The fate of nitrogen in the urban area – the case of Zielona Góra, Poland

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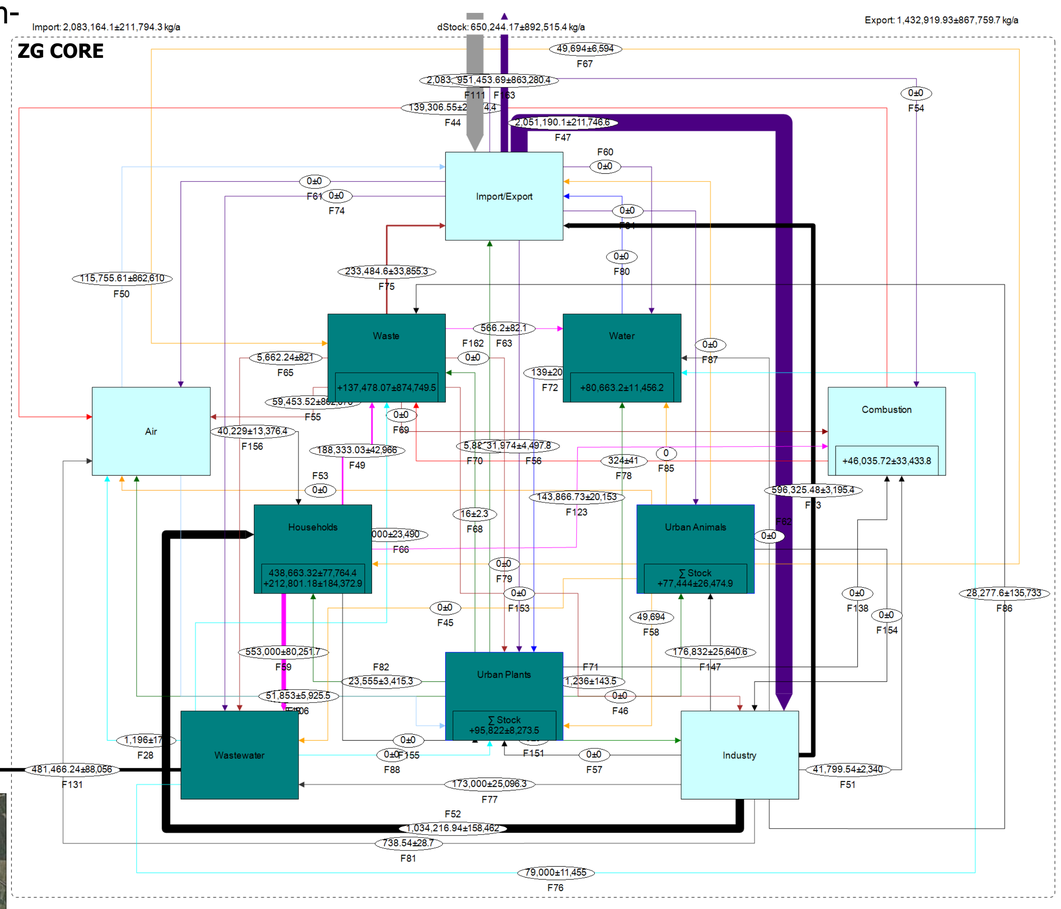
Abstract

Anthropogenic changes in the nitrogen cycle are strongly linked to the structure of urban systems, in which food consumption, energy demand and transportation play an important role. Increased release of reactive nitrogen (Nr) into the urban environment is directly related to population growth, intensive urbanization and socioeconomic development. This situation leads to serious consequences for human health, biodiversity, air and water quality. This presentation presents the characteristic nitrogen flows in a city of 140,000 for two characteristic regions, urban and suburban, which are functionally related.

Urban flows, for better quantification, are divided into two main areas: "**urban agri-food chain**" - including urban agriculture, households, trade, wastewater and waste, and "**urban combustion chain**" - comprising industry, combustion and air.

The results showed that nitrogen flows are greatest along the agri-food chain. In addition to food imports, fertilizer imports are also a significant contributor, accounting for 39%. Most of the N coming from the agrifood sector (45%) is denitrified in wastewater treatment. N associated with combustion (mainly NOx emissions from vehicles) accounts for a much smaller share, at 22% of the N entering the agrifood system. This overall picture is maintained also when specifically addressing the city center, with the exception of mineral fertilizer that plays a significantly smaller role.



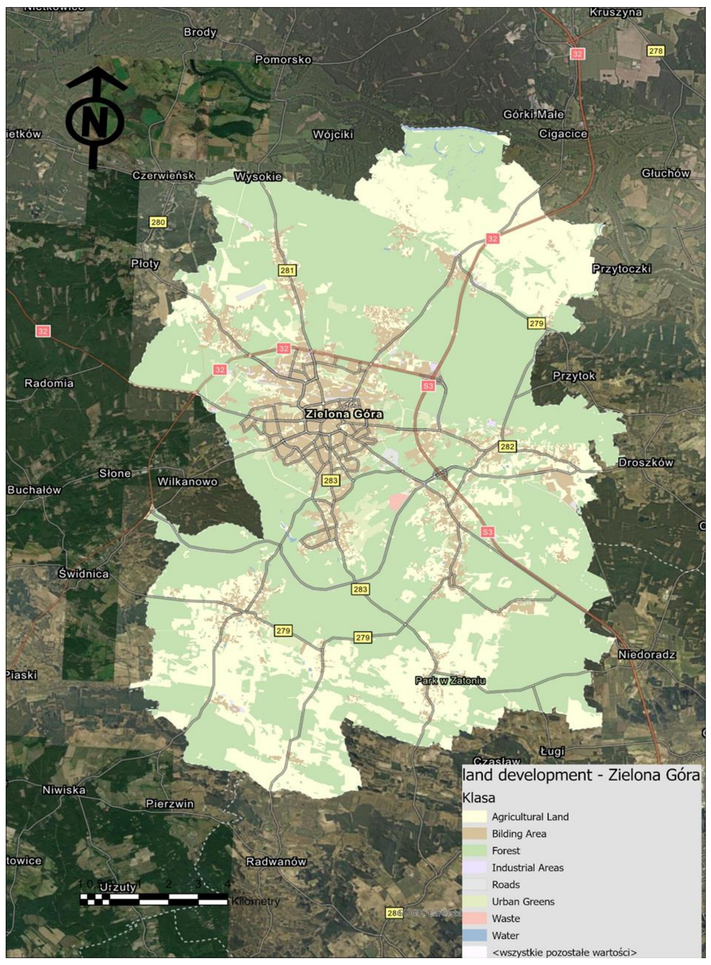


Fig. 1. Zielona Góra broken down by diversified land use

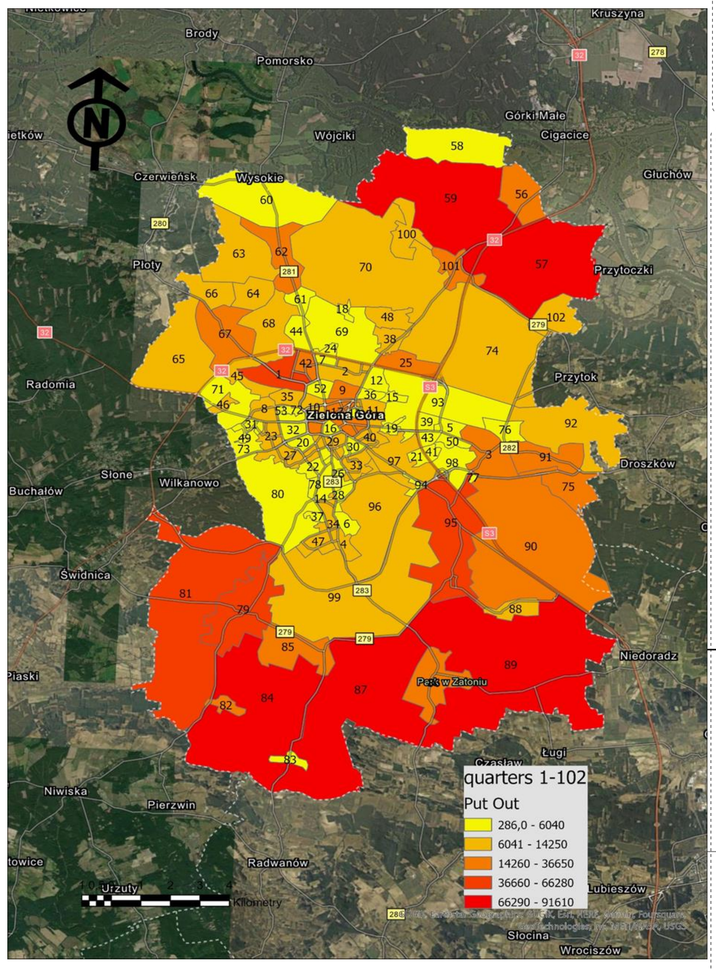
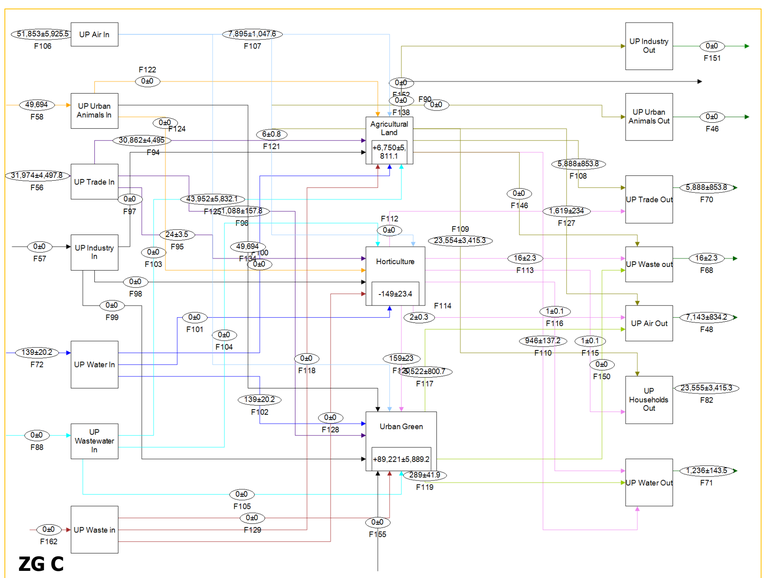


Fig. 2. Emission of nitrogen to the air in the city



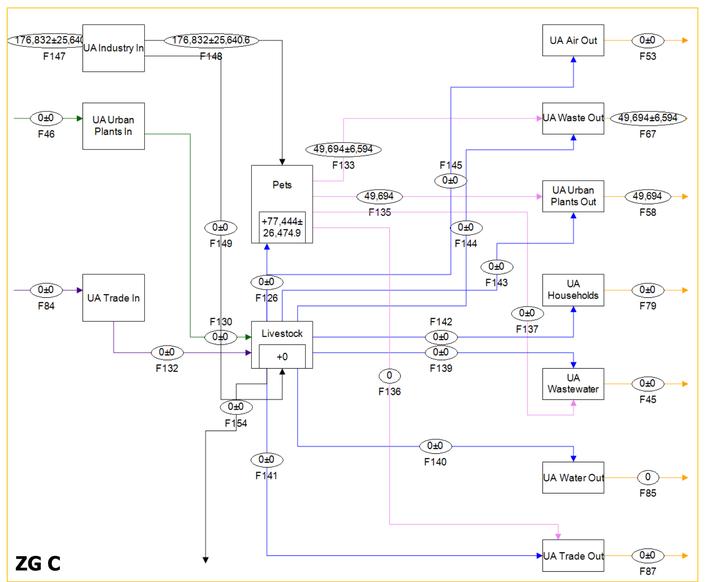
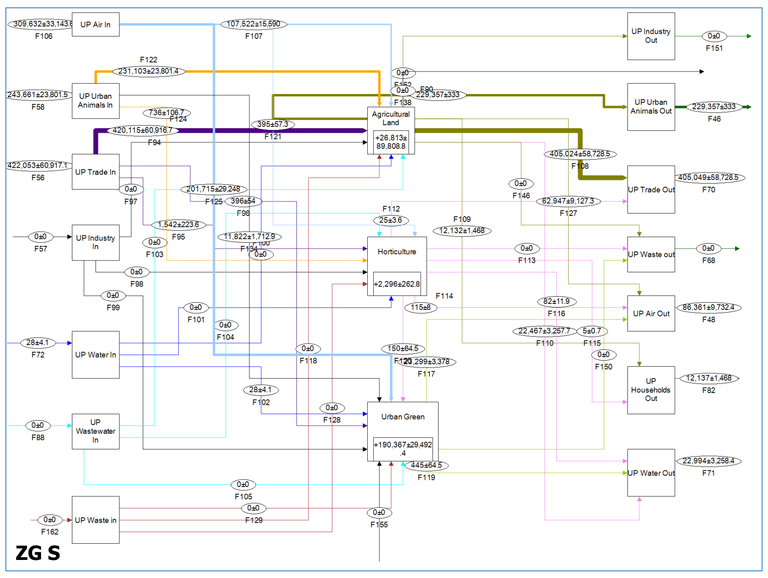


Fig. 3. Nitrogen flows in Zielona Góra Core (ZG C) and Zielona Góra Surrounding (ZG S)



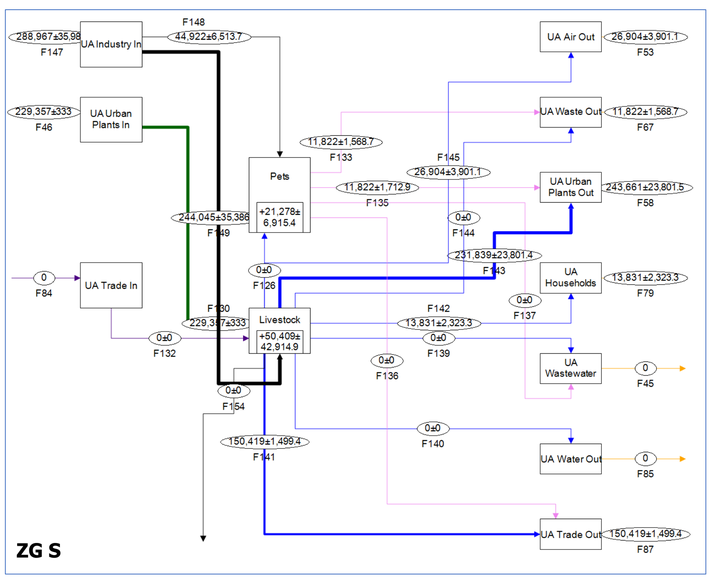


Fig. 4. Nitrogen flows in the agri-food chain in Zielona Góra Core (ZG C) and Zielona Góra Surrounding (ZG S)

Summary

1. Reducing the flows of Nr can be achieved in part by increasing separately collected waste, including food waste, and its recycling in the urban and suburban area.
2. From the point of view of nitrogen circulation in the city, it may be beneficial to shorten the supply chains of local agri-food products, which will allow for increasing their use in the urban and suburban area.
3. Improving the ventilation of the city core by creating areas constituting a reservoir of cool air (meadows, wetlands) will be able to counteract stagnation Nr.

Results

Analyzing nitrogen flows in the city in two areas: urban area - Zielona Góra Core **(ZG C)** and Suburban area - Zielona Góra Souranding **(ZG S),** it can be seen that in **ZG C**, the largest share of N entering to the area is transformed through consumption or industrial production and is then exported as a product or emitted to the atmosphere in the form of N_2 from wastewater treatment, NO_x from combustion processes and waste treatment facilities (mainly NH_3 and to a small extent N_20). In the suburban area (**ZG S)** the largest share of N entering the area is in synthetic fertilizers and is transformed through agricultural production into commodities, some of which are exported. Thanks to local production, the **ZG S** area is more self-sufficient in plant and animal foods than **ZG C** areas, while also showing higher accumulation of Nr in soil or water. Nevertheless, the share of the consumption of local products by the inhabitants is relatively small, amounting to about 20% (Table 1).

Reducing Nr flows can be achieved in part by increasing recycling. In **ZG C** Nr is not recycled. Selectively collected waste and sewage sludge are recycled outside the study area. A different situation is observed in the suburban area, where manure from agricultural production is entirely managed on agricultural land (the recycling rate is 21%).

Table 1. Parameters & Indicators – urban N buged Zielona Góra

Parameter	Zielona Góra Core	Zielona Góra Surrounding
In [kgN]	2,083164.10	1,078704.04
In [kg/ha]/[kg/cap]	357/18	49/55
Out [kgN]	1,432920	715,190
Out [kg/ha]/[kg/cap]	246/12	33/36
dStock (% of import)	29	36
Recycling (% of import)	0	21
Agri-food Chain		
Self-sufficiency plant food	6	20
Self-sufficiency livestock products	0	20
NUE on agricultural land	76	85
N surplus [kgN/ha]	19	16
Emission and Deposition		
N deposition [kgN/ha]	16	16
Emission [khN/ha]	35	35

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