over 200 lakes or approximately 3000 ha of surface area were severely impacted by acid deposition. The New York State Department of Environmental Conservation (NYSDEC) has been using lake liming as a management technique since the early 1960's (Blake, 1981).

Early applications of neutralizing materials in New York State were made primarily on naturally acidic (dystrophic) bog ponds. This program has involved over 125 treatments on approximately 60 waters (Kretser and Colquhoun, 1984). However, operational liming since 1964 has focused on waters thought to be anthropogenically acidified. Most of the early treatments utilized hydrated lime [Ca(OH)$_2$] although CaCO$_3$ was used in later treatments and is now the material of choice for the NYSDEC program. In addition to the NYSDEC efforts, liming has been conducted during the past two decades on private lands in New York where waters have been too acidic to support healthy fish populations (Flick et al., 1982). State and private waters in New York represent the most substantial data base for investigating the effectiveness of liming in the United States.

The NYSDEC programs have been described by Blake (1981) and Kretser and Colquhoun (1984) and a data compilation was published by Britt and Fraser (1983). A review of some data from the privately owned waters was provided by Flick et al. (1982). However, no