ROLE OF PRECIPITATION CHEMISTRY VERSUS OTHER WATERSHED PROPERTIES IN WISCONSIN LAKE ACIDIFICATION

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ABSTRACT. Data for over 100 watershed properties, including aspects of topography, hydrology, geology, soils, vegetation, lake morphometry and input precipitation chemistry, have been developed since 1980 for 316 watersheds in northern Wisconsin. The hypothesis being evaluated for this lake population is that the observed water chemistry, can be accounted for as a function of antecedent water and chemical inputs, after considering exchange processes in the lake and watershed and the lake/groundwater interactions. The variables found by regression analysis to explain observed variability in color, sulfate, and acid neutralizing capacity (ANC) levels in Wisconsin lakes are: for color, vegetative characteristics, mean depth, and water renewal times; for sulfate, precipitation concentration of sulfur, evaporative concentration, and lake water renewal time; ANC appears to be controlled by the size of the watershed, lake depth or water renewal time, and the intensity of anthropogenic inputs and cultural developments in the watershed. These results differ from previous studies in Wisconsin and nearby areas of Michigan and Minnesota by indicating that in some lakes acidity may not be in equilibrium with current precipitation chemistry.

1. INTRODUCTION

The northeastern portion of Minnesota, north central Wisconsin, and the Upper Peninsula of Michigan are areas with several characteristics of acid sensitivity in common: all three regions support a large number of lakes with recreational importance to their respective states, they are all located on bedrock or surficial deposits of low buffering
capacity, and they are all characterized by a mixed conifer-hardwood vegetation with a similar history of logging and forest recovery during the twentieth century. There are differences from one state to the other, however, in total rainfall and evaporation, in the total inputs of acidic substances (Glass and Loucks, 1986), in cultural development, and in present-day lake chemistry, a response pattern that could be attributable either to the differences in precipitation chemistry or the differences in land use. This paper utilizes data on the chemical deposition patterns and on watershed and land use variables to evaluate the role of watershed characteristics, particularly land use, hydrology and groundwater, in controlling the concentration of chemicals in a population of Wisconsin lakes.

The study utilizes the watershed approach found effective in previous research (Likens et al. 1977; Chen et al. 1982) and extends its application to entire populations of watersheds and subtending lakes in the upper midwest (see Rapp et al. 1986 for details). The study considers the possibility of defining a dose/response relationship utilizing both known causal relationships (linkages within the framework of a single lake/watershed system), and population-based relationships recognizable through correlations describing the association between lake water chemistry and watershed characteristics.

The research framework has been described in previous papers (Glass and Loucks, 1986; Rapp et al., 1986). Briefly stated, it utilizes the conceptual abstraction of a watershed as a receptor system with the following major processes influencing the inputs and outputs of water and other substances: runoff; recharge; evaporation; ionic neutralization and mobilization; biological uptake; and anthropogenic interactions. Specific properties of the lake and terrestrial watershed can be quantified to represent the potential for each of the above processes to have a significant influence on chemical exchange within the watershed and, therefore, on the concentrations observed in the subtending lake. The hypotheses to be tested are essentially that watershed factors can each have a significant influence on reactions following the input of chemicals, producing a multiple factor explanation of the observed lake chemistry. Accordingly, the principal methodology is a combination of single-factor relationship and matrix correlation studies.

2. THE STUDY AREA AND DATABASE

The principal geomorphological characteristics of the study area have been determined by glacial processes. The resulting topography consists of areas of pitted outwash with lakes in deep deposits of outwash sands and sandy morainal till. The coarse texture of the sandy outwash and moraines allows much of the drainage from one basin to another to take place as seepage below the surface of the soil. The result is that a relatively large proportion (locally, as much as 40%) of the lakes are "seepage lakes" with neither inlet nor outlet streams. Most of the larger watersheds, however, have sufficient flow to maintain a surface water stream which controls the hydrology and chemistry of