Title: Cross-disciplinary scaling of hydrological, chemical, biological, medical and socio-economic quantities as function of molecular, catchment, organism or city size for fundamental understanding and environmental assessment.

Supervisor: Jan Hendriks and specific disciplinary experts.

Setting. Over the last decades, anthropogenic pressures on the environment have dramatically intensified and diversified. Nowadays, we have to deal with 100,000+ pollutants, 10,000+ species and 1,500,000+ sites. To set the right priorities among environmental problems and to select the best alternatives among sustainable solutions, proper assessment tools are urgently needed.

Gaps. While models are available, application to thousands of cases is severely limited by data gaps due to financial, ethical, disciplinary and other constraints. As an alternative, missing information can be obtained by linking parameters to size (e.g., molecular mass, catchment area, organism weight, city volume), temperature and other universal characteristics. While such a kind of scaling has proven valuable for assessment of cases, relationships are far from complete, largely mono-disciplinary and of an ad hoc nature. Consequently, a comprehensive, transdisciplinary and integrative framework is missing.

Objectives. Following urgent societal needs and bright scientific prospects, the overall aim is to obtain a cross-disciplinary suite of mechanistic and statistical relationships for scaling of parameters in assessment models as a function of size and related attributes. Based on research gaps, policy priorities, information availability and ongoing/awarded projects, we focus on synthetic and natural substances, addressing emission and fate in catchments and cities as well as accumulation in and effect on individuals, populations and communities. Following a curiosity- and mission-driven approach, we ultimately, aim to 1) “cover thousands of substances, constructs/species by data-efficient models”, 2. “indicate how much variability can be explained by size and other universal characteristics)”.

During development, the suite will be used to explain both fundamental and applied topics a diverse as:

- How can we identify sustainable cities?

- What is the combined impact of temperature change on fate, exposure and effects in the Arctic?

- How can we improve PBK (Physiologically Based Kinetic models) to better predict concentrations of substances in human organs?

- Why was the largest reptilian predator (T. rex) ten times larger than the largest mammalian predators (sable tooth tiger)?

- When does diversity de/increase with temperature?

Additional examples can be found (as highlighted text) in the draft-textbook to be downloaded from:

https://www.ru.nl/environmentalscience/research/themes/human-environmental-risk-assessment-hera/models/software-literature/

Depending on your interest and background, you will focus on specific relationships in physical (e.g., hydrology), chemical, biological (e.g., physiology, ecology), medical or socio-economic sciences. So, you might compare transport of water in catchments, materials in cities, blood in organisms and biomass in communities as well as the substances they generate, carry and degrade. In addition, you will be made familiar with the principles of transdisciplinary scaling as covered by other B/MSc/PhD students.

Methods: depending on the selection to focus on you will

- obtain relationships for rate (e.g., consumption of food by animals or of materials by humans), time (e.g., lifespan of products or organisms), density (e.g., number organisms in regions, inhabitants in cities) or other parameters Y as a function of substance, city, catchment, organism and community characteristics X, such as size, temperature and the like either by

- collecting and deriving Y as empirical functions of X, based on databases, reviews and articles or
- deriving theoretical relationships between Y and X, typically represented in simple equations like $Y = a \cdot X^b$ or $Y = a \cdot e^{b \cdot X}$ from overarching principles
- identify and reconcile inconsistencies, compare functions to those derived by other and those of other disciplines
- test the relationship(s) found in (a) case(s)
- apply the relationship(s) found to (a) fundamental question(s) as described in the objectives.

Expected results: Typically graph and tables describing the relationships.