The grey water footprint for human and veterinary pharmaceuticals

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1. Introduction & Background

- Water pollution by pharmaceuticals is widespread, causing both environmental and human health risks
- Several emission sources and pathways for human and veterinary pharmaceuticals have been identified (see figure on the right)
- Study gives insight about pharmaceutical pollution at different geographical levels by estimating and mapping the grey water footprint (GWF) as an indicator of polluted water volumes

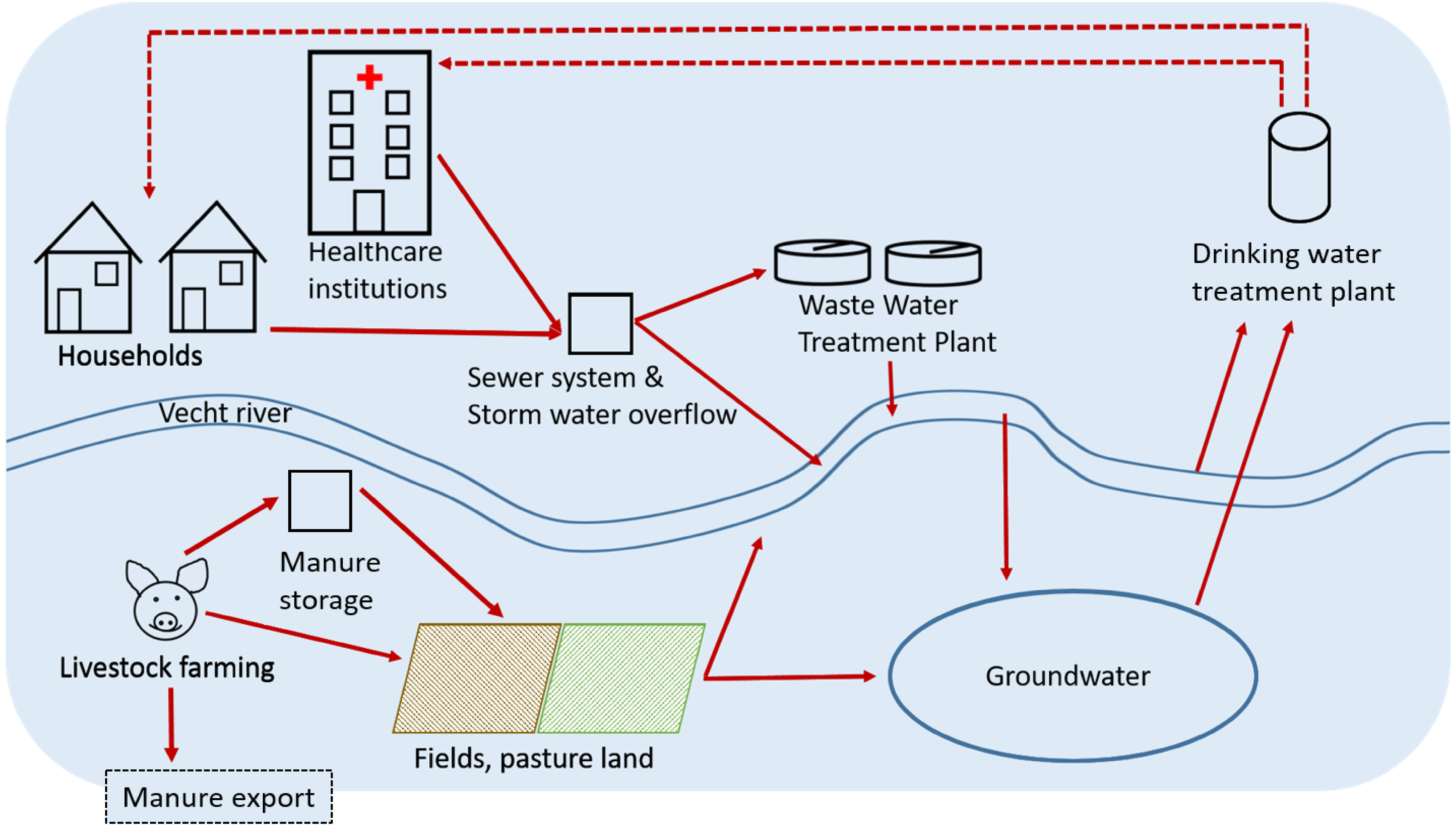

Figure 1. Pharmaceutical emission sources and pathways considered in this study.

2. Method

The GWF is estimated distinguishing between GWFs related to wastewater from households and hospitals and to various types of livestock farming. The GWF is expressed as polluted water volumes per region, per capita, and per unit of animal product.

Pollutant loads are estimated from pharmaceutical sales. Predicted no effect concentrations (PNECs) are taken as maximum allowed concentrations. Water pollution levels (WPL) are estimated for the Vecht river basin shared by Germany and the Netherlands.

$$\mathrm{GWF} = \frac{\text{Pollutant load}}{\text{Max. allowed concentration}}$$

$$\mathrm{WPL} = \frac{\mathrm{GWF}}{\text{Runoff}}$$

3. Results

- Global GWFs assessed for carbamazepine and ciprofloxacin result in 7 $m^3\ yr^{-1}$ and 1,900 $m^3\ yr^{-1}$, respectively
- For Germany (GE) and the Netherlands (NL), largest GWFs were found for ethinylestradiol (human) and amoxicillin (veterinary)
- Findings Vecht basin: The total GWF results from human pharmaceutical use; hospital's influence play a minor role compared to households, a fraction of veterinary GWF is externalized from the region due to manure export

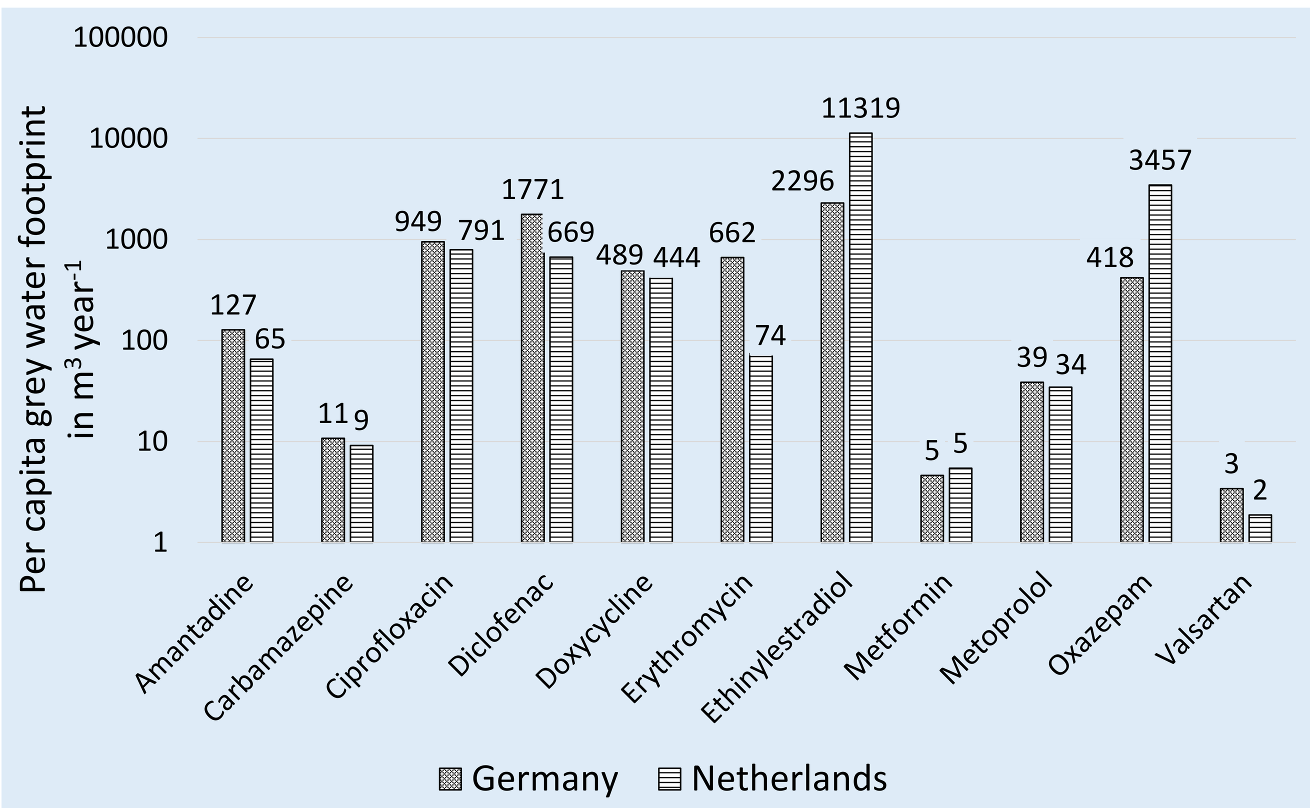

Figure 2. National per capita GWFs from human pharmaceutical use.

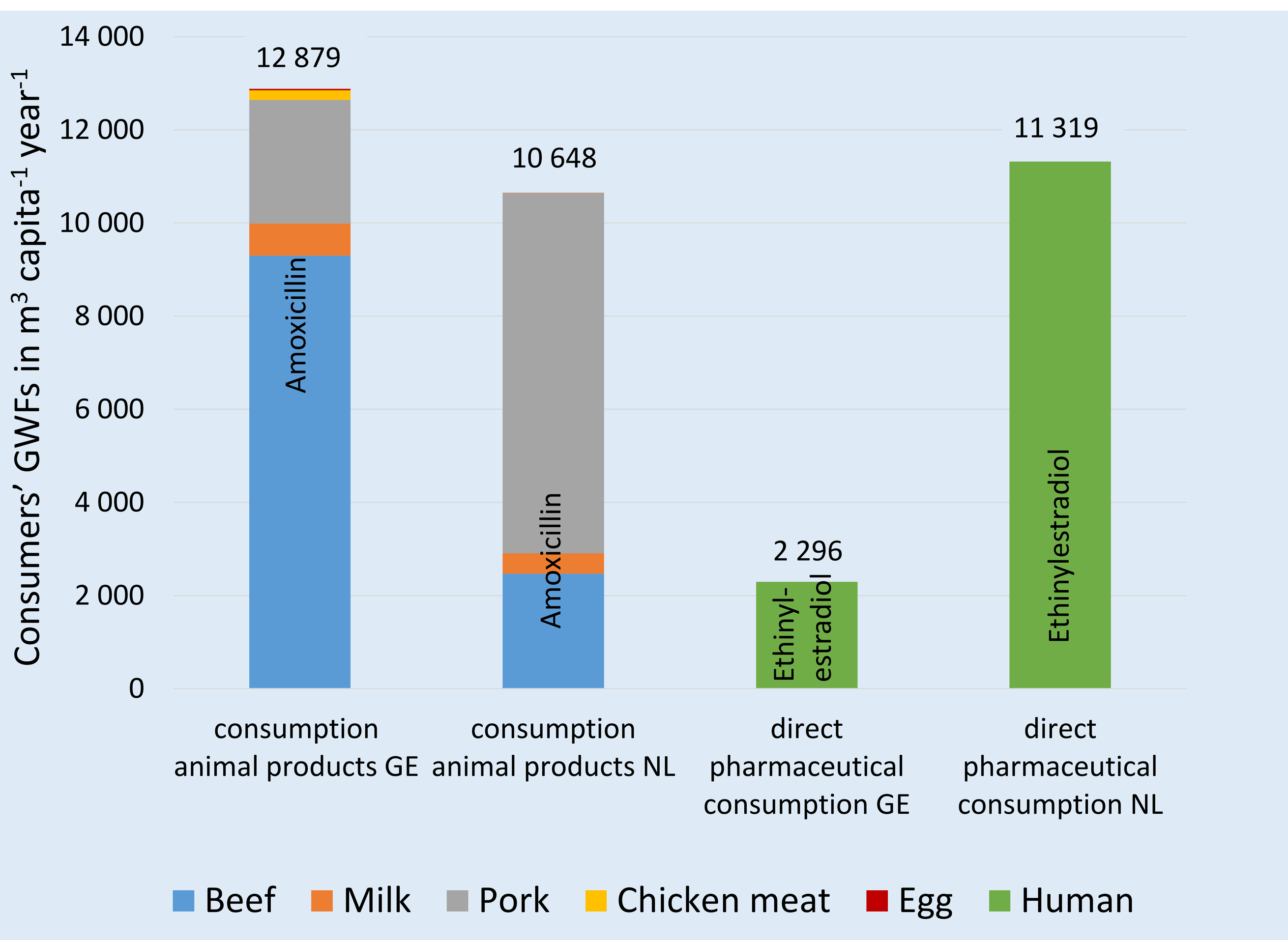

Figure 3. German and Dutch consumers' GWFs.

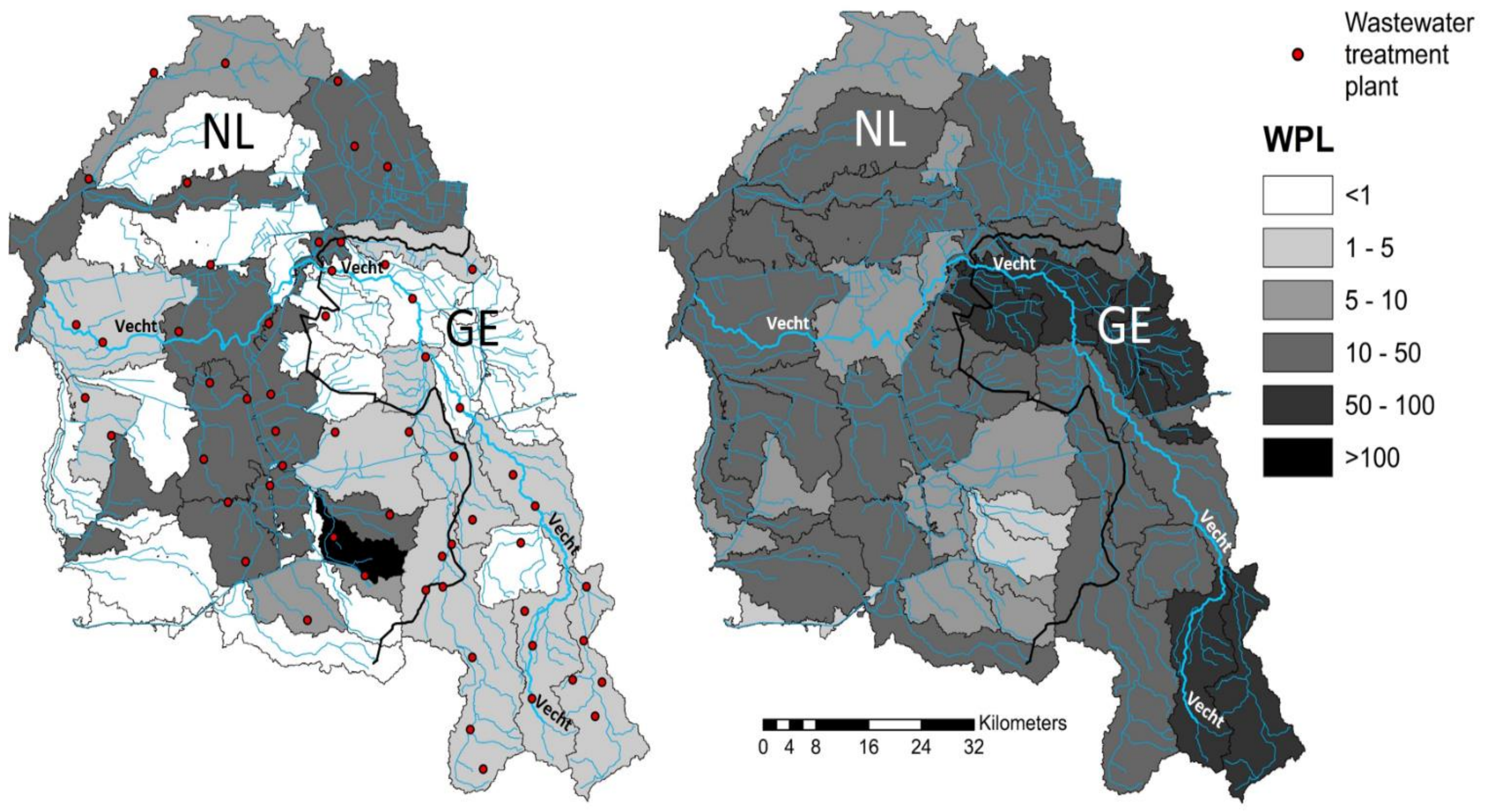

Figure 4. Annual average WPL in the Vecht catchment resulting from the maximum GWF of human (left) and veterinary (right) pharmaceutical use, resulting from ethinylestradiol and amoxicillin, respectively.

4. Conclusions

- GWFs can vary substantially among compounds (influenced by loads and PNECs) and regions (influenced by loads)
- From a consumption perspective, an individual's pharmaceutical-related GWF depends on direct pharmaceutical consumption as well as consumption of animal products
- In the Vecht basin, WPLs exceed acceptable levels for both human and veterinary pharmaceutical
- Pharmaceutical water pollution substantially adds to earlier water footprint studies that excluded this type of pollution

References:

Hoekstra, A. et al. (2011): The Water Footprint Assessment Manual.
Oldenkamp, R. et al. (2019): Aquatic risks from human pharmaceuticals- modelling temporal trends of carbamazepine and ciprofloxacin at the global scale. Environmental Research Letters.

Acknowledgements:
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