ARAB FERTILIZER ASSOCIATION (AFA)

10TH INTERNATIONAL ANNUAL CONFERENCE

CAIRO, 20-22 JANUARY 2004

The International Nitrogen Initiative: Implications for the Fertilizer Industry

by L.M. Maene

Director General

International Fertilizer Industry Association (IFA)

Paris, France

INTRODUCTION

Nitrogen is essential to the survival of all life forms yet the natural abundance of useable nitrogen is so low that massive human alteration of the nitrogen cycle has been required to feed the world's population. The alteration has been made even greater by the release of nitrogen oxides to the atmosphere during fossil fuel combustion. These changes in the nitrogen cycle have raised a number of environmental issues, all of which have impacts on people and ecosystems on a regional or global basis.

As a response to growing concerns about these unwanted impacts, the International Nitrogen Unit was jointly established in 1978 by the Scientific Committee on Problems of the Environment (SCOPE) and the United Nations Environment Programme (UNEP).

Progress in learning about nitrogen biogeochemistry was continued at two major international conferences on nitrogen over the past six years. The First International Nitrogen Conference, with a focus on Europe, was held in the Netherlands in March 1998. Three years later, the Second International Nitrogen Conference was held in the United States in October 2001 with a focus on North America and Europe. The Third Conference, organized by the Chinese Academy of Sciences and other organizations in Nanjing, China in October 2004, will focus on Asia.

One of the recommendations of the Second Conference was to establish the International Nitrogen Initiative (INI). In December 2002, both SCOPE and the International Geosphere-Biosphere Programme (IGBP) agreed to become founding sponsors. The overall goal of the Initiative is to optimize nitrogen's beneficial role in sustainable food production and minimize nitrogen's negative effects on human health and the environment from food production and fossil fuel consumption.

In September 2001, the International Fertilizer Industry Association (IFA) indicated its interest in being associated with the development of a project on nitrogen emissions from agriculture, particularly those resulting from the use of N fertilizers. Given that there are still major uncertainties regarding the fate of fertilizer N added to agricultural soils and the potential for reducing emissions to the environment by enhancing the efficiency of N fertilizer use, this was of interest and importance to SCOPE.

From an early stage the International Fertilizer Industry Association (IFA) has been associated with these efforts both because the fertilizer industry recognizes that it shares responsibility for the impact of its products throughout their life cycle and because initiatives to reduce negative impacts resulting from interference with the nitrogen cycle could have deleterious effects on the fertilizer industry's operating environment.

THE EVOLUTION OF HUMAN EFFECTS ON THE NITROGEN CYCLE

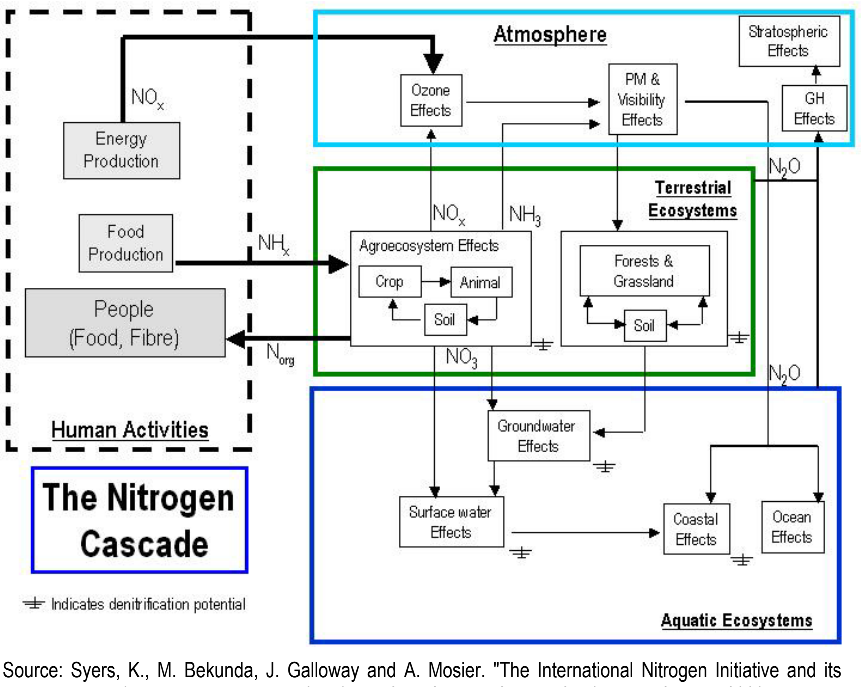
Two related developments have been key in driving human impacts on the nitrogen cycle. The first has been the global explosion in the human population since the dawn of the Industrial Revolution. Between 1900 and 2000, the population expanded by about sixfold, an exponential increase that is unparalleled in human history. Although this leap in population numbers is expected to level off within the next fifty years, the increase has outstripped a number of coping responses. However, contrary to all expectations, food production has not only kept pace, but exceeded the population growth rate. Modern agriculture is even managing to fulfill demands stemming from a qualitative shift in human diets to include more meat. This being said, due to uneven distribution and other constraints, the Food and Agriculture Organization of the United Nations (FAO) estimates that some 800 million people still live in a chronic state of hunger[1].

One of the key elements of modern agriculture that has helped to meet expanding food demand has also opened the door to significant human impacts on the nitrogen cycle. The Haber-Bosch process, developed in the early twentieth century is credited with supplying some 40 per cent of the protein consumed by humans around the globe today.[2] This technology captures inert atmospheric N and converts it into a form that plants can absorb; however, when supplied in excess this now reactive nitrogen can also have unwanted impacts on the environment. Reactive nitrogen can contribute to smog, acid deposition, climate change, coastal eutrophication and stratospheric ozone depletion.

The second human activity that contributes significantly to the release of reactive nitrogen is the burning of fossil fuels, which has also increased notably during the Industrial Age.

Human activities now fix some 165 million tonnes (Mt) of nitrogen annually. Natural processes only fix about 100 Mt, so human activities have increased the global load by some 150 per cent. Since 1950, the sharply rising curves for the creation of reactive nitrogen and fertilizer use have run almost perfectly in parallel. The problem is compounded by the fact that nitrogen remains reactive in the environment for a long time before being reconverted to its inert state. Cascading through the environment, the nitrogen can have multiple negative impacts before biological processes eventually revert it to its non-reactive form.

In the 1970s, scientists began to note the potential negative impacts associated with industrial nitrogen fixation, which had previously been considered an unquestionable success because it allowed farmers to meet global food needs. Since that decade, regulators have had some success in addressing the emissions of NO_x, largely because industrial releases are easier to pinpoint than those arising from agriculture. For example, following amendments to the US Clean Air Act in 1990, NO_x levels have been stabilized in the United States.



Source: Syers, K., M. Bekunda, J. Galloway and A. Mosier. "The International Nitrogen Initiative and its Relevance to Africa". Presented at the 6th African Crop Science Society Conference. October 2003.

Reactive nitrogen in agriculture has proved much more difficult to control, because sources are diffuse, emanating from a large number of farms. As a result, a significant number of sampled streams in the United States have nitrogen levels that exceed the background amounts. Nitrate concentration in groundwater has increased in some parts of Europe. Asia is particularly concerned due to the political imperative to feed burgeoning populations. Asia now contributes about 35

[1] *The State of Food Insecurity in the World 2003*. Food and Agriculture Organization of the United Nations. November 2003.

[2] Smil, V. "How many people does fertilizer nitrogen feed?". In *Enriching the Earth*. MIT Press. Cambridge, Massachusetts, USA. 2001: pp. 156-161.

per cent of synthetically fixed nitrogen, and the actual amount is expected to double over the next three decades.[3] Latin America has a mixed experience with agricultural nitrogen use, and Africa stands out as the only continent that totally defies this trend: Africa suffers from an alarming depletion of plant-available nitrogen and other nutrients in its soils.

At the same time, following a regulation-induced reduction of nitrogen fertilizer use in Denmark, the protein content of feed wheat has declined by almost two per cent over the last decade. Both food quality and food quantity are closely linked with an adequate supply of plant-available nitrogen.

Therefore, although excessive reactive nitrogen has negative effects at local, regional and global levels, it is clear that there is no one-size-fits-all solution. Nor would a policy of simply reducing global fertilizer use fulfill the double demand of producing enough high-quality and nutritious food for the world and reducing negative impacts.

THE INTERNATIONAL NITROGEN INITIATIVE

It is precisely with this double mandate that the scientific community created the International Nitrogen Initiative. Recognizing that humanity today cannot live without the nitrogen currently fixed by the Haber-Bosch process, scientists decided to undertake an interdisciplinary effort to learn how best to live with industrial nitrogen fixation. To date, the scientific assessment of the nitrogen issue has been fragmented, creating a need for an integrated scientific effort to evaluate past research, to consider the implications of various future scenarios and to identify and assess potential mitigation strategies. Successful nitrogen management will clearly involve a wide range of actors, and it is evident that the fertilizer industry has a significant place at the table.

The work of the International Nitrogen Initiative builds on efforts of the International Council for Science (ICSU) / Scientific Committee on Problems of the Environment (SCOPE) Nitrogen Project. Over the past decade experts have synthesized a mountain of knowledge on the nitrogen cycle, with a particular focus on East Asia, Europe, Latin America and North America. Some fifteen workshops and symposia as well as two major international conferences have been held. The results have been published in seven books and several special issues of scientific journals.

Nonetheless, substantial uncertainties remain about how to maximize food production and the efficiency of fossil fuel consumption while maintaining a healthy environment. This lingering doubt led to the creation of the International Nitrogen Initiative (INI) at the recommendation of the Second International Nitrogen Conference.

The Initiative is organized on a regional basis, with centres being established in Africa, Asia, Europe, Latin America, North America and Oceania. A Scientific Advisory Committee oversees and coordinates the different parts of the programme. The activities of any given centre will be determined by the maturity of both nitrogen science and policy for that region.

Each regional centre will use a three-phase approach:

1. Assessment of knowledge on nitrogen flows and related problems;

2. Development of region-specific solutions to the problems identified in Phase I;

3. The use of scientific, engineering and policy tools to implement these solutions, in cooperation with critical stakeholder groups.

Phase I is organized around cross-cutting themes at both global and regional levels. Initial themes are natural processes (e.g. biological N fixation, denitrification), agriculture, fertilizers, animal production, human waste and energy production / use.

Funding for the Initiative comes from a wide number of sources. Costs related to the secretariat have so far been contributed by the Dutch government, the International Council for Science and SCOPE. IFA, the United States Department of Agriculture's Agricultural Research Service (USDA/ARS) and the USDA Foreign Agriculture Service have all contributed to the Nitrogen Fertilizer Rapid Assessment Project. Additional support has not yet been confirmed.

---

[3] Kaiser, Jocelyne. "The Other Global Pollutant: Nitrogen Proves Tough to Curb". *Science*. American Association for the Advancement of Science. Washington, DC, USA. Vol. 294 (9 November 2001): p. 1268.

The American National Science Foundation and Environmental Protection Agency have pledged money to support the scheduled Denitrification Workshop, and other contributions are pending.

THE FERTILIZER RAPID ASSESSMENT PROJECT

Given the important uncertainties regarding the fate of fertilizer N added to agricultural soils and the potential for reducing emissions to the environment by enhancing the efficiency of fertilizer N use, it is natural that fertilizers are an initial focus of the International Nitrogen Initiative. Therefore, at the XIth General Assembly of SCOPE in September 2001, the International Fertilizer Industry Association (IFA) indicated its interest in being associated with a project on nitrogen emissions from agriculture.

The following issues were identified as priorities:

- Develop a better understanding and quantification of the fate of fertilizer N added to different farming systems in diverse environments (a regional need);

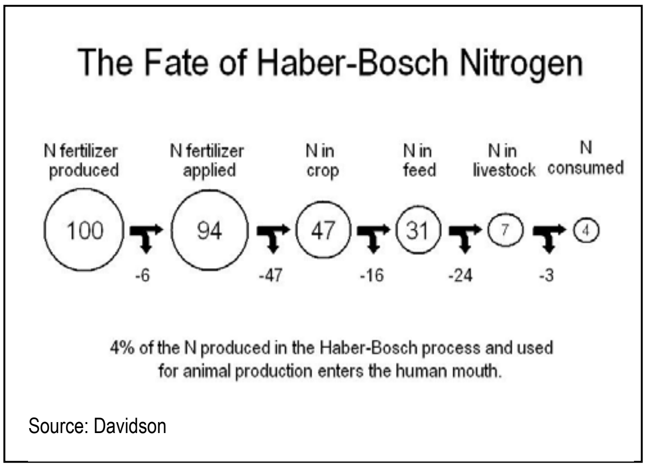
- Elaborate the concept of reactive N in agricultural systems and put this in context with other sources of N to water and the atmosphere (a conceptual and contextual need);

- Identify and assess the technological and management strategies for enhancing the agronomic efficiency of fertilizer N and reducing emissions to the environment, with positive benefits to the economic efficiency of fertilizer N use (a management and societal need).

Following the approval by SCOPE of this Rapid Assessment Project (RAP), a planning meeting was held in April 2003. The Working Group has the mandate "to assess the fate of mineral fertilizer N in the context of overall N inputs into agricultural systems, with a view to enhancing the efficiency of mineral fertilizer N use and reducing negative impacts on the environment".

A workshop will be held in Kampala, Uganda on this subject in mid-January 2004, with the final report is expected to be completed in time for the Third International Nitrogen Conference in October 2004 in China. Kampala was chosen as the site for the meeting to emphasize that management of the global nitrogen cycle is not just about reducing fertilizer use, a statement that seems totally absurd in an African context. Proper management of nitrogen globally will mean rebalancing its use across regions, according to local needs.

THE FERTILIZER INDUSTRY AND THE NITROGEN CONUNDRUM: THREATS, OPPORTUNITIES AND RESPONSIBILITIES



Concerns regarding the nitrogen cycle pose potential policy and economic challenges to the fertilizer industry. Although scientists have been careful to underline the vital role of the industry in efforts to feed the world, a number of them frequently highlight the inherent inefficiency of the delivery of nitrogen fertilizer products, most of which have remained virtually unchanged since industrial nitrogen fertilizer production began. The industry itself often cites a figure of 30 to 40 per cent maximum uptake by the plant of the nitrogen applied in fertilizer to rice grown under tropical conditions. Other crops grown under temperate conditions may use as much as 80 per cent of the applied nitrogen. The estimations of one scientist[4] put the average at about 47 per cent. However, the researcher carries the analysis further,

[4] Davidson, Eric A. "Human Alteration of the Global Nitrogen Cycle: Scale and Scope of the Problem". Presented at the open meeting of the Ad hoc Group of Experts on Nitrogen Management for Food Security and Ecosystem Security held in the context of the World Summit on Sustainable Development. Johannesburg: August 2002.

pointing out the losses that occur at harvesting and in food production. As a result, a vegetarian consumes some 14 per cent of the nitrogen fixed in the fertilizer. For a meat-based diet, end consumption drops to a mere four per cent.

It is puzzling that farmers, who are often squeezed between the relatively high cost of inputs and low prices for their crops, tolerate such inefficiency, when simple management practices could make a significant improvement. By developing products that favour efficient uptake, the industry could reduce the overall cost of raw materials, with a positive impact on per unit margins. A number of other industries have discovered that increasing the eco-efficiency of production methods and the final products themselves often pays for itself by reducing production costs significantly. Society has probably been tolerant of this performance in part because of the essential role of fertilizers in helping feed humanity. Furthermore, scientists have only begun to understand the consequences of introducing excessive reactive nitrogen into the environment fairly recently. However, there are strong signals that this state of affairs will not last. The industry therefore has the choice of adopting a voluntary, proactive response or of assuming the unpredictable and likely high costs of a response designed by policymakers rather than fertilizer experts.

Scientists involved in the International Nitrogen Initiative suggest that there are two major ways to reduce the unwanted effects arising from the human disruption of the nitrogen cycle. The first is to create less reactive nitrogen by increasing the N use efficiency in food production and recycling reactive N within agroecosystems. The second is to convert unused nitrogen back to N_2 before it is lost to the environment.

For the fertilizer industry, there are three potential points of action.

The first is in the nature of its fertilizer products. Although some slow-release fertilizers, controlled-release products and nitrification inhibitors exist, this market remains underdeveloped. Research on such products is concentrated in a handful of companies. The usual argument is that markets will not bear the extra cost of research and development because margins on fertilizers are extremely small. Even scientists note the difficult economics of the current system, where farmers have no economic incentive to demand products with a better performance. However, these calculations only hold in a short-term perspective. Considering the issue more strategically, stricter regulation of crop nutrient use is quite likely to be imposed within the next decade unless efforts succeed in reversing the growing negative impacts arising from nutrient leaching and loss to the environment. Compliance is likely to be costly for companies that have not previously increased the efficiency of their products. At the end of the day, the decision to continue producing low-efficiency commodity fertilizers or high-performance products could be a major factor deciding the viability of nitrogen fertilizer producers over the long term.

The second opportunity to improve the efficiency of nitrogen fertilizer use and, therefore, to reduce regulatory pressure is in the field. No matter how advanced the technology used in the factory, excessive application or bad timing of fertilizer use could still trigger negative environmental impacts. It is therefore vital to continually improve on-farm fertilizer management, an objective that is complicated considerably by the almost limitless combinations of soil types, agroclimatic conditions, crop varieties and other site-specific factors that together define the best practice. Again, although the industry dedicates some resources to supporting agronomic research, there is some reluctance to expand this support both because of small profit margins and because increasing fertilizer use efficiency could be interpreted as detrimental to sales within a short-term perspective. Taking into account that fertilizer use is likely to continue growing in developing regions to meet increasing food demands, the long-term costs of supporting more agricultural research are probably lower than the eventually adaptation costs of responding to stringent regulations.

The third area for potential action is the conversion of “lost” nitrogen back into its inert state. Within an industrial context, it is easier to imagine possible solutions for this problem: systems similar to chimney scrubbers could be developed to reconvert NO_x to N_2 as it is emitted. Doing this in the agricultural sphere is less obvious, precisely because the release of reactive nitrogen is intentional, since plants cannot take up inert nitrogen. However, it might be possible to develop mechanisms in buffer zones around fields that reconvert nitrogen in run-off water, therefore reducing the loss of reactive nitrogen, especially into waterways. This would require a combination of technology and management adjustments.

CONCLUSIONS

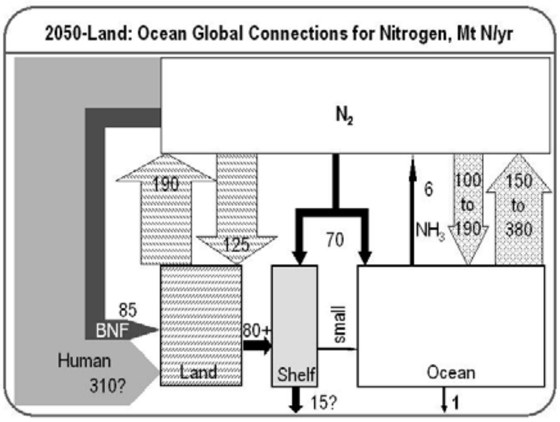
Until recently, human interference in the nitrogen cycle has not attracted the same level of global attention as chlorofluorocarbons (CFCs) that damage the ozone layer or contribute to global warming, but experts increasingly warn that the nitrogen issue is also problematic. Scientists have become more active on this issue, and it is likely that policy efforts to address the topic will multiply in the coming decade. The International Fertilizer Industry Association (IFA) already participates in the International Nitrogen Initiative with a number of objectives:

- To ensure that the perspective of the industry is taken into account during deliberations, an effort that has borne fruit by ensuring that the Initiative considers regions that lack reactive nitrogen as well as those dealing with an excess;
- To monitor potential regulations on reactive nitrogen that could have negative impacts on the fertilizer industry's operating environment;
- To identify areas where voluntary efforts by the industry could contribute to the alleviation of demonstrated problems, thus creating goodwill on the part of other stakeholders, such as regulators.

The scientists addressing the nitrogen issue note that managing the N cycle presents a dilemma: the Haber-Bosch process that led to the production of manufactured nitrogen fertilizers has been a major success by allowing global food production to meet the needs of a burgeoning population. However, this success has not been unqualified: the fixation of such a large quantity of reactive nitrogen has some negative environmental impacts as the reactive nitrogen cascades through an ecosystem, triggering an entire chain of impacts. Solutions lie in finding the balance between meeting the nitrogen requirements of global agriculture and limiting the losses of reactive nitrogen to the environment. This means greatly increasing the efficiency of nitrogen fertilizer use, and subsequently diminishing the need to fix new nitrogen. Techniques for reconverting escaped nitrogen into its inert form will also play a role.

The technological improvement of nitrogen fertilizers and better agricultural management practices both have an important role in meeting this challenge. The global nitrogen fertilizer industry is now faced with a strategic decision and must weigh the costs of voluntary, proactive action against the costs of the imposition of heavy-handed regulation.

In fact the industry has the opportunity to be a leader by proactively reshaping its future to prevent a restrictive operating environment that could result from the business-as-usual scenario pictured at the left. Heavy regulation is not inevitable, but a careful examination of possible future scenarios shows that a business-as-usual response would increase the chances that government authorities would be the primary architects of a future nitrogen management system. The chances of an optimal outcome increase if the fertilizer industry adopts a proactive stance that seeks solutions in partnership with scientists to increase fertilizer use efficiency and to reduce the amount of fertilizer N that can cascade through the environment.



Source: Davidson

The participation of IFA in the International Nitrogen Initiative constitutes a first step towards industry engagement in finding ways to feed the world without endangering the global ecosystem through the introduction of excess reactive nitrogen. However, it is a challenge that all fertilizer producers need to take up and address individually and as a community.