Nitrogen budget estimation in the East Europe: A case study for Dniester and Prut catchments

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INTRODUCTION

Agriculture, industry and other human activities have been altering Nitrogen (N) cycling leading to N imbalance at ecosystem and regional levels. This results at numerous environmental impacts on air, water and soil quality, GHG balance and ecosystem functioning (ENA, 2011). Quantification of N flows at district scale to build joint N budget is an efficient tool for identification of relevant domains to apply mitigation measures.

The aim of this study is to develop N budget for the transboundary region in East Europe to assess N flows contribution and impact on the Black Sea.

METHODS

The study region embraced the catchments of Dniester and Prut (and the Danube Delta area) with total land area of 121 897 km^2 and aquatic surface of 2 863 km^2.

To calculate N flows we used available data from different sources (national statistics, environmental monitoring and research). Estimates of EMEP, FAO, EDGAR, GRDC etc. and methodology described in ECE/EB.AIR/113 have been also taken into account.

RESULTS and DISCUSSION

In this study we tried to develop the conceptual scheme for N budget estimation at a river catchment scale, which might be applied in a transboundary watersheds within the Eastern Europe or elsewhere under limited data availability.

We conceptualized to distinguish three main categories of N flows within boundaries of the studied system: input (incoming from elsewhere to the system), output (outgoing to elsewhere from the system) and internal cycle flows (which originate/ produce and consume/ utilize within the system boundaries). Temporal boundaries were suggested to be on a calendar year basis if annual statistics are planned to be used; however, multiannual dataset use may increase the credibility of mean estimates avoiding the impact of climate- and economy-related N flow variations in a particular year. Below we present an example of the main N flows for N budget estimation made for the watersheds of Prut and Dniester (and Danube delta) in 2015 within the Towards INMS project (Fig. 1; shown results are indicative to illustrate the order of magnitudes and the availability in the region).

Input N flows

- Total N fertilizer use in the region was accounted to be 190 Gg N yr^{-1}
- Mean TN deposition was estimated as 145±8 Gg N yr^{-1} to the entire study area in 2015 (Medinets et al., 2020a), where ca. 60% were deposited in organic forms, 'oftener unaccounted' in the inventories and previous assessments
- Annually ca. 62 Gg N was consumed with food (animal and plant) protein by population in the region
- Biological N fixation (BNF) was estimated from 13 to 54 Gg N yr^{-1}
- Around 13.5 Gg N was fixed by surface water from the atmosphere annually
- The input of N with fish stocking to the rivers was minor (0.004 Gg N yr^{-1})
- N transported to the region with imported product was not estimated

We found that ~50% of N came into region with synthetic N fertiliser applied. N deposited from atmosphere was the second largest source (~40%).

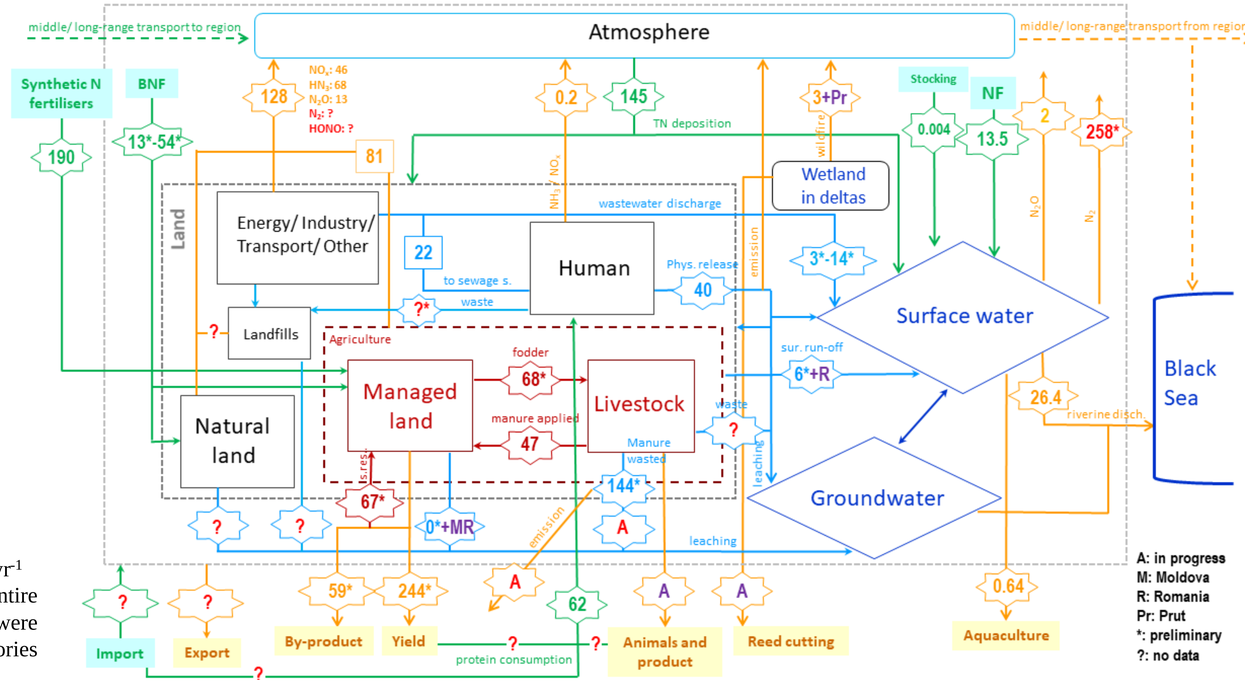

Fig. 1. Conceptual scheme of N budget (Gg N yr^{-1}) in the study region [BNF: biological N fixation; NF: N fixation]

CONCLUSION

- **The developed concept for the main N flows in a river catchment might be applied in a transboundary watersheds within the Eastern Europe or elsewhere under limited data availability to estimate N budget**
- **The first N budget estimation within transboundary region in East Europe covering two watersheds (Dniester and Prut) and Danube delta area in three countries showed total N input was assessed in a range of 350-390 Gg N yr^{-1}, where ~40% derived from atmospheric N deposition. Though some N output calculations (N removal with animal products) are still in progress, N output from system were assessed from 460 Gg N yr^{-1} to 720 Gg N yr-1 (if N2 loss estimates from surface waters were accounted), where N losses to the atmosphere estimated in a range of 130-390 Gg N in 2015**
- **More than 26 Gg N was directly discharged to the Black Sea from the Dniester catchment**
- **Incomplete N budget already reflects N depletion from the system in 2015, i.e. preliminary N removal likely outcompeted N input**

Internal cycle N flows

Within sub-system agriculture

- Approx. 68 Gg N of fodder crops were transferred from plant growing system to animal husbandry in 2015
- Only 47 Gg N were returned to the crop and grasslands with animal manure as organic fertilizers (less than 25% of total manure produced in the region)
- Plant residues returned ca. 67 Gg N back to fields

Between land and hydrosphere

- Wastewater discharges contributed from 3 to 14 Gg N to the rivers annually
- Ca. 40 Gg N was released by population and not treated with sewage system
- Approx. 144 Gg N of animal manure was wasted
- The rates of N run-off and leached to the surface and groundwater were understudied

Estimates of N flows between land (agriculture/ humans) and aquatic sub-systems were largely unknown due to the lack of targeted research

Output N flows

- The largest amount of N was removed form the system with crop yield (244 Gg N yr^{-1}) and by-product (59 Gg N yr^{-1})
- Losses (NO_x+NH_3+N_2O) to the atmosphere from the land-based sources (industry and agriculture) were estimated as 128 Gg N yr^{-1}; agriculture sector contributed ~63% of N-gas emissions
- Dniester riverine discharge removed ca. 26.4 Gg N to the Black Sea (Medinets et al., 2020b)
- At least 3 Gg N were emitted from wetland areas due to fires
- Around 2 Gg N were emitted as N2O form surface waters
- Freshwater aquaculture likely contributed to less than 1 Gg N removal
- Estimates of N_2 production and emission (via denitrification and anammox) were highly uncertain, but might be huge enough (up to 258 Gg N yr^{-1})
- N removal with animal product and red cutting has not been quantify by the date of this poster release; currently in progress

N losses to the atmosphere from land-based activities were comparable to crop production in Ukrainian part.

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