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Living World / Agriculture

The Nitrogen Bomb

By learning to draw fertilizer from a clear blue sky, chemists have fed the multitudes, they've also unleashed a fury as threatening as atomic energy.

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In 1898, Sir William Crookes called on science to save Europe from impending starvation... What then would happen to Europe? "It is the chemist who must come to the rescue of the threatened communities," Crookes cried.

"It is through the laboratory that starvation may ultimately be turned into plenty."

...Adding nitrogen in the form of nitrate fertilizer raised food production enough to ward off disaster. But now, at the end of the century, the multiplying population was putting a new strain on agriculture. The obvious solution was to use more fertilizers. But most of the world's nitrate deposits were in Chile, and they were insufficient. Where would the additional nitrogen come from?

... those who took up Crookes's challenge were tinkering with life's basic elements for social rather than scientific reasons. And like the men who created the atomic bomb, they set in motion forces beyond their control, forces that have since shaped everything from politics to culture to the environment.

N d air are nearly enough, by themselves, to grow any modern crop. All this plant lacks is water. Photo by James Worrell

Today nitrogen-based fertilizers help feed billions of people, but they are also poisoning ecosystems, destroying fisheries, and sickening and killing children throughout the world. In ensuring our supply of food, they are wreaking havoc on our water and air.

...Nearly 80 percent of the world's atmosphere is made up of nitrogen— enough to feed human populations until the end of time. But atmospheric nitrogen is made up of extremely stable N_2 molecules that are reluctant to react with other molecules. Bacteria convert some atmospheric nitrogen first into ammonia (NH_3), then into nitrites (NO_2^-) and nitrates (NO_3^-),

but not nearly enough for modern agriculture. What was needed by the end of the 19th century was a way of imitating these microbes— of "fixing" atmospheric nitrogen into a chemically active form...

After a long search Haber found the element uranium to be...a catalyst (to allow the commercial possibility of industrial nitrogen fixation), and with a few further technical refinements he was able to produce nearly half a liter of ammonia an hour. Best of all, the process required little energy, and this obscure metal, having no other commercial use, was cheap.

...by 1912 the Haber-Bosch process was a viable means of producing fertilizer. Haber and Bosch would later receive Nobel prizes for their efforts, the threat of famine was averted, and the world lived happily ever after. Well, not quite.

...in trying to feed humankind, we may yet starve it...the paradox of nitrogen remains. First it was all around us and we couldn't use it. Now we know how to use it, and it's suffocating us.

Nitrogen makes up nearly 80 percent of Earth's atmosphere, yet 20th-century Europeans nearly starved for lack of it Photo by James Worrell

The planet's 6 billion humans (and counting) rely more than ever on fertilizer to augment the natural nitrogen in soils. In fact, we now produce more fixed nitrogen, via a somewhat modified Haber-Bosch process, than the soil's natural microbial processes do. Farmers tend to apply more fertilizer rather than take a chance on less, so more nitrogen accumulates than the soil can absorb or break down. Nitrates from automobile exhaust and other fossil-fuel combustion add appreciably to this overload. The excess either gets washed off by rainfall or irrigation or else leaches from the soil into groundwater. An estimated 20 percent of the nitrogen that humans contribute to watersheds eventually ends up in lakes, rivers, oceans, and public reservoirs, opening a virtual Pandora's box of problems.

Algae, like all living organisms, are limited by their food supply, and nitrogen is their staff of life. So when excess nitrogen is washed off into warm, sunlit waters, an algal bacchanalia ensues. Some species form what is known as a "red tide" for its lurid color, producing chemical toxins that kill fish and devastate commercial fisheries. When people eat shellfish tainted by a red tide, they can suffer everything from skin irritation to liver damage, paralysis, and even death. As Yeats put it, "the blood-dimmed tide is loosed."

Algal blooms, even when nontoxic, block out sunlight and cut off photosynthesis for the plants living below. Then they die off and sink, depleting the water's supply of oxygen through their decomposition and killing clams, crabs, and other bottom dwellers. In the Baltic Sea, nitrogen levels increased by a factor of four during the 20th century, causing massive increases in springtime algal blooms. Some ecologists believe this was the main cause of the collapse of the Baltic cod fishery in the early 1990s...

Nitrogen also contaminates drinking water, making it especially dangerous for infants. It interferes with the necessary transformation of methemoglobin into hemoglobin, thus

decreasing the blood's ability to carry oxygen and causing methemoglobinemia, or blue baby syndrome. The EPA has named nitrates, along with bacteria, as the only contaminants that pose an immediate threat to health whenever base levels are exceeded, and increasingly they are being exceeded...

Beefing up agriculture not only contaminates our water, it corrupts the air. As fertilizers build up in the soil, bacteria convert more and more of it into nitrous oxide (N_2O). Nitrous oxide is best known as "laughing gas," a common dental anesthetic, but it is also a powerful greenhouse gas, hundreds of times more effective than carbon dioxide, and a threat to the ozone layer...

Mass-produced Nitrogen made modern warfare possible. What other explosions lie ahead?
Photo by James Worrell

Improving the management of fertilizer is one good way to decrease runoff. If we can better understand exactly when crops need to absorb nitrogen, farmers can learn to apply fertilizer sparingly, at just the right time...

Another, less drastic strategy for reducing the use of nitrogen is called "intercropping" and goes back to Roman times. By alternating rows of standard crops with rows of nitrogen-fixing crops, such as soybeans or alfalfa, farmers can let nature do their fertilizing for them. Intercropping could be a godsend to the developing world, where fertilizer is hard to come by. The difficulty is devising new plowing schemes, and farmers, like everyone else, are reluctant to abandon tried-and-true methods. But even successful farmers in the United States might be convinced. Aside from protecting the global environment— a somewhat intangible goal— intercropping could save them money on fertilizer. And farming areas are often most affected by groundwater contaminated by nitrates.

For more detail and link to the full article: http://discovermagazine.com/2001/apr/featbomb