

Atmospheric S Deposition near Sudbury, Ontario, 1930-2000; Inferred from Sulfate in Groundwater

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ABSTRACT

The ~90% reduction in SO₂ emissions from Sudbury smelters during the past four decades (2500 ktonnes/yr, 1960 vs 250 ktonnes/yr, 2000) represented a unique and nonrecurring opportunity to quantify the effect of emission reductions from a very major point source on the local rate of S deposition. Unfortunately, comprehensive atmospheric monitoring was not implemented in the Sudbury area until the late 1970s (CANSAP, APIOS, networks), well after significant reductions had already occurred. As a result, the overall impact of these reductions can only be inferred by indirect means.

We use groundwater sulfate concentrations at a field site near Sturgeon Falls, Ontario (100 km east of Sudbury) to infer atmospheric deposition for most of the period when major SO₂ emissions were occurring at Sudbury (1930-2000). The site is an undisturbed forested catchment on the paleodelta of the Sturgeon River, where a detailed monitoring network of 68 piezometers was installed along a groundwater flow transect in a recharge area. The simple flow system, combined with successful tritium transport modeling, has allowed groundwater at this site to be age-dated with unusual precision (± 3 yrs). Sulfate concentrations have declined by 64% since 1960 (17.6 vs 6.4 mg/L, average) and show a strong similarity to the trend inferred from changes in lake water chemistry in the Sudbury area (Snucins et al. 1999). This decline is greater than that observed in other areas where long term records are available, for example in stream water at Hubbard Brook, New Hampshire (23% decline in SO₄ during 1963-1993, Likens et al. 1996) and in SO₄ concentrations in wet deposition in the northeastern US (average 36% decline during 1981-1998, Nilles and Conley, 2001), pointing to the additional effect of Sudbury emission reductions at this site. Groundwater sulfate concentrations suggest that atmospheric S deposition at this location is now lower than at any other time during the past 70 years.