‘Waiting until we near some suggested limit for nitrogen deposition and other pollutions will just permit us to continue to a point where it is too late.’

William Schlesinger, biogeochemist

Foto: StadtPresse Klagenfurt | Franz Gerdl

Urban Nitrogen Cycles

https://www.uncnet.org/

- Nitrogen is the main component of air, accounting for 78 %
- It is a common element in the universe, estimated at about seventh in total abundance in the Milky Way and the Solar System.
- Global atmospheric nitrous oxide (N_2O) mole fractions have increased from a pre-industrial value of ~270 nmol/mol to ~319 nmol/mol in 2005
- Human activities account for over one-third of N_2O emissions, most of which are due to the agricultural sector.
- Nitrogen occurs in all organisms, primarily in amino acids (and thus proteins), in the nucleic acids (DNA and RNA) and in the energy transfer molecule adenosine triphosphate.
- The human body contains about 3 % nitrogen by mass, the fourth most abundant element in the body after oxygen, carbon, and hydrogen.

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Project duration: 03/2019–02/2022

‘Nature does not waste nitrogen.’

Wilfried Winiwarter (UNCNET)

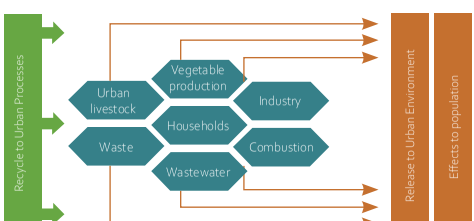
Foto: Stadt Presse Klagenfurt

Urban nitrogen metabolism

https://www.uncnet.org/

More atmospheric nitrogen (N_2) is now converted to reactive forms by human activities **than by all terrestrial processes on Earth combined**. This makes it difficult for both organisms and industry to convert N2 into useful compounds, but at the same time means that large amounts of often useful energy are released when nitrogen compounds are burned, exploded or decomposed to form nitrogen gas.

UNCNET studied and compared the nitrogen cycles in four cities – Vienna, Zielona Góra in Poland, and Shijiazhuang and Beijing in China. Klagenfurt played a special role here, as it served as a pilot region for the large cities.



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‘Ammonia is contributing to health-damaging fine particles in cities. Measures against ammonia emissions have many times greater benefits than their implementation costs.’

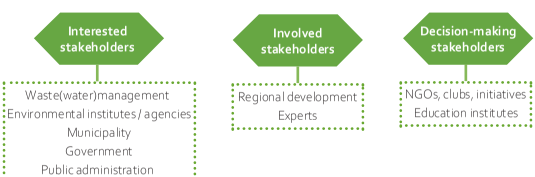
UNCNET

Foto: Stadtpresse Klagenfurt, Ingo Pauer

Stakeholder process

https://www.uncnet.org/

Especially in urban areas, the accumulation of nitrogen compounds leads to major problems. Ammonia and nitrate from imported food or nitrogen oxides from traffic and industry pollute air and water, accelerate climate change, impair biodiversity and endanger health. Particularly in cities, many people are directly affected. On the other hand, it is precisely here that a better understanding of the interrelationships can help to make sustainable decisions and significantly improve the effectiveness of measures.



During several workshops with different stakeholders, the project results could be discussed, coordinated and reflected with different decision-makers and stakeholders. For political decisions, it is essential to understand what makes stakeholders tick and how robust a scientific statement is.

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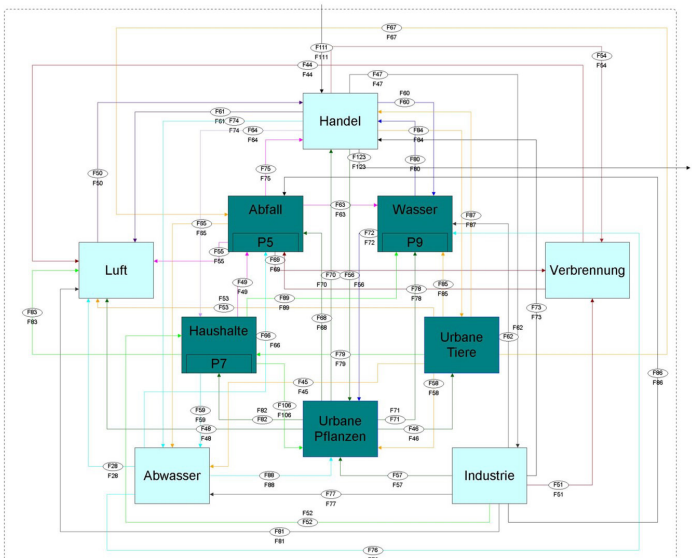
‘Nitrogen is life.’

Wim de Fris

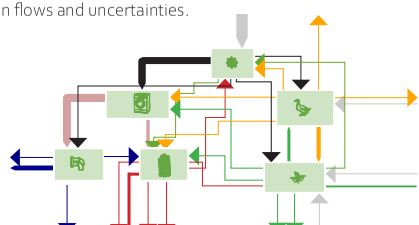


Period under review: 2015

Substance Flow Analysis

https://www.uncnet.org/

The complex nitrogen cycles and flows in cities were analysed during the project using different data. The STAN (subSTance flow ANalysis) model, developed by TU Wien, is a model for material flow analysis. It allowed not only the representation of the different processes, their deposits and the flows within the urban system boundaries, but also the calculation of unknown flows and uncertainties.



Data can be imported from an Excel file into the model as well as exported as an Excel file. The finished graph can be exported as an image. The representation of the flows is done in Sankey style, a graphical representation of quantity flows. This allows the arrow width to be shown in proportion to the flow size. The model is freely accessible to everyone: stan2web.net

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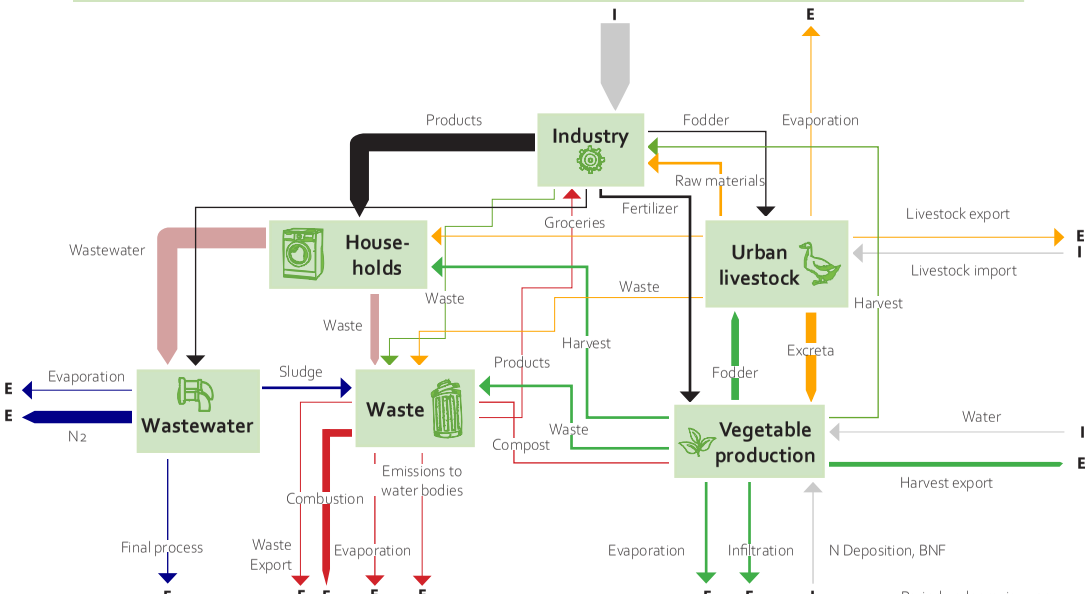
‘Saving nitrogen fertiliser would not jeopardise food security.’

UNCNET



Agriculture and food security

The importance of agriculture in urban areas can be considerable: the Chinese urban province of Beijing produces more milk than it consumes. Although milk consumption in China is generally much lower than in Europe, for example, it is remarkable that urban agricultural production requires local exports.

If we shut down the Haber-Bosch plants today, the nitrogen overabundance in the biosphere would decrease again in a few years. This is in contrast to the climate problem, where the atmosphere stores greenhouse gases such as CO_2 in the long term (even after the end of emissions, the effects of global warming remain in the long term). The question is whether we really need so much mineral fertiliser; the Haber-Bosch process is often cited; there are considerations on how to produce artificial fertiliser with hydrogen, but we need a lot of energy for this, our own wind farms; the advantage would be to bring back something that is already in the cycle so that we don't have to produce it separately.

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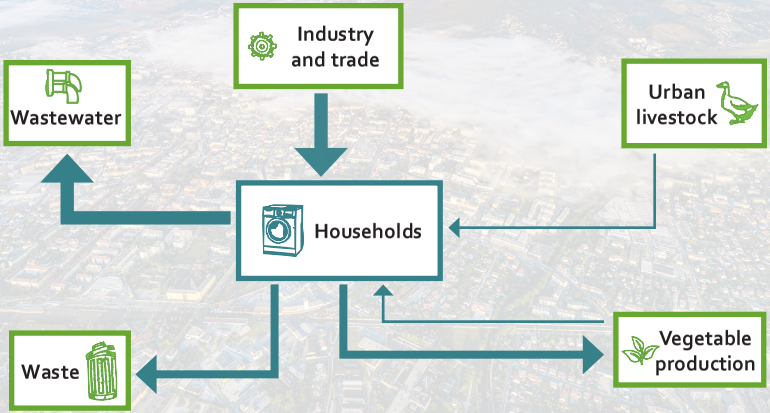
‘According to a new report, air pollution shortens the lives of billions of people by up to six years, making it a far bigger killer than smoking, car accidents or HIV/Aids.’

The Guardian



Period under review: 2015
Unit: t N / a

Foto: StadtPresse Klagenfurt | Helge Bauer

Households

Households refer to consumers. For a household, the nitrogen pools are calculated based on all products stored in the households (e.g. clothing, furniture, etc.).

The inflows to the household pool currently include the inflows from these pools: industry and trade, urban livestock and urban vegetable production. Industrial products also include commercial products, such as small retailers or supermarkets. Other important N fluxes here relate to consumed livestock products, harvested plants, flowers and garden fruits / vegetables and household waste. All types of waste are considered, which means that the waste composition is included in the calculations. With regard to households, the N discharged by the population into domestic wastewater, e.g. via excreta and household chemicals, is also taken into account.

Thus, the total amount of transported nitrogen can be properly assessed.

In addition, one can still calculate the N fluxes between households and combustion. These include all N emissions (NO_x, NO_2, NH_3 and N_2O) from the private transport and heating sectors as well as from other household appliances that emit N.

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‘The chemical industry used to fix nitrogen requires about 1.3 % of global energy, mostly using fossil fuels.’

Wilfried Winiwarter

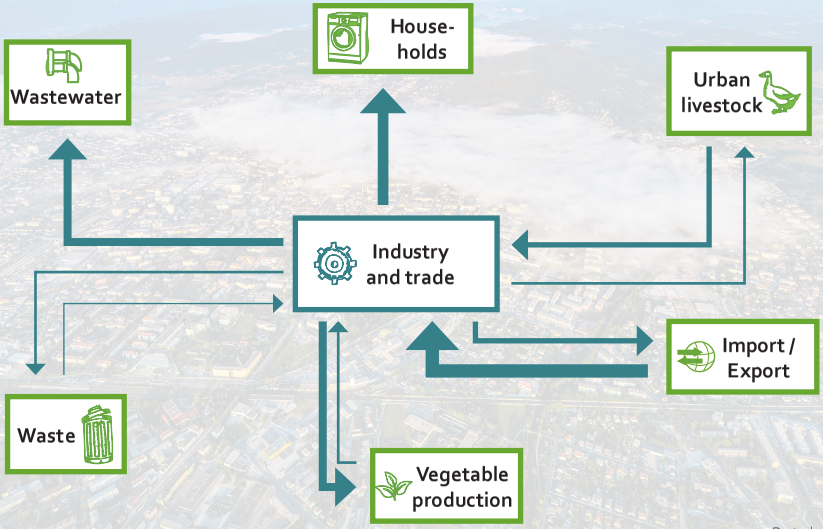

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Foto: StadtPresse Klagenfurt | Helge Bauer

Industry and trade

Nitrogen is used as a starting material for the synthesis of a wide variety of compounds, such as nitrites, ammonia or nitric acid. It is used primarily in the production of fertilizers, but also in the electrical and metal industries. Nitrogen is suitable as a filler gas for incandescent lamps, a propellant in sprays, and as a diluent. In the food and pharmaceutical industries, as well as in medicine, liquid nitrogen is used because it is suitable for shock freezing or freeze drying, for example for preserving tissue, blood, vaccines and medicines, as well as sausage and fresh poultry products. The accumulation of nitrogen compounds is not always directly relevant to the environment, but may indicate a potential for later release, for example when things are sent to landfills or groundwater and substances are released there.

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‘The death of thousands of fish in the “Warme Fischa” River in the district of Wiener Neustadt is due to a lack of oxygen and excessive nitrate pollution.’

ORF

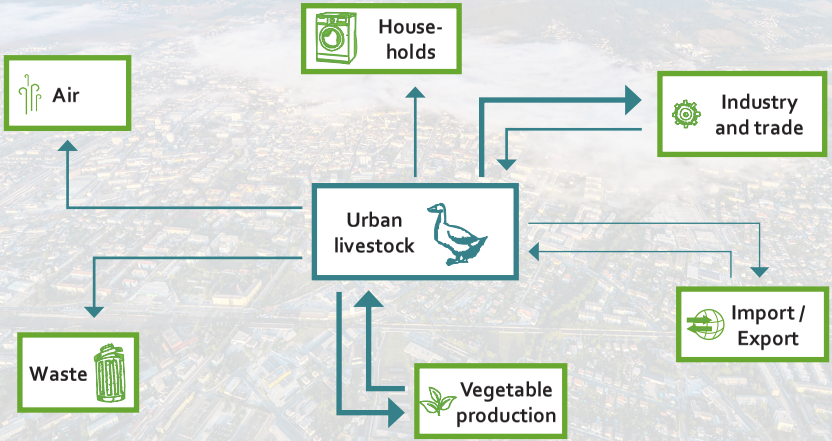

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Foto: StadtPresse Klagenfurt | Helge Bauer

Urban livestock

Animal husbandry also plays a role in the budgeting of nitrogen fluxes in urban areas. Here, one refers to farm animals and domestic animals in cities. A combination of different statistics is used. First, one looks at the animal population and the associated feed requirements as well as the excreta.

In the N-pool of urban livestock, one also includes the number of slaughterings. This results in the meat production. Another statistic provides information about live animal transports from or to the respective cities.

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‘NO_2 makes plants stunt, age faster, it turns their leaves yellow. It overfertilizes and acidifies soils and waters.’

Falter

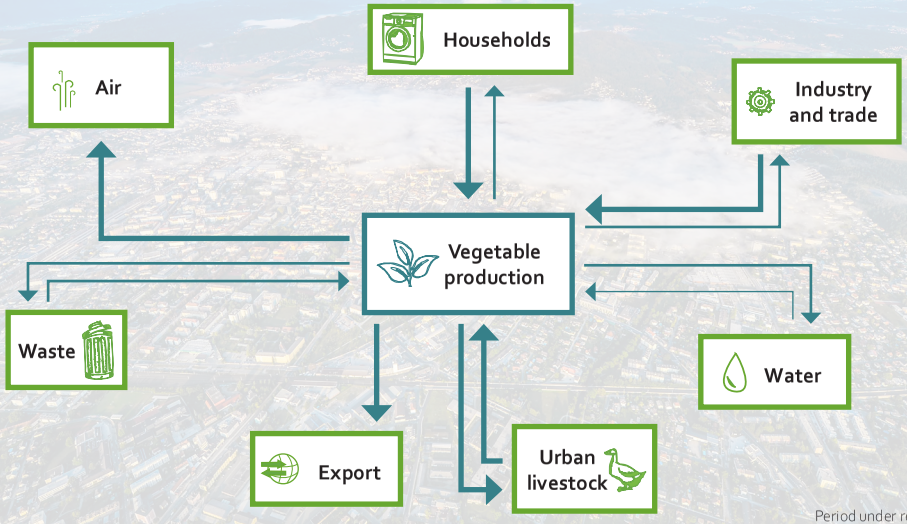

Foto: StadtPresse Klagenfurt | Helge Bauer

Vegetable production

Plants need nitrogen to synthesize proteins, such as enzymes, and DNA – nitrogen is therefore essential for metabolism. A lot of energy is needed to convert atmospheric nitrogen into chemical compounds that are also available to plants (illustrated figuratively: nitrogen oxides are formed from atmospheric nitrogen and atmospheric oxygen during a lightning strike).

The addition of nitrogen as fertilizer is essential for plant growth. However, in Europe only about 60-70% of the available nitrogen fertilizer is absorbed (globally even much less). The rest may leach to groundwater or run off to surface waters. Accurate quantification is difficult, depends on local conditions (soil texture, slope, precipitation).

This pool contains three sub-pools: agricultural land, horticultural land, and urban green space. Agricultural land includes cropland and grassland. Urban green includes public parks, private gardens, backyards, forests, and greenbelts. Horticulture includes horticultural land according to the respective national definition.

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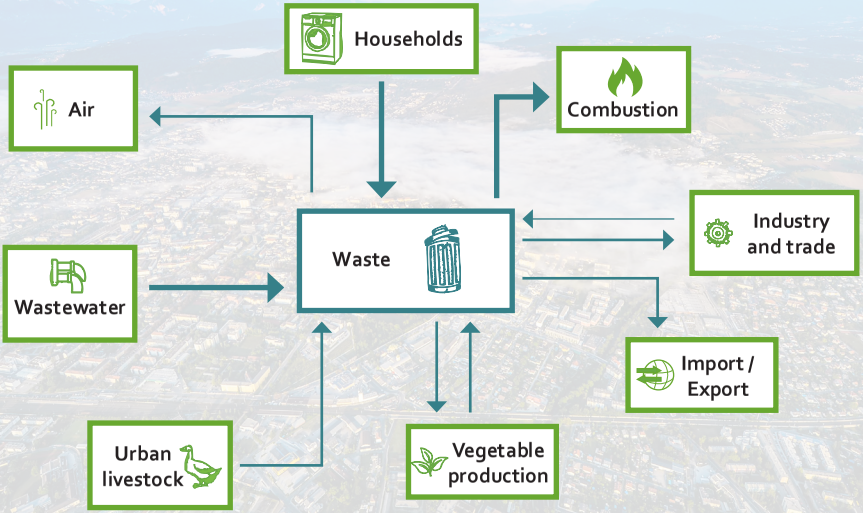
‘The planet is suffocating in nitrogen.’

Wilfried Winiwarter



Period under review: 2015
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Waste

Technically, the reduction of nitrogen oxide emissions has been solved. With the help of catalytic converters in vehicles, or even without catalytic converters in denox plants of power plants, emissions can be reduced by up to 95%.

Nevertheless, nitrogen compounds such as nitrous oxide (N_2O) are released into the atmosphere and the air. Households transfer nitrogen to landfills and wastewater through their garbage and sewage. Nitrogen is also passed directly through landfills via wastewater.

Appropriate limits help to make this problem largely a thing of the past. Emission ceilings (according to EU regulations) also exist for sulfur dioxide, particulate matter, and volatile organic compounds. Each EU country may only emit a certain amount, because emissions also influence the respective neighboring EU countries.

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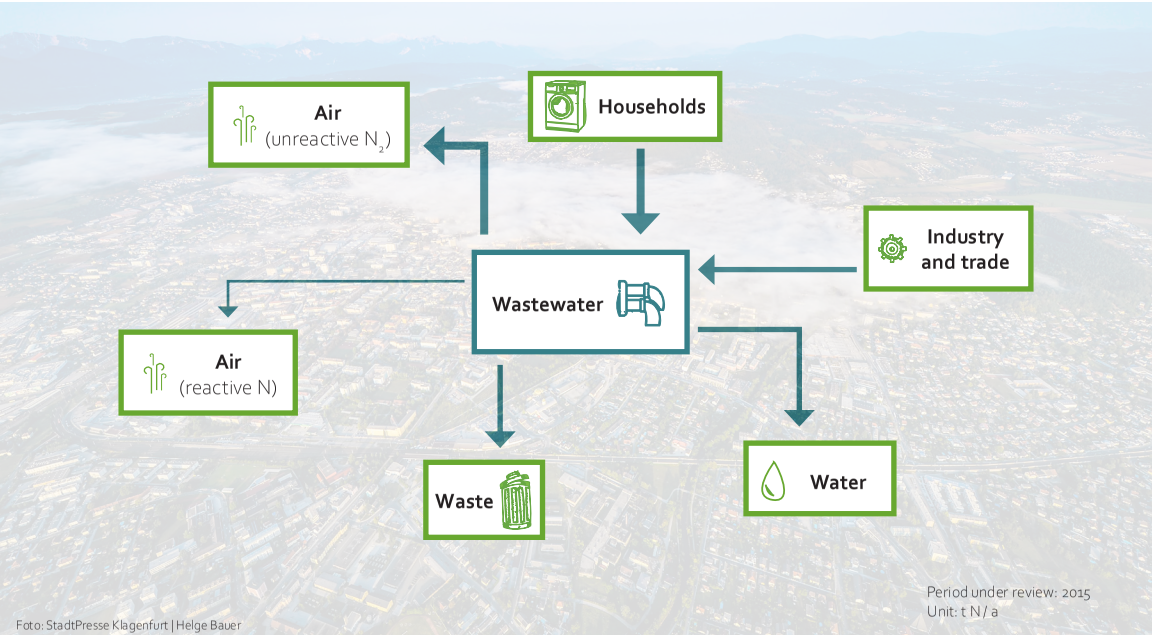
‘Nature does not waste nitrogen.’

UNCNET



Period under review: 2015
Unit: t N / a

Foto: StadtPresse Klagenfurt | Helge Bauer

Waste water

Wastewater treatment plants are often the last link in the chain in terms of nitrogen flows. Elemental nitrogen is released from them and beyond the system boundaries. The largest proportion escapes into the air and volatilizes as nitrous oxide (N_2O) and thus as a greenhouse gas. What is surprising is that a great deal is released into the air. ¾ of the nitrogen in wastewater is removed at the wastewater treatment plant, with the remainder going into streams (not groundwater). N_2 that re-enters the air through the biological processes is not problematic. This should be considered as an energetic loss, because there would be potential here for further use of the nitrogen.

Specifically, one must ask whether we are consuming more than we need. What can be reduced in terms of waste? What nitrogen consumption and excretion do we get per person?

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