Acid rain II - the details

Part I of these pages looked at the long-term and large-scale aspects of acid rain. This page instead looks at short-term aspects observed at smaller geographic scale.

Acid rain is rain made acidic by the oxidation of SO₂ and NO₂, which are commonly released to the atmosphere where coal and/or petroleum are burned.¹ The oxidizing reactions are

\[
\text{Oxidizing}
\]

\[
P\text{ollutant} + \text{agent} \rightarrow \text{Sulfuric or nitric acid}
\]

\[
\text{SO}_2 + 2\text{OH}^0 \rightarrow 2\text{H}^+ + \text{SO}_4^{2-}
\]

\[
\text{SO}_2 + \text{H}_2\text{O}_2^0 \rightarrow 2\text{H}^+ + \text{SO}_4^{2-}
\]

\[
\text{NO}_2 + \text{OH}^0 \rightarrow \text{H}^+ + \text{NO}_3^-
\]

Production of acidity depends on the availability of OH⁻ and H₂O₂, which are produced by photo-chemical reactions. The pH of acid rain thus depends on light to generate the necessary oxidizing agents. Rainwater pH thus varies seasonally with the length of the day, as shown by the curves at right (although seasonal changes in prevailing winds can also be significant in changing the extent of delivery of SO₂ and NO₂, and there can seasonal variation in industrial output of those pollutants). Because of the dependence on light, rainwater pH also varies diurnally between daylight and darkness, as is shown by the histograms at right.

¹ This is the usual meaning of “acid rain”, but one should realize that rainwater unaffected by oxides of nitrogen or sulfur almost always has a pH less than 7 and thus is more acidic than chemical neutrality. That’s because natural atmospheric CO₂ hydrates to yield H₂CO₃ (carbonic acid), and thus natural rainwater has a pH of about 5.7. Anthropogenic addition of CO₂ has lowered that pH slightly, but even anticipated high values of P₃O₂ over the coming decades or centuries will not lower the pH of rainwater to the extent that oxidation of SO₂ and NO₂ can cause lower pH.