Geographic relationships between soil and water acidity, soil-forming factors and acid rain

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Abstract

Acid rain has been credited for the existence of most \( \text{pH} < 6.0 \) surface waters in eastern North America and northern Europe. The absence or presence of acidic surface waters are reportedly due to the absence or presence of acid rain. However, climate is responsible for two regional distributions – acid rain and acid soils. Moist climates with reasonable growing seasons are needed to develop regionally-acidic soils and to support sufficient human population and activity to generate regionally-acidified precipitation. That the \( \text{pH} \) of water passing through acid soils resembles soil \( \text{pH} \) and is but little influenced by the acidity of precipitation; acidic waters were nearly as common in areas receiving acid rain in pre-industrial times as they are today; regional land-use changes co-occur with acid rain, and; acidic surface waters are comparatively common in Southern Hemisphere watersheds with acid soils in the absence of acid rain all indicate that acid rain incrementally adds to the acidity of surface waters rather than creating the perceived profound widespread aquatic acidification.

Introduction

Atmospheric sulfur deposition (acid rain) is generally believed to be responsible for profound regional acidification of surface waters in eastern North America and northern Europe. This belief has been sustained by temporal/geographic arguments, namely, reports of measured historical acidification (e.g., Burns et al., 1981; Dillon et al., 1978; Oden, 1976; Schofield, 1976; Wright, 1977) and reports that acid lakes and streams are comparatively rare or absent from ‘equivalent’ areas not receiving acid rain such as: the Rocky Mountains versus Adirondacks; northern versus southern Scandinavia; northern versus southern Ontario (e.g., Malanchuk and Turner, 1987; Neary and Dillon, 1988; Oden, 1976; Ruess et al., 1987; Schnoor et al., 1986; Sullivan et al., 1988; Wright, 1977; Wright et al., 1988). In areas where there was also regional soil acidity data, the north-south and east-west acidity gradients were also characterized as being the result of acid rain (Malanchuk and Turner, 1987; Oden, 1976; Wright et al., 1988).

Reports of regional acidification have been further supported by the reported scientific consensus on acidification theory. This theory only considers watershed processes that can produce alkalinity (and surface waters of \( \text{pH} \geq 5.5 \)), not acidity, as being those processes which interact with deposited \( \text{H}_2\text{SO}_4 \), i.e., mineral bases and sesquioxide retention of sulfate (Alcamo et al., 1987; NAPAP, 1987; National Research Council, 1984; Neary and Dillon, 1988; Reuss et al., 1986; Stumm et al., 1987; Sullivan et al., 1988).

This theory necessarily predicts that because many acid lakes and streams receive most of their water from near-surface runoff through highly acidic, organic-rich soil materials and/or acidophilic vegetation (Fig. 1), just slight addi-
tions of acid are predicted to result in tremendous pH depressions due to the paucity of reactive sesquioxides and bases (Krug and Frink, 1983; Krug, 1989; Marmorek et al., 1989; Reuss et al., 1986). Accordingly, it is concluded that pH < 6
lakes of NAPAP’s National Surface Water Survey (NSWS) in which SO$_4^{2-}$ is the dominant anion have been recently acidified by acid rain (Marmorek et al., 1989). pH 5.5, the pH of pure water slightly supersaturated in respect to pCO$_2$ atm, is not used as the threshold value because watersheds generally contribute at least some base cations and, assumedly, alkalinity to surface waters. National lake survey data for Canada and Norway are similarly interpreted (Henriksen et al., 1989; Kelso et al., 1986; Schindler, 1988).

**Acid soil, vegetation and water relationships**

**Acid soil and water**

Contrary to popular acidification theory, as early as the 1960’s and 1970’s scientists reported that