Increasing environmental pollution load

An increasingly complex mix of pollutants threatens the Earth's regulatory mechanisms. Particulates, nitrogen and ground-level ozone merit particular attention because of their complex and potentially far-reaching effects on ecosystem functioning, climate regulation and human health. In addition, many other chemical substances are released into the environment, with effects — in isolation or combined — that are still poorly understood.

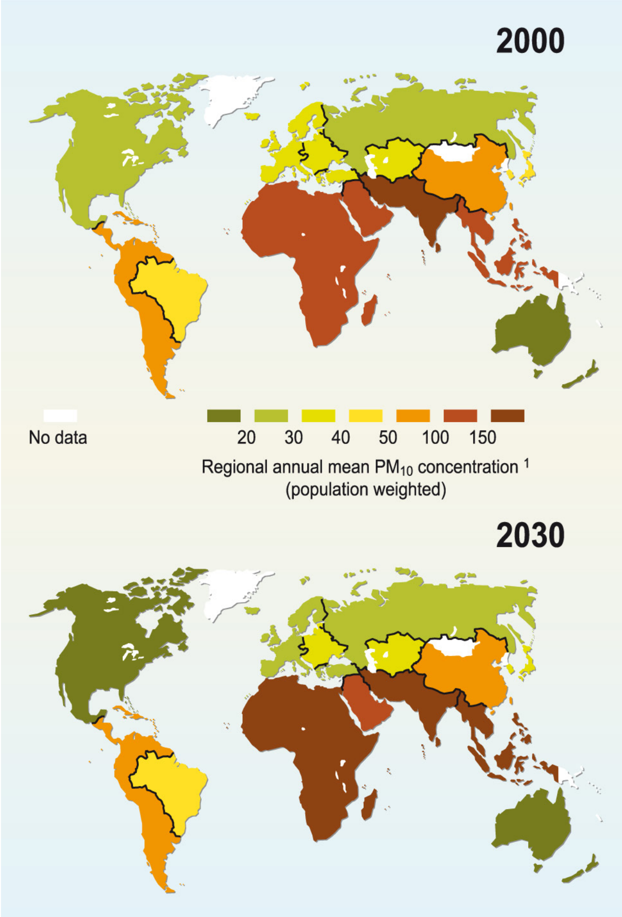
Over recent centuries the human impact on the environment has risen steadily as the population grew. The effects on air and (drinking) water quality were primarily felt locally. In the last few decades we have seen more and more regional impacts (e.g. acid rain) and many problems already have a global impact (e.g. climate change and stratospheric ozone loss). The existing mix of pollutants and their effects (in isolation or combined) has grown more and more complex, with environmental feed-backs becoming apparent at ever-wider scales. The term 'anthropocene' has been suggested to describe our era, where human resource use has become a dominant driving force, shaping the Earth and its regulating mechanisms (Crutzen, 2002).

Four environmental pollution subtrends that merit particular attention in view of their complex nature and potentially far-reaching effects are highlighted below. They share most of the same drivers (for instance industrialisation, globalisation and rising consumption) and contribute to the general deterioration of ecosystems and/or human health.

Particulate matter pollution

Apart from emitting greenhouse gases, fuel burning for heating, industry and transport also leads to pollution of the air with small particles (PM_{10}- particles up to 10 micrometer in diameter). Urban haze or rural smoke can ultimately become transcontinental plumes of atmospheric brown clouds. These brown clouds consist of sulphate, nitrate, hundreds of organic chemicals, black carbon, soil dust, fly ash, and other aerosols (Ramanathan and Feng, 2008). This type of pollution is projected to increase, particularly in rapidly developing countries. Although atmospheric brown clouds so far have predominantly been an Asian phenomenon, long-distance transport to other parts of the world can happen. Recently, an SO_2-rich pollution plume of East Asian origin was detected over Europe, having traveled across the North Pacific, North America and the North Atlantic in only 8 to 10 days (Fiedler et al., 2008).

Particulate matter pollution



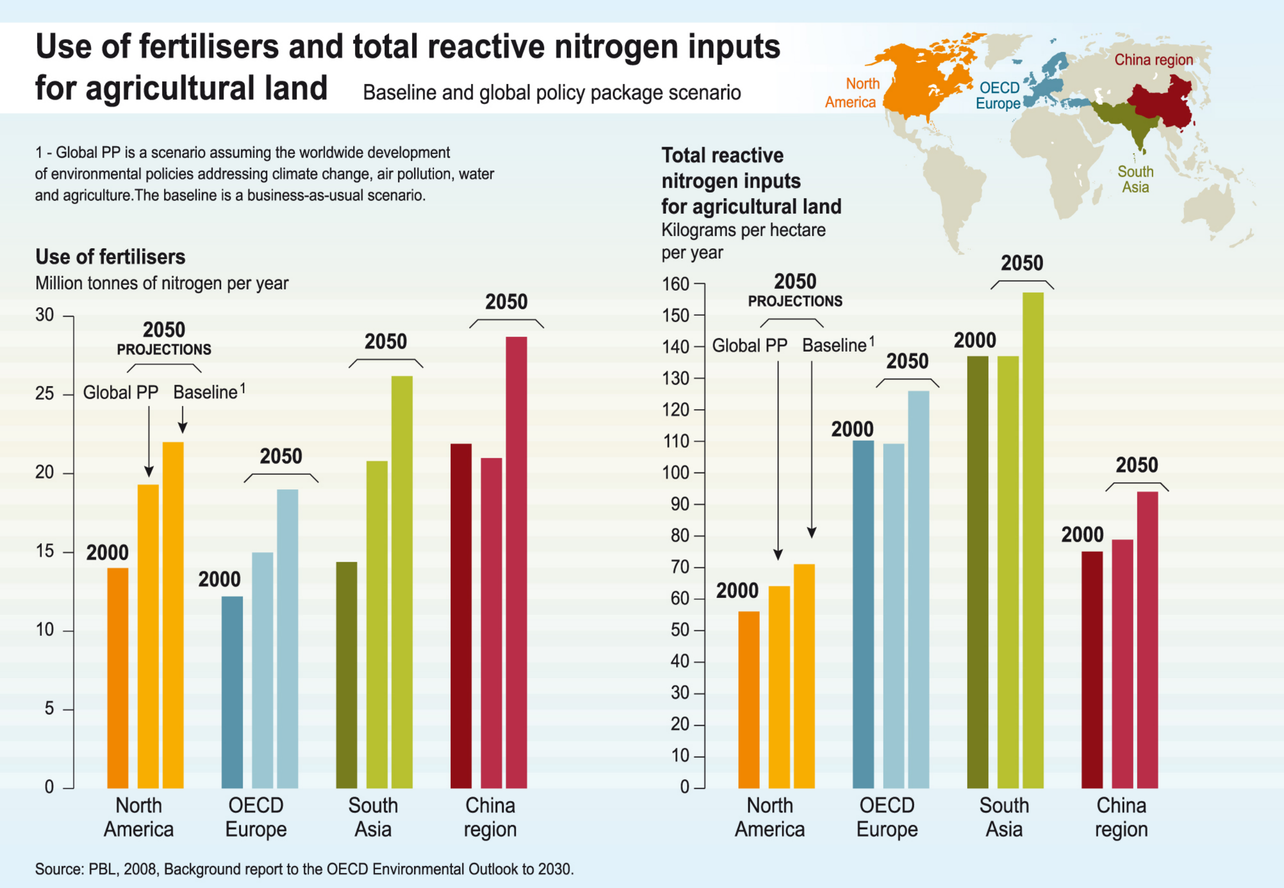
1 - PM_{10} is particulate matter 10 micrometres in diameter, or less.

Source: OECD, 200, *OECD Environmental Outlook to 2030.*

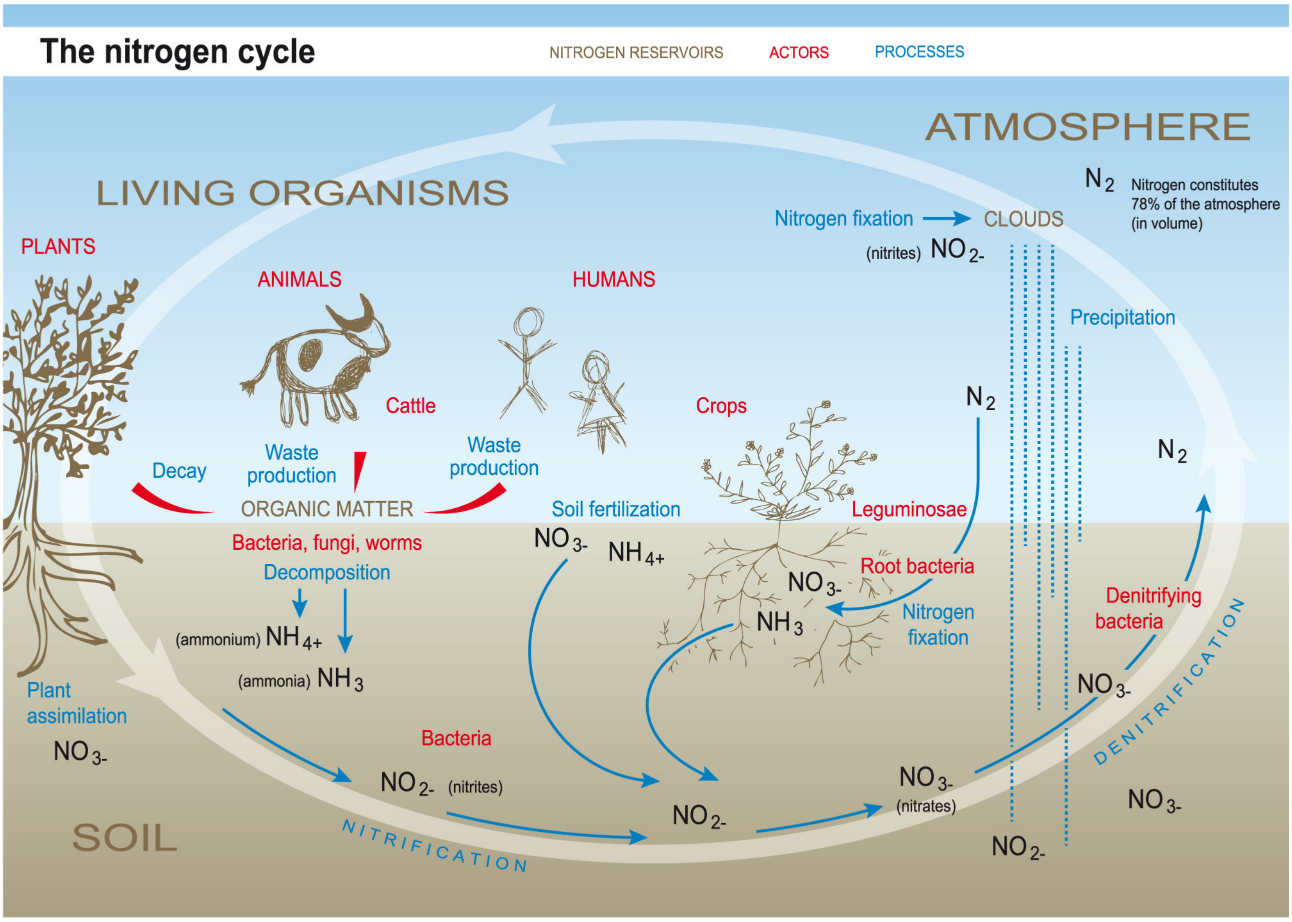
Reactive nitrogen ([1])

Fossil fuel combustion and production and the application of nitrogenous fertilisers both increase the amount of so-called "reactive nitrogen" in the environment, causing air pollution and eutrophication of terrestrial and aquatic habitats. Nitrogen makes up almost 80 % of the atmosphere in the shape of N_2 gas. This nitrogen is only available to plants if it is 'fixated' into reactive forms. Natural fixation in the atmosphere and in the soil is supplemented by industrial production of nitrogenous fertiliser. Fossil fuel combustion, emitting large additional amounts of NO_x, increases the load of reactive nitrogen even further. The total amount of reactive nitrogen in the environment has more than doubled as the result of these human activities (OECD, 2008).

The total amount of reactive nitrogen can be expected to increase further in line with food production and fossil fuel use. In a baseline projection, the total inputs of reactive nitrogen onto agricultural land are expected to increase by about 20 % by 2050, with the highest absolute levels in Asia. The global quantity of reactive nitrogen exported by rivers to coastal marine systems is projected to increase by about 4 % by 2030, with a decrease in OECD countries of about 5 % being overshadowed by an 11 % increase in the BRIC (Brazil, Russia, India, China) countries.



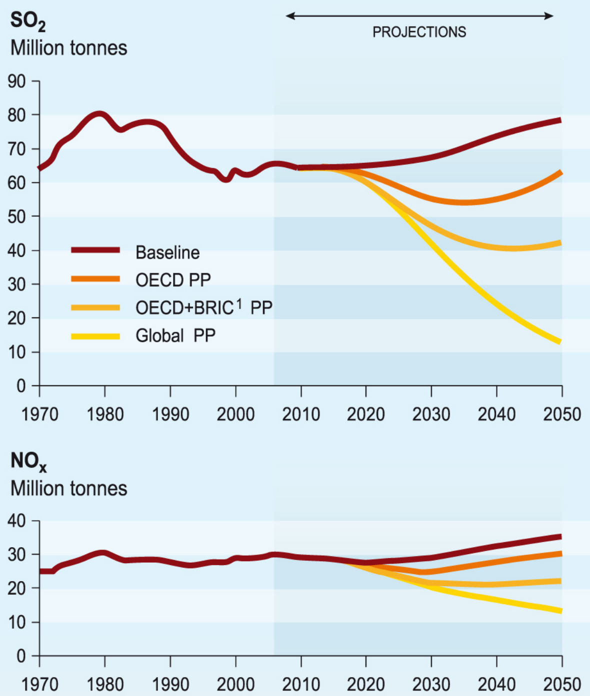
Use of fertilisers and total reactive nitrogen inputs for agricultural land
Baseline and global policy package scenario
North America
OECD Europe
China region
South Asia
1 - Global PP is a scenario assuming the worldwide development of environmental policies addressing climate change, air pollution, water and agriculture. The baseline is a business-as-usual scenario.
Use of fertilisers
Million tonnes of nitrogen per year
2050 PROJECTIONS
Global PP
Baseline 1
2000
2050
Total reactive nitrogen inputs for agricultural land
Kilograms per hectare per year
North America
OECD Europe
South Asia
China region
Source: PBL, 2008, Background report to the OECD Environmental Outlook to 2030.



The nitrogen cycle
NITROGEN RESERVOIRS
ACTORS
PROCESSES
ATMOSPHERE
LIVING ORGANISMS
N2
Nitrogen constitutes 78% of the atmosphere (in volume)
Nitrogen fixation
CLOUDS
(nitrites) NO2-
PLANTS
ANIMALS
HUMANS
Precipitation
Cattle
Crops
Decay
Waste production
Waste production
ORGANIC MATTER
Soil fertilization
Leguminosae
Bacteria, fungi, worms
Decomposition
NO3-
NH4+
Root bacteria
NH3
Nitrogen fixation
Denitrifying bacteria
(ammonium) NH4+
(ammonia) NH3
Plant assimilation
NO3-
Bacteria
NO2- (nitrites)
NO3- (nitrates)
NO2-
SOIL
NITRIFICATION
DENITRIFICATION

Emissions of selected air pollutants

as a result of three environmental policy packages



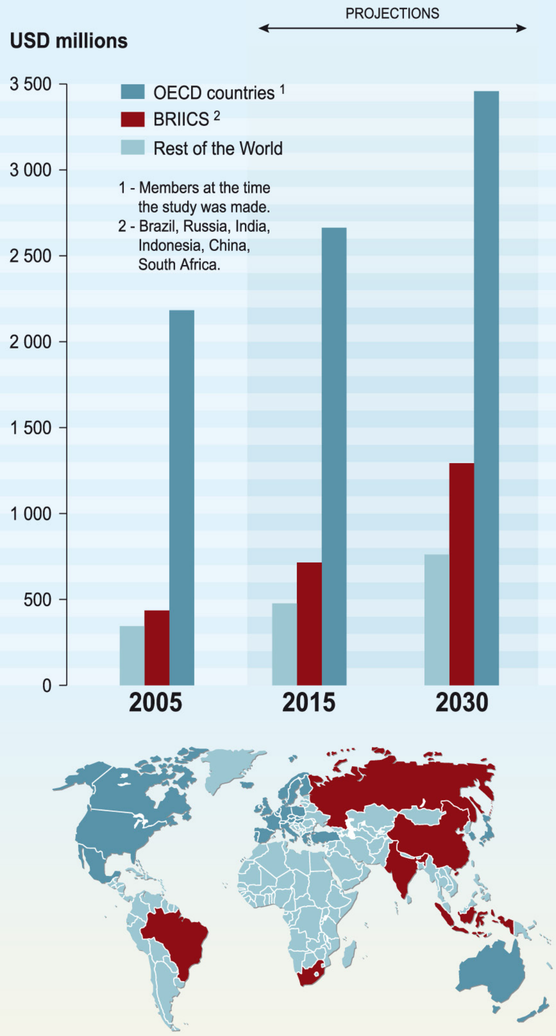
The OECD Environmental Outlook simulated three environmental policy packages (PP) addressing four issues (agriculture, climate change, air pollution and water quality), applied to specific groups of countries and at a global level.

- The OECD PP would result from applying the following policies to OECD countries: carbon taxes, a substantial reduction in air pollution and improved sewage systems.
- The OECD+BRIC PP would result from applying the same policies to OECD and BRIC countries, adding deregulation of agriculture (cutting subsidies and tariffs).
- The Global PP would involve applying all these policies worldwide (with delayed target for low income countries).
- The baseline is a no-new policies scenario (or business-as-usual). It is not the most plausible future development but a good benchmark for comparison.

1 - Brazil, Russia, India and China.

Sources: OECD, 2007, *OECD Environmental Outlook Baseline and policy simulations*; PBL, 2008, *Background report to the OECD Environmental Outlook to 2030.*

Production of chemicals



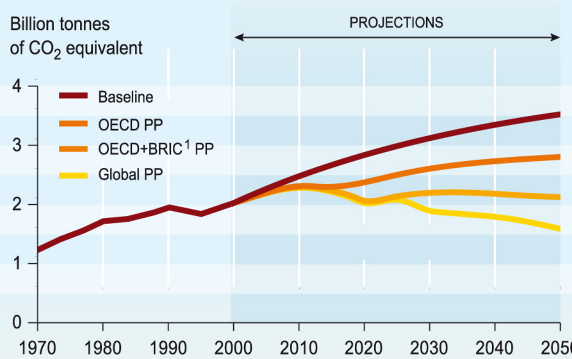
Source: OECD, 2008, *OECD Environmental Outlook to 2030.*

Ground level ozone

Ground level (tropospheric) ozone acts as a greenhouse gas and also affects primary plant production and human health. Background tropospheric ozone concentrations in the Northern Hemisphere have doubled since the Industrial Revolution as a result of anthropogenic emissions of a range of ozone precursors, including nitrogen oxides (NO_x), non-methane volatile organic compounds, carbon monoxide (CO) and methane (CH_4). Fossil fuel burning in industry and transport and agriculture are the main sources of these emissions. Air quality modelling indicates that ozone concentrations may increase further regionally, particularly in Asia, Africa and South America. Whereas NO_x and CO emissions may decrease as a result of technical advances and policy measures, emission of methane is projected to almost double by 2100 (Royal Society, 2008).

Methane emissions

as a result of three environmental policy packages



1 - Brazil, Russia, India, China.

Sources: OECD, 2008, *OECD Environmental Outlook to 2030*; PBL, 2008, *Background report to the OECD Environmental Outlook to 2030.*

Chemicals

The overall picture for chemicals is that we are burdening the environment with a rapidly expanding and increasingly complex pollutant load, the potential effects of which on public health and the environment are poorly understood. An estimated 70 000 to 100 000 chemical substances are already in commerce and this number is rapidly expanding. Almost 5 000 of these substances are produced in high volumes, over one million tonnes a year. The OECD countries are the biggest producers of chemicals, but production is increasing more than twice as fast in India, China, Brazil, South Africa and Indonesia. Their economic share of total world chemical production is projected to rise to around 30 % by 2020 and almost 40 % by 2030 (OECD, 2008).

Whereas some environmental aspects of chemicals, like toxicity and eco-toxicity, exposure or emissions, are regulated by different regulation e.g. on pesticides, biocides, radioactive substances etc., the EU REACH Regulation (2007) provides a comprehensive approach to industrial chemicals in manufacturing and products. It is being taken into account in many parts of the globe.

Why is this increasing pollution load important for Europe?

Particulate matter seriously endangers human health, particularly in urban areas. It can also have an impact on the climate in Europe and affect crop and water security. In Europe, pollution with fine particles ($PM_{2.5}$ – smaller than 2.5 micrometers) is associated with approximately 500 000 premature deaths per year at present.

Nitrogen pollution affects the atmosphere by depleting stratospheric ozone. It also affects groundwater quality and leads to eutrophication of freshwater and marine ecosystems. After application of manure and fertilisers to agricultural land, excess nutrients may be emitted to the air or leak as nitrate into ground water or run off to surface water. This freshwater pollution load is ultimately discharged to coastal waters, where it accelerates the growth of phytoplankton. It can change the composition and abundance of marine organisms and ultimately lead to oxygen depletion, killing bottom-dwelling organisms. Oxygen depletion has risen sharply over the past 50 years, from about 10 documented cases in 1960 to at least 169 in 2007 worldwide, and is expected to become more widespread with increasing sea temperatures induced by climate change.

The current ground level ozone concentrations in industrialized regions of North America, Europe and Asia can reduce yields of staple crops by as much as 10 to 20 %. The productivity and species composition of natural habitats may also change, putting biodiversity at risk, particularly in South East Asia, South America, Central Africa, the eastern USA and Western Europe. The raised ozone levels in North America and Europe are also associated with respiratory and cardiovascular problems and increased mortality. There is increasing evidence that long-term chronic exposure has adverse effects on lung function. Health impacts have been observed at around ambient concentrations (approximately 35 ppb) and below the current WHO guideline of 50 ppb (for a daily eight-hour average concentration). The number of premature deaths due to ground level ozone worldwide is expected to quadruple by 2030.

Chemicals may be toxic and affect human health and ecosystem functioning in many ways, although uncontested evidence for toxicity remains limited to only a few hundreds of the most traded substances. The effects of very persistent chemicals are particularly difficult to assess. Long-term low-dose exposure to these substances may have subtle but serious effects. Exposure to neuro-toxic chemicals, for example, has been associated with mild neuro-developmental disorders in children.

A further concern is that traditional toxicological assessment is normally undertaken only on individual chemicals. The toxicity of the breakdown products is less certain and the overall impact of the cocktail of chemicals on ecosystem structure and function (especially in marine and freshwater ecosystems) and on human health is unknown and hard to adequately test for. Recent research points to the risks of accumulating pharmaceuticals in the environment. These substances may have strong environmental effects, since they are specifically designed to affect biological functioning. The presence of hormone-mimicking substances in water, for example, has been linked to the feminisation of fish.

The potential consequences for Europe of global pollution trends include further impacts on human health and ecosystems. Unsafe drinking and bathing water and contaminated food, from both European products and imports, pose immediate risks. Risks may also be connected to the increasing import of intermediate and final industrial chemical products. In Europe, the reactive nitrogen problem is particularly evident in the Baltic Sea, where the current ecological status is already poor.

Key drivers and uncertainties

Economic growth and population increase cause increasing emissions of reactive nitrogen, ozone precursors and chemical waste. Climate change and land use changes may influence the production of emissions from natural sources. Increased demand for energy, transport, food and non-food crops and other resources may further increase emissions arising from human activity, and changes in patterns of consumption and production are likely to affect the distribution of the pollutants. Legislation and technology may, however, contribute to decoupling pollution from economic growth.

Key uncertainties concern the actual impacts on health and ecosystems of the different pollutants, as well as their compound effects. The possible effects of nitrogen, ozone and particulate matter on climate change poses a complex cross-cutting issue with many uncertainties. Consumer behaviour, risk awareness, technology developments and policy responses are major uncertainty factors.

(1) Reactive N (Nr) includes: inorganic reduced forms of N (e.g. ammonia [NH3] and ammonium [NH4 +]); inorganic oxidised forms (e.g. nitrogen oxide [NOx], nitric acid [HNO3], nitrous oxide [N2O] and nitrate [NO3 –]); organic compounds (e.g. urea, amines, proteins and nucleic acids) (Source: PBL, 2010).

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Map (page 60): Particulate matter pollution
OECD, 2008. *OECD Environmental Outlook to 2030.* Organisation for Economic Co-operation and Development (http://www.oecd.org/document/20/0,3343,en_2649_34305_39676628_1_1_1_37465,00.html) accessed 17 November 2010.

Figure (page 61): Use of fertilisers and total reactive nitrogen inputs for agricultural land
PBL, 2008. *Background report to the OECD Environmental Outlook to 2030.* Overviews, details, and methodology of model-based analysis. Netherlands Environmental Assessment Agency, and Organisation for Economic Co-Operation and Development (http://www.rivm.nl/bibliotheek/rapporten/500113001.pdf) accessed 10 October 2010.

Figure (page 61): The nitrogen cycle
Bournay E., 2010.

Figure (page 62): Emissions of selected air pollutants
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Figure (page 62): Production of chemicals
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Figure (page 62): Methane emissions
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