Spring snowmelt and stream acidification

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Most Northeasterners are familiar with the causes of acid rain: nitrates and sulfates from the burning of fossil fuels that enter the atmosphere and cause rain, snow, and fog to be far more acidic than they would otherwise be. Most people probably also know that acid rain can kill fish; it has been known for over a decade that the higher the acidity of a given lake or stream, the lower the number of fish species that will be found in it.

But what few people know is that springtime is when the problem is most acute. The reason is very straightforward: acidity that has been held up in the snow pack all winter is released into streams very quickly during the spring thaw. The resulting surge brings streams and rivers to their most acidic levels of any time of the year. Heavy downpours in any season can acidify streams and rivers to a lesser extent.

Some streams are affected by this surge more than others. Indeed, although acid precipitation has been falling on the Northeast for decades, some streams still support high species diversity while others do not. The majority of Northeastern streams fall somewhere in between – not, on average, overly acidic, yet still susceptible to the high pulse of acidification that occurs during the spring thaw. Understanding what is happening in these streams is of utmost importance since any benefits from reduced air pollution and acid rain will first be seen in the recovery of these streams.

How much a particular stream is affected by acidification depends on two key properties of the soils in the surrounding watershed. The first is how well the soil drains or, more technically, the residence time of water in the soil. Acidity needs time in contact with individual soil particles to be neutralized, just as in a good cup of coffee, water needs time in contact with the coffee grounds to absorb the most flavor. During snowmelt and heavy rainstorms, water moves through the soil so quickly that this neutralization never has a chance to happen.

The second key property of soil is called buffering capacity – the soil's ability to neutralize acidity if given the time to do so. Soils rich in calcium and other positively charged ions are able to exchange these ions for the positively charged hydrogen ions in rainwater that makes the rain acidic. Soils with good buffering capacity have lots of these positively charged ions. Soils with poor buffering capacity do not.

Farmers and gardeners, incidentally, spread lime to increase the buffering capacity of their soils, knowing that the calcium in lime is an excellent way to counteract the effects of acid rain. Natural soil buffering capacity, on the other hand, is rebuilt very slowly by the weathering of calcium and other positively charged ions from the bedrock into the soil.

When acid rain falls on poorly buffered soils, the acidity dissolves aluminum from the soil and streambed and moves it into the waters of our streams and rivers. Aluminum is a very common element in our rocks and soils, but it is not very mobile, and hence does not enter living things, until it is dissolved by acidic water. In high concentrations, aluminum is toxic to trout and other aquatic life, and is the primary cause of fish mortality during acid episodes in lakes and streams.

In our region, the Battenkill river in western Vermont drains an area underlain by marble bedrock. Marble is a rock rich in calcium, and consequently the Battenkill is a good example of a stream with very well buffered soils. Not coincidentally, it is also a very good trout stream. In contrast, Hubbard Brook in the western White Mountains drains an area underlain by granitic rock relatively poor in calcium. These soils have a limited buffering capacity, and though the stream is not normally very acidic, it is very susceptible to acidification during the spring runoff. In fact, the water in this brook can be 100-times more acidic during spring runoff than during late summer when the flow is at its lowest. Many fish that could inhabit Hubbard Brook during the summer can't tolerate the rush of acidity that occurs each spring.

Our problem in the Northeast is that our soils are being depleted by acid rain faster than they are being replenished by the bedrock. This has been true for the past half century, and many of our soils now have very little buffering capacity left. Recent improvements in air quality have led to a slight decrease in the acidity of precipitation falling in the Northeast, and while this is a step in the right direction, it has done nothing except slow the rate at which damage is occurring. Until the rate of replenishment is higher than the rate of removal – until acid rain from the combustion of fossil fuels ceases to bathe the Northeast - our soils will continue to lose their ability to mitigate the effects of acid precipitation, and the spring thaw will become ever more stressful for fish and other aquatic life.

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