Le Monde diplomatique

> March 2019

Monoculture farming wrecks the environment

Nitrogen, the miracle that destroys

Synthetic nitrogen fertilisers revolutionised agriculture and fed the world's growing population. But a century later they are depleting the soil and poisoning the environment. Time to change policies.

by Claude Aubert

Health hazard: a beach at Tresmalouen, France, covered with algae due to nitrate pollution
Yves-Marie Quemener · Gamma-Rapho · Getty

THERE is a paradox in plant nutrition: plants require nitrogen for growth, but while it is mostly found in the air (78% nitrogen, 21% oxygen), plants obtain it from the soil as nitrates ($NO3$) or ammonia ($NH3$), which can they absorb from humus and other organic matter such as harvest residue, manure, and compost, once they have been mineralised by bacteria.

In 1909 the German chemist Fritz Haber succeeded in combining atmospheric nitrogen with hydrogen to produce ammonia. He won the 1918 Nobel prize in chemistry for this work, which allowed the development of new fertilisers that made it possible to feed a world population that rose from 1.5 billion to more than 6 billion over the 20th century. A few bags of fertiliser were enough to provide all the nitrogen to grow crops and improve yields, doubling or tripling them. Farmers no longer needed to spread manure or compost, or cultivate nitrogen-rich leguminous plants.

The unlimited availability of cheap reactive nitrogen transformed agriculture, and by the 1960s chemical fertilisers were one of the four pillars of the 'green revolution', alongside high-yield crop varieties, pesticides and irrigation. The revolution was considered a great success, but in industrialised countries, and later in developing ones, massive use of synthetic nitrogen fertilisers produced unexpected results.

Once farmers had no need for solid or liquid manure, or for leguminous plants, they decided that breeding cows and sheep and letting them graze in fields was no longer worthwhile. Many got rid of their animals and produced only crops, mostly cereals. But milk and meat were still needed, and demand for them was growing rapidly, so other farmers specialised in livestock, and the most productive farms used industrial techniques, keeping animals indoors, and replacing fodder with cereal or oilseed-based feeds.

Thousand-cow farms

Within decades, European farming radically altered. In central and northeastern France, cattle-free cereal-growing regions switched to highly mechanised agriculture with massive use of synthetic nitrogen fertilisers. In Normandy, Brittany, Jutland (Denmark) and Bavaria (Germany), cattle rearing was industrialised with huge concentrations of animals. Thousand-cow farms became commonplace, as did farms producing tens of thousands of pigs or hundreds of thousands of chickens. These developments were the direct result of Haber's invention.

Such transformations were logical in the short term, but had a negative impact on the environment and on health. Many problems caused by modern agriculture are a direct result of the incorrect use of synthetic nitrogen fertilisers. Levels of organic matter in the soil are falling in intensively farmed regions, because no organic fertilisers are used and because there is no rotation of crops with plants such as alfalfa, which naturally enrich the soil. Yields can still be high, but have tended to stagnate and even fall, despite increased use of synthetic fertilisers. Meanwhile, the soil's ability to hold water, and the speed with which it absorbs water, have fallen, leading to increased risk of flooding and erosion due to surface runoff.

Pests and diseases are spreading, requiring more pesticides. Synthetic fertilisers have contributed to this by eliminating any need for crop rotation, which interrupts the reproductive cycles of pathogens and insects. Higher nitrogen content in leaves encourages the proliferation of pests such as aphids.

Nitrates and ammonia the culprits

Quasi-monoculture cereal farming weakens biodiversity and disrupts biological activity in the soil, as do rising levels of atmospheric nitrogen caused by ammonia given off by the soil and by intensive livestock farming. Excess nitrogen has serious impacts on health and the environment, though these are disputed owing to insufficient scientific data. However, an important piece of research by 200 European scientists, which unfortunately went almost unnoticed (1), identifies the main culprits: nitrates and ammonia.

Nitrates are present in the soil, where plant roots absorb some, but there is always a surplus, especially when large quantities of nitrogen-based fertilisers are used; it is carried off by rainwater and ends up in groundwater, rivers and our tap water. This risks an increase in certain types of cancer, and the eutrophication of rivers, killing fish and depositing green algae on coasts. Nitrates are found in food, sometimes with very high levels in certain vegetables.

Ammonia is a lesser-known pollutant but worse for health and the environment. Almost all ammonia emissions in France (679,000 tonnes in 2016) are from agriculture (64%) and cattle breeding (34.4%) (2). Ammonia does not remain in the atmosphere for long; some is deposited on the ground and on vegetation, while the rest produces undesirable compounds such as nitrous oxide, nitrogen oxides and ozone. Nitrogen oxides combine with other airborne pollutants to form secondary fine particles (3) that can penetrate the lungs' alveoli, leading to cancers and cardiovascular and respiratory diseases. The World Health Organisation estimates that in 2016 exposure to fine particles resulted in some 4.2m premature deaths (4).

According to the Interprofessional Technical Centre for the Study of Air Pollution (Citepa), agriculture and forestry were to blame for 55% of all suspended particulate matter in 2016, and levels are rising (5), which they are not in industry or transport. Farming accounts for the majority of primary emissions of all particles, but intensive livestock farming is above all responsible for fine particles. During pollution peaks, especially in spring, agriculture produces large quantities of fine particles, the result of ammonia emissions from soil after the application of fertilisers, as well as from animal manure, liquid manure and slurry.

The scientists who worked on the European assessment believe the environmental cost of excess nitrogen to the continent is between €70bn and €320bn a year, in the form of impacts on ecosystems, water and air quality and human health (6). They believe that this cost outweighs the economic benefits of synthetic fertilisers, and that excess nitrogen is a major ecological problem, like global warming and loss of biodiversity.

Changing farming methods

One solution would be to reduce, or even stop, the use of synthetic nitrogen fertilisers. That could be done by changing farming methods, especially by re-introducing leguminous plants such as peas, beans and alfalfa in rotation (which would have the added benefit of freeing us from our dependence on imported soybeans). A major argument in favour of organic farming is that it would be possible to avoid such imports, and the result would be as significant as ceasing to use synthetic pesticides.

> ***Pests and diseases are spreading, requiring more pesticides. Synthetic fertilisers have contributed to this by eliminating any need for crop rotation***

It would be impossible to stop all farmers using synthetic fertilisers immediately, since the conversion to organic farming can only be a gradual process and requires a complete overhaul of production systems. Most specialists have agreed that such a measure would lead to a fall in yields, but recent a meta-analysis concluded that, at global level, the average yield differential between organic and conventional farming would be only 19% (7), falling to 8-9% with varied crop rotation. Another study claimed that the addition of associated or intercropped crops (different crops growing in the field at the same time) would give an average yield increase of 30% (8). So it would be possible to feed the world without synthetic fertilisers, but that would require a radical change in our agricultural model.

The easiest short-term change would be to reduce intensive livestock farming and meat consumption. Livestock accounts for 75% of ammonia emissions. Animals housed indoors release four times more ammonia into the atmosphere than those in pastures (assuming grazing is not too intensive). There are technical measures for reducing emissions (covering or burying slurry, and using ammonium nitrate rather than urea), but these can be costly and in some cases relatively inefficient. Ending the use of synthetic nitrogen fertilisers would mean returning to combined arable and cattle farming, which would reduce the proportion of animals reared indoors. Chemical fertilisers have enabled us to produce relatively cheap cattle fodder and satisfy demand for meat and dairy products. In Europe, that demand has fallen, and we need to encourage this by eating less, but better-quality, meat.

A new green revolution to correct the disastrous consequences of the first one is possible. We must gradually cut the use of synthetic nitrogen fertilisers and opt for less intensive, free-range livestock farming. All that is missing is consumer information and political will.

CLAUDE AUBERT
Claude Aubert is an agricultural engineer specialising in organic agriculture, and a co-founder of the publishing house Terre Vivante.

Translated by Krystyna Horko

---

(1) Mark A Sutton et al (eds), *The European Nitrogen Assessment: Sources, Effects and Policy Perspectives,* Cambridge University Press, 2011.

(2) Secten Emissions Inventory [http://www.citepa.org/], Interprofessional Technical Centre for the Study of Air Pollution, Paris, 2017 (updated 10 July 2018).

(3) The name given to particles suspended in air with a diameter below 2.5 micrometres, or PM2.5.

(4) 'Ambient (outdoor) air quality and health [https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health]', World Health Organisation, Geneva, 2 May 2018.

(5) Secten Emissions Inventory, 2017, op cit.

(6) 'Nitrogen in Europe: assessment of current problems and future solutions (NinE) [http://archives.esf.org/coordinating-research/research-networking-programmes/life-earth-and-environmental-sciences-lee/completed-esf-research-networking-programmes-in-life-earth-and-environmental-sciences/nitrogen-in-europe-assessment-of-current-problems-and-future-solutions-nine.html]', International Nitrogen Initiative, European Science Foundation, Strasbourg, 2011, www.nine-esf.org/ [http://www.nine-esf.org/].

(7) Lauren C Ponisio et al, 'Diversification practices reduce organic to conventional yield gap', *Proceedings of the Royal Society B,* vol 282, no 1799, London, 22 January 2015.

(8) Marc-Olivier Martin-Guay et al, 'The new Green Revolution: sustainable intensification of agriculture by intercropping', *Science of the Total Environment,* vol 615, Amsterdam, 15 February 2018.

TRANSLATIONS >>

FRANÇAIS Les engrais azotés, providence devenue poison (fr)

ESPAÑOL Los fertilizantes nitrogenados, una bendición convertida en veneno (es)