Physiological Nitrogen release from human population: A case study within East Europe

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INTRODUCTION

Per capita N footprint in various regions differs and strongly related to protein consumption rates and food production N losses (Galloway et al., 2014). It is essential that in regions with sanitation facilities physiological N excretion from humans is not considered as potential N loss pathway to the environment

The aim of this study is to estimate annual mean rates of N consumption and excretion by human population, and N loss to the environment and N discharge to sewage system in the East Europe demonstration region.

RESULTS and DISCUSSION

Human population

- Human population density varied within and between Moldova, Romania and Ukraine as well as these country areas of demonstration region over 2007-2018 (Fig. 1)
- The highest density was in the territory of Moldova and especially in its high-densely Transnistria district (an autonomous territorial unit of Moldova with special legal status), where a 10-year average made ca. 117.2 and 144.8 cap km^{-2}, respectively
- Both Romania and Ukraine had lesser population densities of 84.5 and 74.3 cap km^{-2} at a country scale, respectively. Local population was 13% more dense in Romanian and Ukrainian parts of the demo-region compared to those per entire countries
- Share of rural population in the region was nearly equal to urban varying from ca. 46% in Ukraine and Romania to 57% in Moldova as of 2015

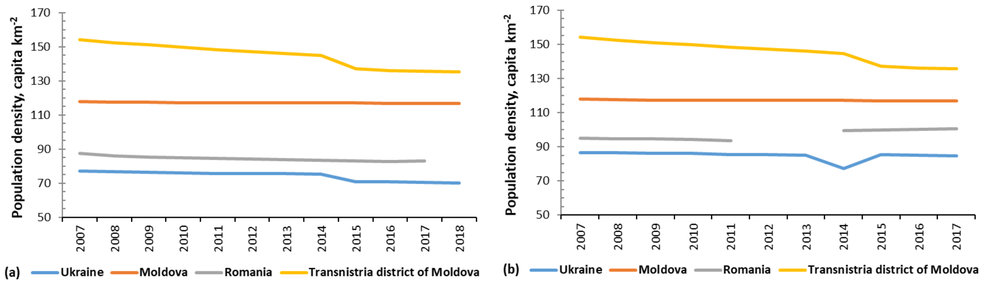

Fig. 1. Mean population density in Moldova, Transnistria district of Moldova, Romania and Ukraine at country (a) and at demo-region (b) scale.

Access to sewage system

- In the East Europe demonstration region (and wider EECCA area) countries are faced with sanitation issues especially in rural areas
- Romania was ranked as the last in the EU on the share of sanitation access to its population with ca. 30% of households (>50% in rural areas) being without access to clean water and sanitation in 2018 (INSSE, 2020)
- In Ukraine approximately 94% of households were connected to sewage system, while in rural areas around 50% had no access to such facilities in 2018 (UkrStat, 2020).
- Only ca. 30% of population accessed to sewage system, while in rural areas this share was negligible (<3%) in 2018 (Statistica Moldovei, 2020)
- Moreover, both Moldova and Ukraine are faced with big issues related to the modernization of entire sewage systems (collection network and treatment facilities), which have been operated since 1950-70

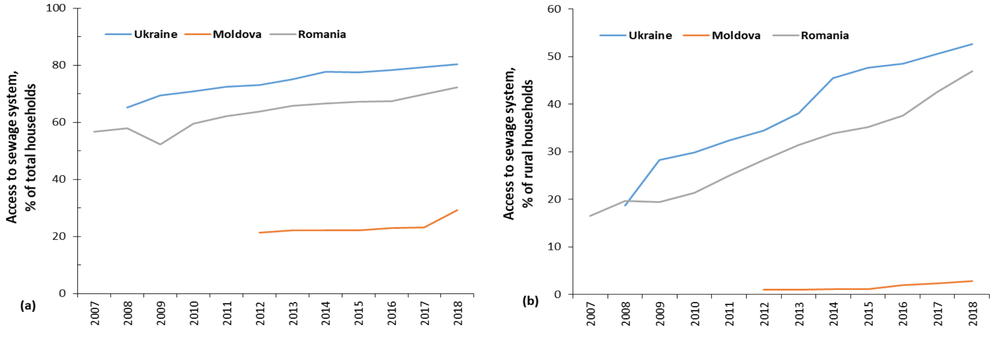

Fig. 2. Share of total (a) and rural (b) households connected to sewage system in Moldova, Romania and Ukraine.

METHODS

The East Europe study region embraced the catchments of Dniester, Prut and the Danube Delta area.

We used FAO data to compute food N consumption using top-down approach. Physiological N release (via excretion, exhaling and sweating) calculation was based on peer-review studies and medical norms adopted in Ukraine; bottom-up approach was used. National statistics/ reports for Moldova (Statistica Moldovei, 2020), Romania (INSSE, 2020) and Ukraine (UkrStat, 2020) were utilized to estimate urban and rural population as well as sanitation facilities in the region.

N flows within human vital functions

Food N protein consumption by humans

- At all times, Romanian have the highest protein-containing diet with animal protein content of ca. 50%
- Moldavians had the lowest N-containing food with mixed pattern: doubled within the period of 1999-2013 and then decreased one third. This fluctuations were related to plant food consumption, animal protein consumption was near constant across time
- Ukrainians became to consume 17-20% more proteins over the last decade compared to 1999-2001
- The mean N consumptions in Moldova, Ukraine and Romania were 3.62, 5.09 and 6.37 kg N cap^{-1} yr^{-1}, respectively, over 2014-2018
- The weighted means for the whole studied region area were 4.5 kg N ha^{-1} yr^{-1} consumed in 2015 respectively (Fig. 3)
- The total flow of N consumption by population in the demo-region was estimated to be *ca.* 60 Gg N as of 2015 (Fig. 3)

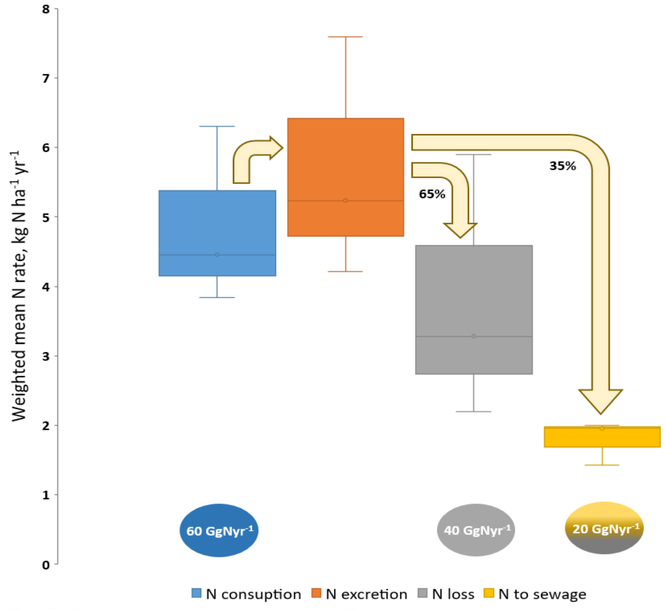

Fig. 2. Weighted annual mean rates of N consumption and excretion by human population, and N loss to the environment and N discharge to sewage system estimated per hectare of demo-region as of 2015 [cumulative N flows per category for the whole demo area are presented in the ellipses].

Physiological N release by humans

- We have quantified that the largest portion of N is excreted from humans via urine (~5.1 kg N cap^{-1} yr^{-1}) and feaces (~0.4 kg N cap^{-1} yr^{-1}), while minor via sweating (~14 g N cap^{-1} yr^{-1}) and exhaling (~3 g N yr^{-1})
- A healthy person may physiologically release 4.34-6.78 kg N yr^{-1} (or 11.9-18.6 g N d^{-1}), which was in line with the estimation of Rose *et al.* (2015).
- Our results demonstrated that N released from humans is nearly equal to that of consumed with food in the region
- Essentially, Nr containing in human excreta goes via sanitation facilities to sewage system or leak to the environment if household is not connected to sewage system (use a dump well) and/ or lack advanced sanitation tank.
- About 21.8 Gg N yr^{-1} excreted by locals run into to sewage system in 2015 (Fig. 3)
- Approx. 40.4 Gg N yr^{-1} (i.e. 65%) leaked via dump well to the environment in 2015 (Fig. 3); this large N waste source to the aquatic (and air) environment in the demo-region, are often not taken into consideration upon regional/ national assessments

Acknowledgements

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CONCLUSION

- **On average N equilibrium (zero balance) between N consumption and N release from humans within the region was shown, which means that there is no general tendency towards overweight or obese in local population**
- **Mean consumption of N proteins by population was quantified to be ca. 5 kg N cap^{-1} yr^{-1} being considered as a significant incoming N flow of ca. 60 Gg N for the regional N budget, while mean physiological release of N from population was estimated in a range of 4.3 to 6.8 kg N cap^{-1} yr^{-1}**
- **Connection of household to the sewage system is still a big challenge in the region especially in rural areas, which resulted in that around 65% of excreted N was likely leaked through dump well to the environment being a significant N source (ca. 40.4 Gg N yr^{-1}) polluting hydrosphere**
- **Low efficiency of treatment facilities (or even absence) for domestic wastewaters may give an additional N pollution source of ca. 21.8 Gg N yr^{-1} via discharge to rivers**