A network diagram with nodes and connecting lines in shades of blue and teal, set against a dark blue background. The nodes are represented by small circles, and the lines are thin and connect the nodes in a complex, interconnected pattern.

11th Annual Water and Sanitation Innovations for  
the Arctic Workshop

International focus: how this  
technology has been used in  
the past

Frederic Béen

KWR Water Research Institute

**KWR**

Bridging Science to Practice

# Sewage surveillance or wastewater-based epidemiology

Biomarkers



Research



Public Health





# Applications

1. Environmental surveillance of pathogens
2. (Illicit) drug use
3. Population dynamics
4. Environmental contaminants
5. Antibiotic resistance
6. Health biomarkers

# 1. Environmental surveillance

## Poliovirus

- absence of virus circulation in (unvaccinated) population
- early warning outbreaks
- ‘herd monitoring’: only 0.1-1% paralysis

## Adenovirus, norovirus, rotavirus, parechovirus, enterovirus, astroviruses, hepatitis A and E viruses

- early warning outbreaks
- virus circulation in population
- virus genotypes circulating in population

### REVIEW ARTICLE

#### Role of environmental poliovirus surveillance in global polio eradication and beyond

T. HOVI<sup>1\*</sup>, L. M. SHULMAN<sup>2</sup>, H. VAN DER AVOORT<sup>3</sup>, J. DESHPANDE<sup>4</sup>,  
M. ROIVAINEN<sup>1</sup> AND E. M. DE GOURVILLE<sup>5</sup>

<sup>1</sup> National Institute for Health and Welfare (THL), Helsinki, Finland

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<sup>3</sup> National Institute of Public Health and the Environment (RIVM), Bilthoven, The Netherlands

<sup>4</sup> Enterovirus Research Centre (ERC), Mumbai, India

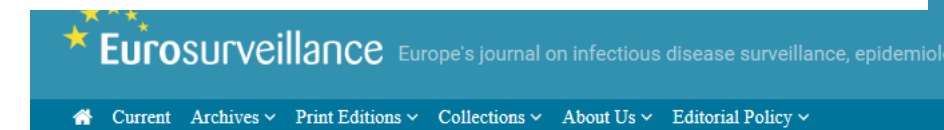
<sup>5</sup> Global Poliomyelitis Eradication Initiative, WHO, Geneva, Switzerland



#### Detection of Pathogenic Viruses in Sewage Provided Early Warnings of Hepatitis A Virus and Norovirus Outbreaks

Maria Hellmér,<sup>a</sup> Nicklas Paxéus,<sup>b</sup> Lars Magnus,<sup>c</sup> Lucica Enache,<sup>b</sup> Birgitta Arnholm,<sup>d</sup> Annette Johansson,<sup>b</sup> Tomas Bergström,<sup>a</sup> Heléne Norder<sup>a,c</sup>

Department of Clinical Microbiology, Sahlgrenska Academy, Gothenburg University, Gothenburg, Sweden<sup>a</sup>; Gryaab AB, Gothenburg, Sweden<sup>b</sup>; MTC, Karolinska Institutet, Stockholm, Sweden<sup>c</sup>; Department of Communicable Disease Control, Västra Götaland Region, Sweden<sup>d</sup>



Home / Eurosurveillance / Volume 23, Issue 7, 15/Feb/2018 / Article

#### Research article

Open Access

Monitoring human enteric viruses in wastewater and relevance to infections encountered in the clinical setting: a one-year experiment in central France, 2014 to 2015 |

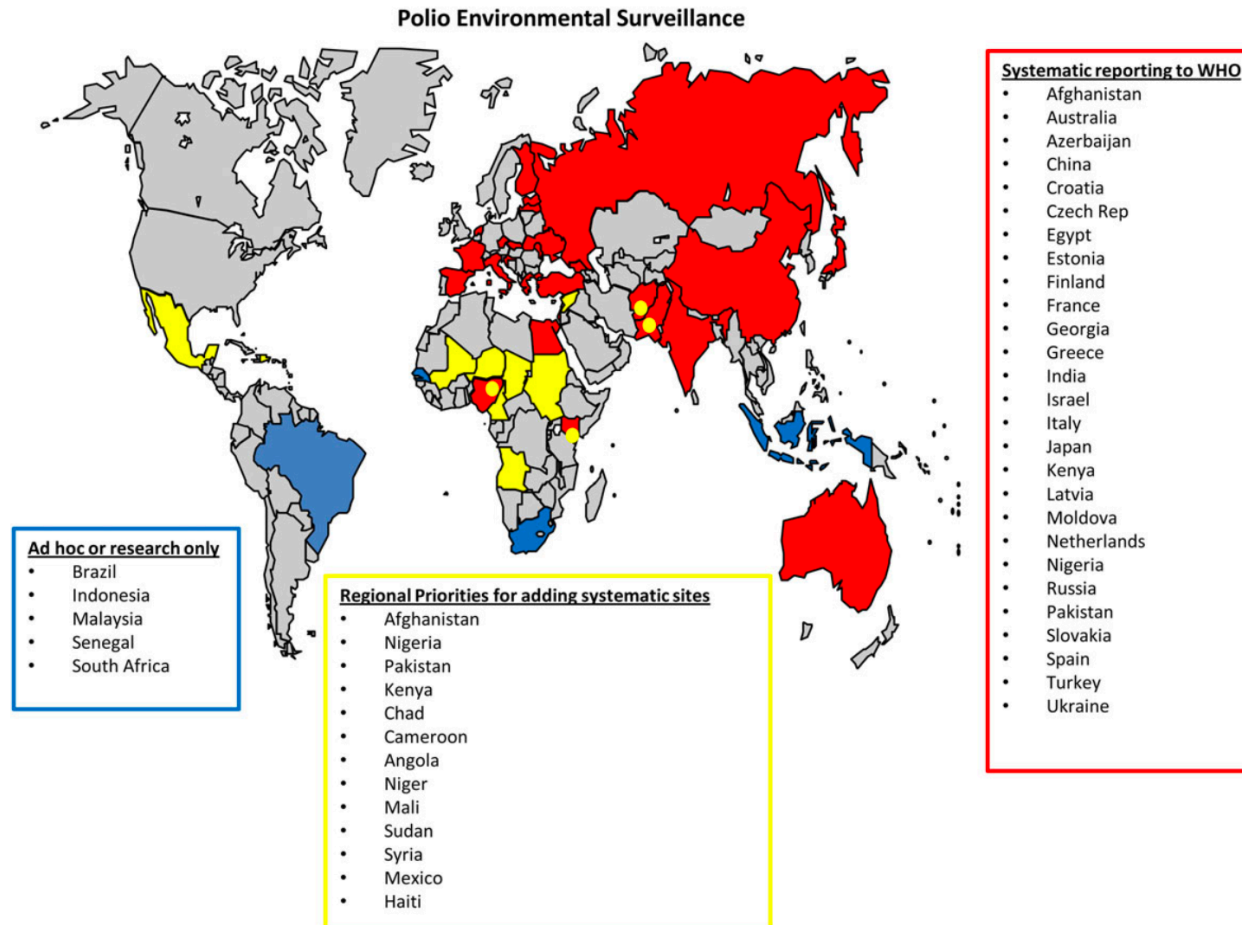
Like 0

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Maxime Bisseux<sup>1,2</sup>, Jonathan Colombet<sup>1</sup>, Audrey Mirand<sup>1,2</sup>, Anne-Marie Roque-Afonso<sup>2</sup>, Florence Abravanel<sup>2</sup>, Jacques Izopet<sup>4</sup>, Christine Archimbaud<sup>1,2</sup>, Héléne Peigue-Lafeuille<sup>1,2</sup>, Didier Debroas<sup>1</sup>, Jean-Luc Bailly<sup>1</sup>, Cécile Henquell<sup>1,2</sup>

# 1. Environmental surveillance

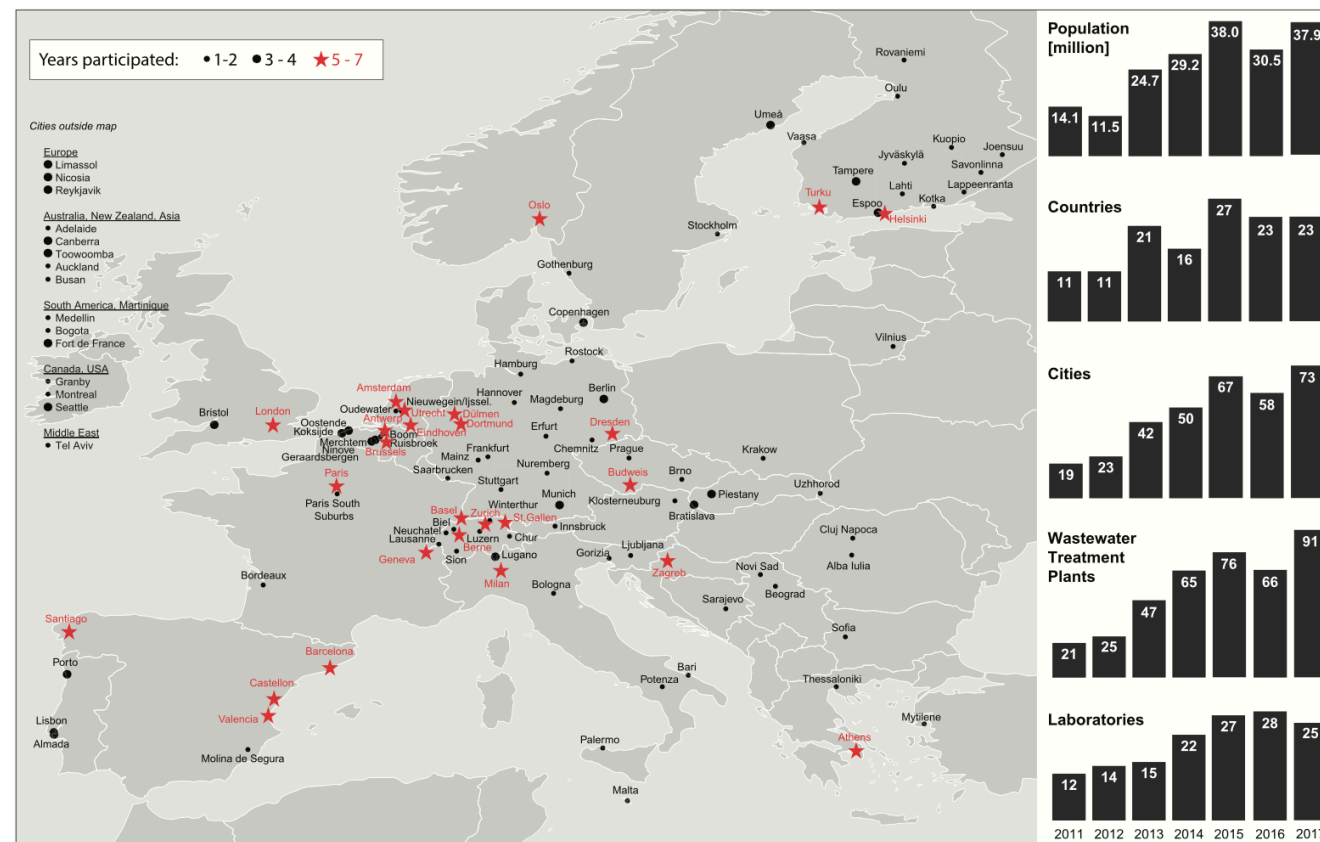
Polio virus



**Figure 1.** Countries that have undertaken environmental surveillance or sampling projects for polioviruses. Data are from the Global Polio Eradication Initiative.

## 2. (Illicit) drug use

- First implementation in 2005, monitoring cocaine use in Milan, Italy
- Number of studies increased substantially ever since
- EU and Australia main drivers
- Cocaine, amphetamine, MDMA, methamphetamine, cannabis and “novel psychoactive substances” (NPS)
- Extensions to (counterfeit) pharmaceuticals



## 2. (Illicit) drug use

- Creation of the **Sewage Analysis CORE group Europe (SCORE)** network
  - Yearly monitoring campaign and interlaboratory exercises
- Endorsement by the **European Monitoring Centre for Drugs and Drug Addiction (EMCDDA)**
  - WBE as indicator for drug use surveillance

# score

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Sewage Analysis CORE group Europe

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### Sewage Analysis CORE group Europe (SCORE)

SCORE will develop and expand an existing pan-European inter-disciplinary network, bringing together experts from relevant disciplines interested in the application and development of using the quantitative measurement of human biomarkers in sewage to evaluate lifestyle, health and exposure at the community level.

Wastewater monitoring data 2011-2019 now available



European Monitoring Centre  
for Drugs and Drug Addiction



Results hosted on duckduckgo.com

Data Countries Topics (A-Z) Our activities Best practice Publications Events News About

Home Topics

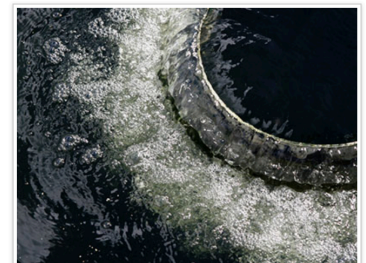
### Wastewater-based epidemiology and drugs topic page

Topics

Publications News Events Data Library Media

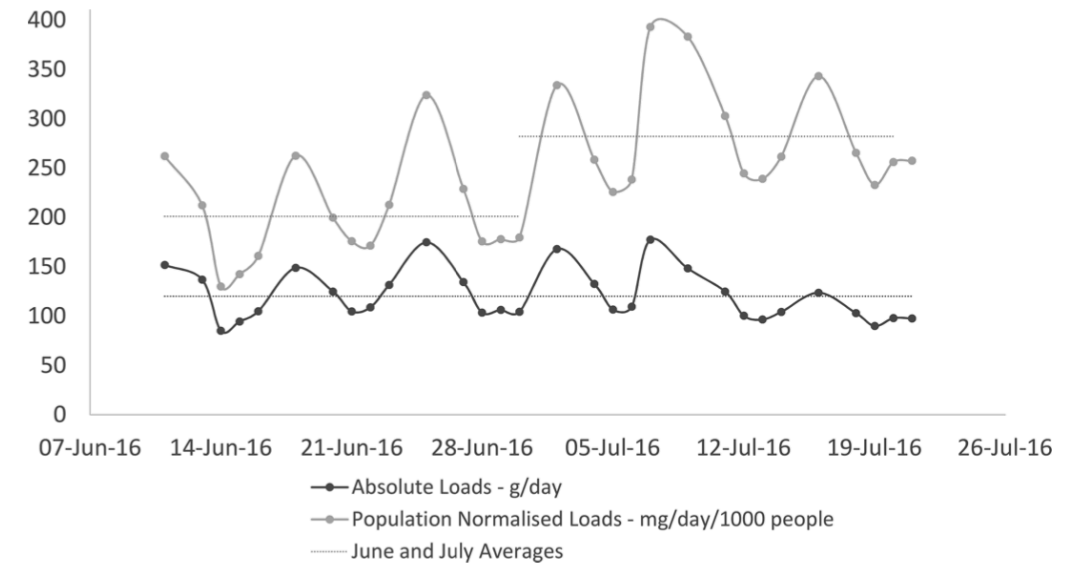
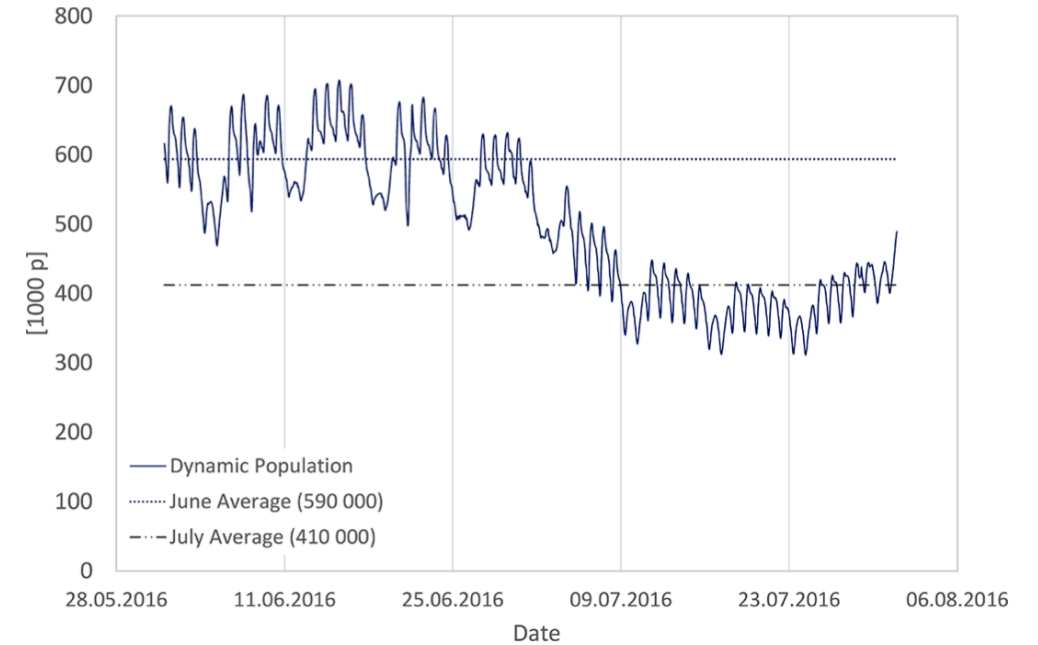
#### Overview

Analysing communal wastewaters for drugs and their metabolic products in order to estimate their consumption in the community is a developing field, involving scientists working in different research areas, including analytical chemistry, physiology and biochemistry, sewage engineering, spatial epidemiology and statistics, and conventional drug epidemiology. On this page you can find links to various EMCDDA outputs on this topic as well as links to external resources.



### 3. Population dynamics

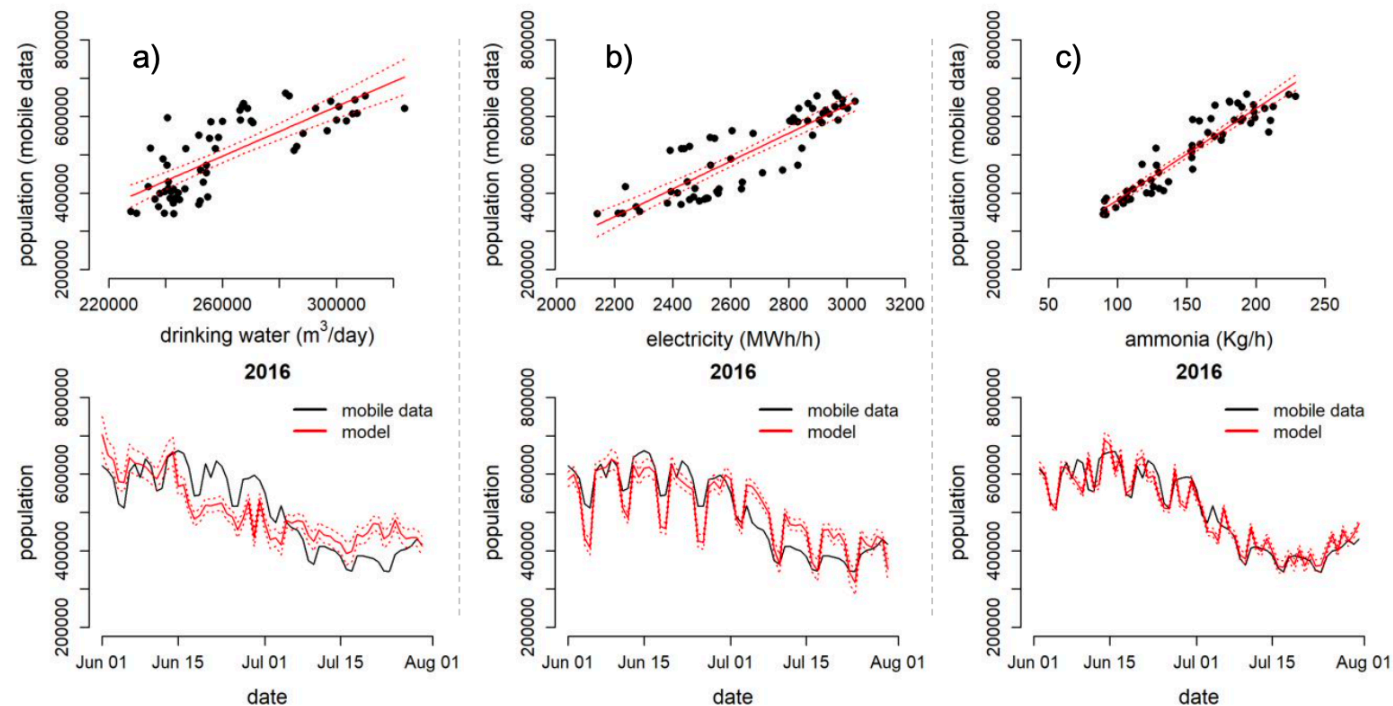
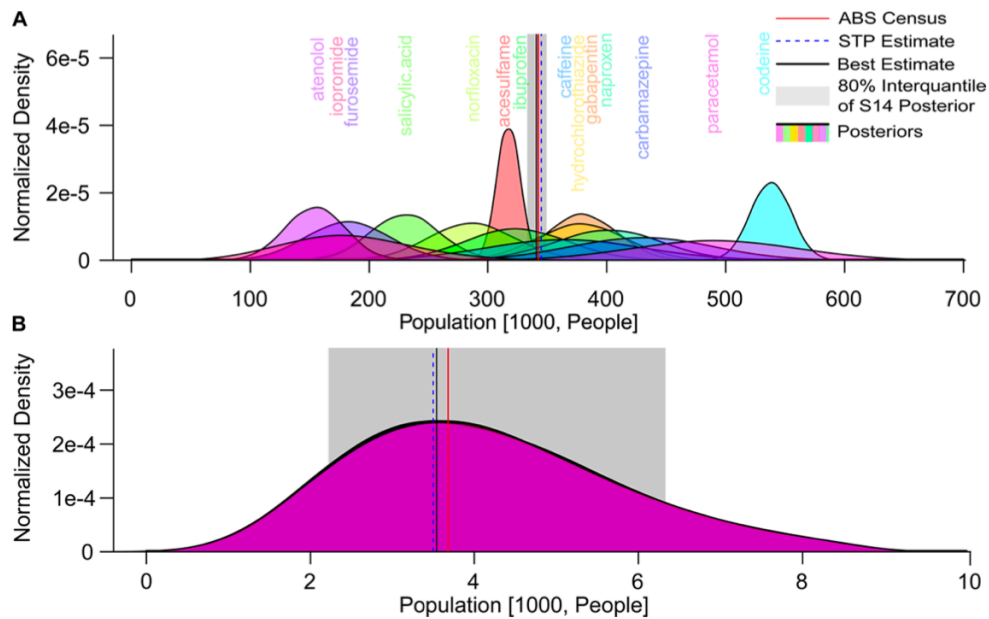
- Size of the population contributing to (highly) variable
- Commuters
- Holidays
- Public events
- Interpretation of observed trends?
- Increased consumption (drugs) or prevalence (pathogen/disease) or
- Increase in absolute number of inhabitants





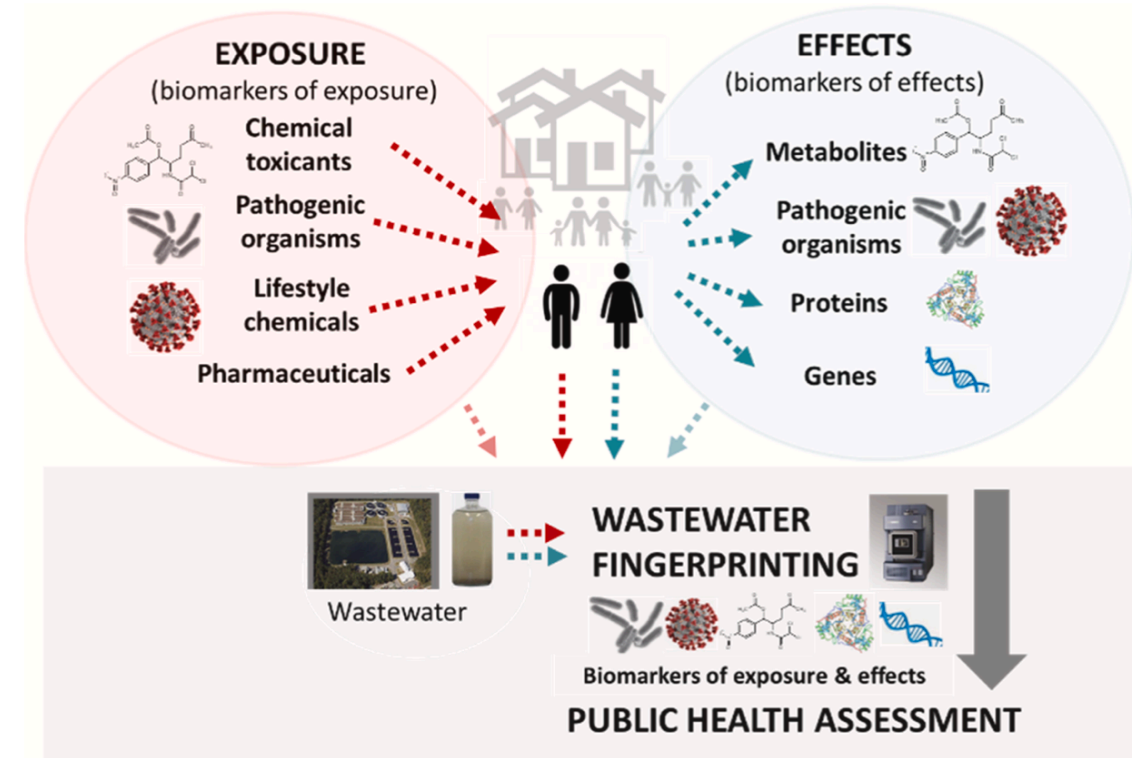
# 3. Population dynamics

- Anthropogenic markers
- Mobile phone data (\$)



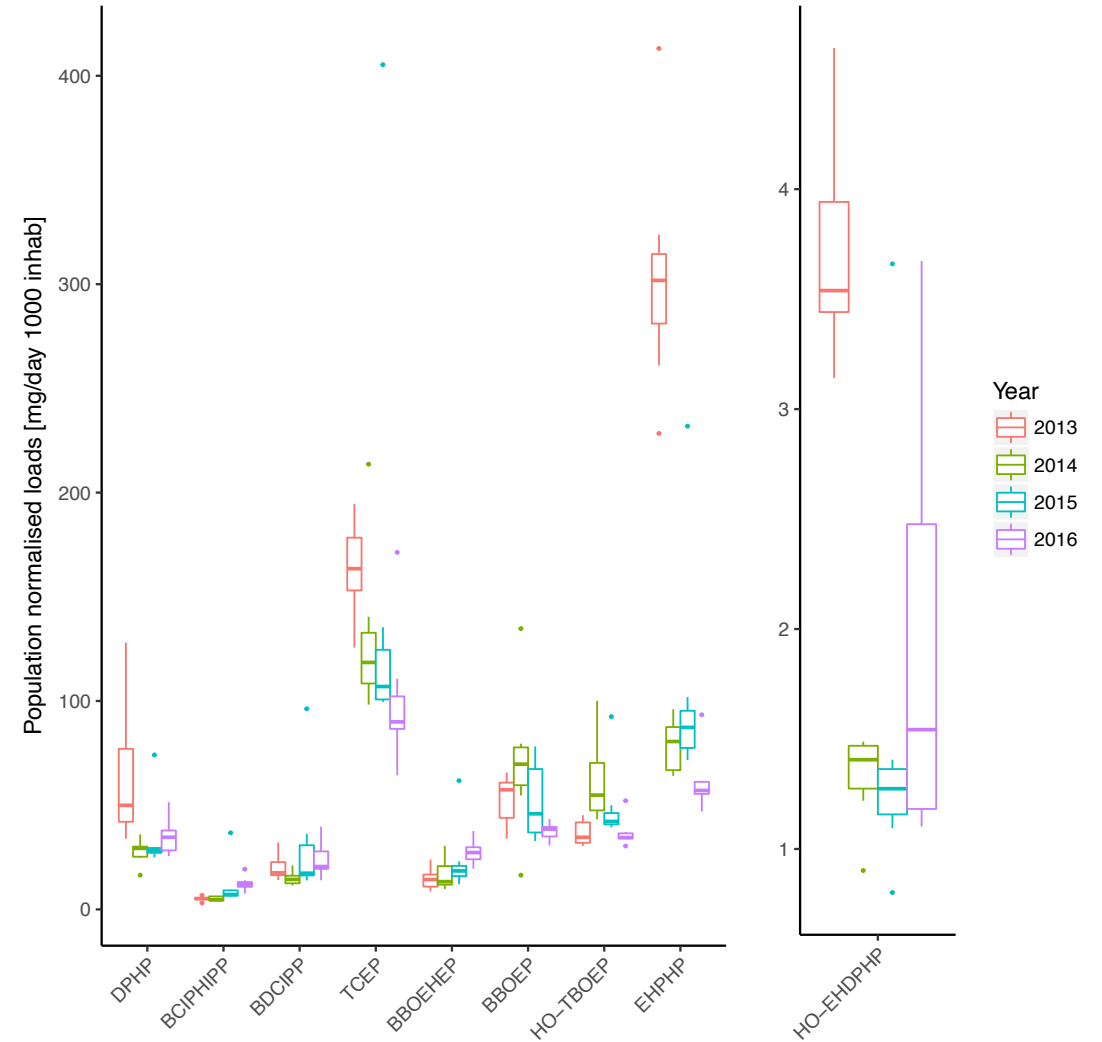
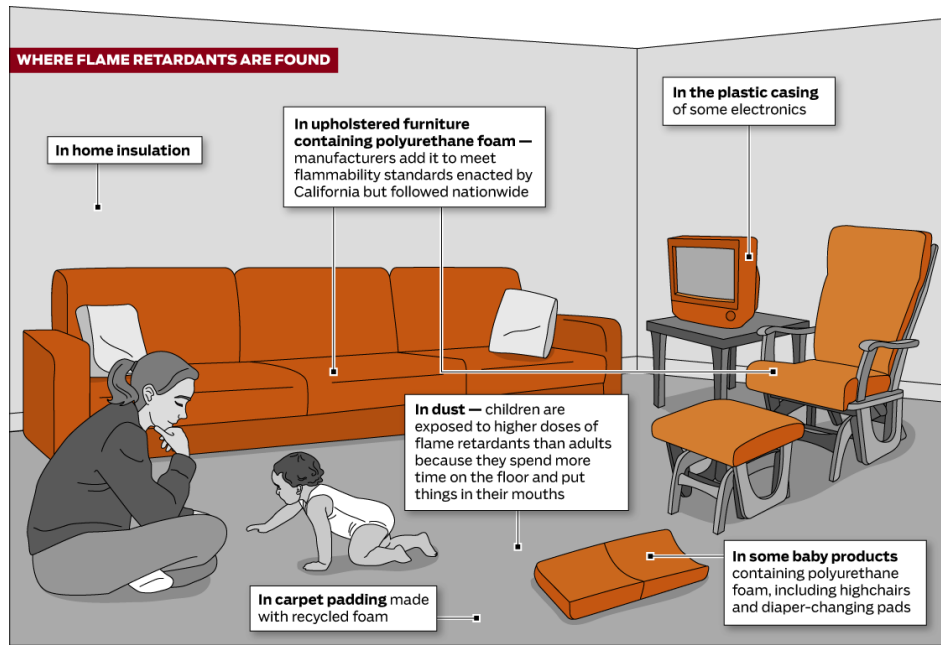
## 4. Environmental contaminants

- Link with the concept of *Exposome*
- Clinical/cohort studies monitor human exposure to environmental contaminants
  - Exposure biomarkers (e.g. urinary metabolites)
  - Used to establish causality: exposure  $\leftrightarrow$  health endpoint
  - Limited in **size, space and time**



# 4. Environmental contaminants

- Pesticides
- Mycotoxins
- Phthalates
- Flame retardants



## 5. Antibiotic resistance

- Monitoring antibiotics and AMR emissions and HGT in WWTP
- Focus on emissions to the environment and further selective pressure
- Inversed perspective: use WWTP to monitor community-wide AMR burden
- Monitor ARGs and/or sequencing
- Measure antibiotics/antimicrobials (e.g. (over)prescription)

### Complementary systems

Sewage-based surveillance using metagenomics is flexible, scalable, and easy to quickly implement and standardize, while complementing clinical, isolate-based surveillance.

**Community population**  
Hundreds of thousands mostly healthy people (but also includes patients in the health care system)

**Hospital or clinical patients**  
Hundreds to thousands of people within the health care system

#### Proposed



Sewage samples are tested by DNA purification.

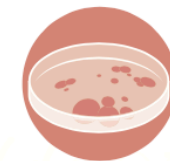


Sequence data contain information on all known types of resistance.



Bioinformatics analysis extracts resistance information.

#### Current



Samples from patients are tested by bacterial isolation and culture.



Resistance to only a few antibiotics is tested.



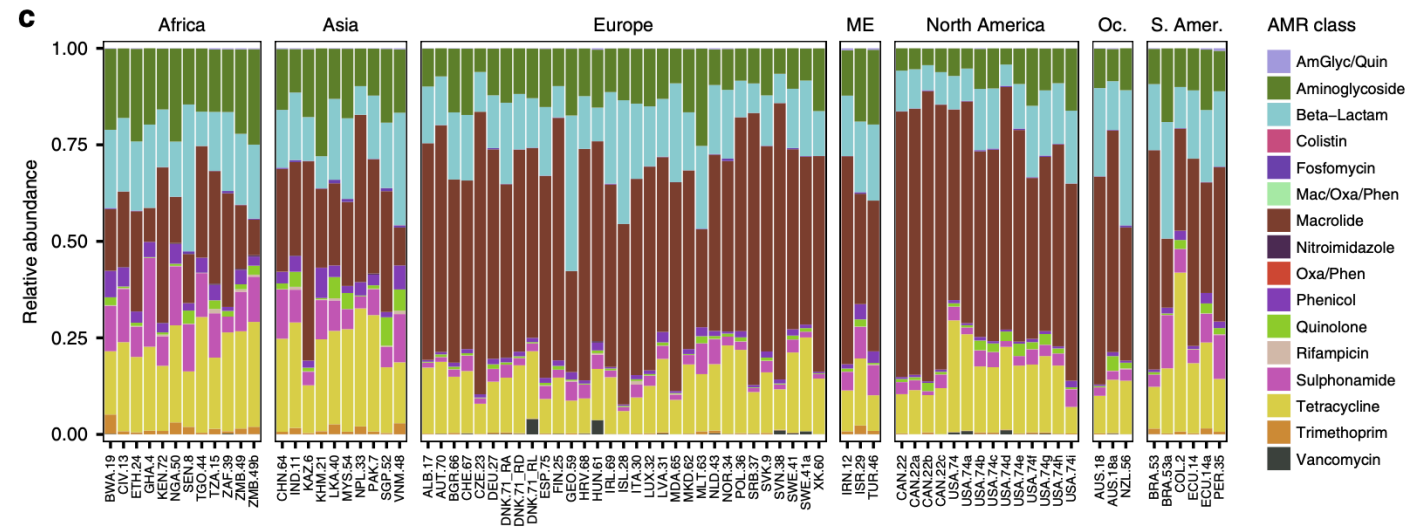
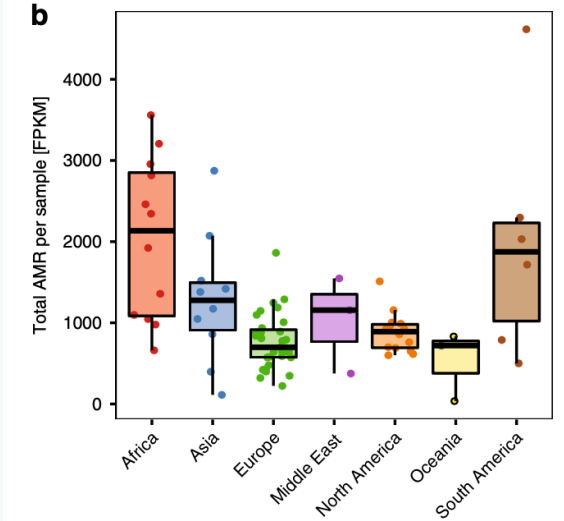
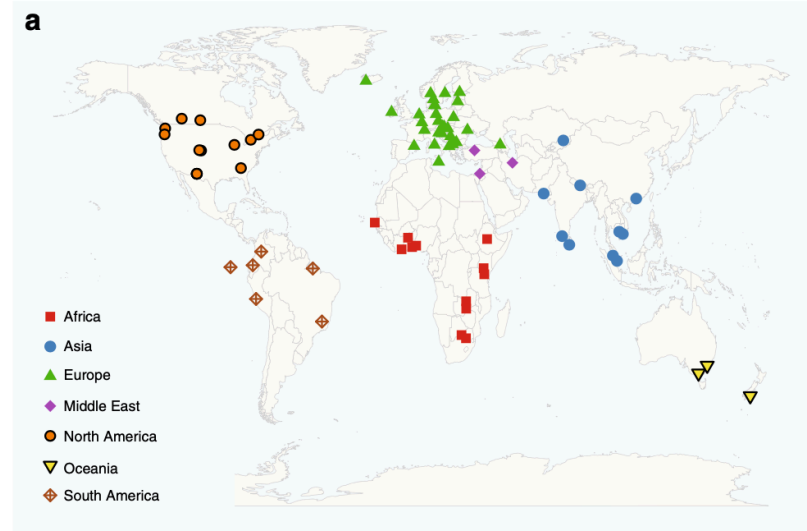
Results are manually recorded.

National and international reporting



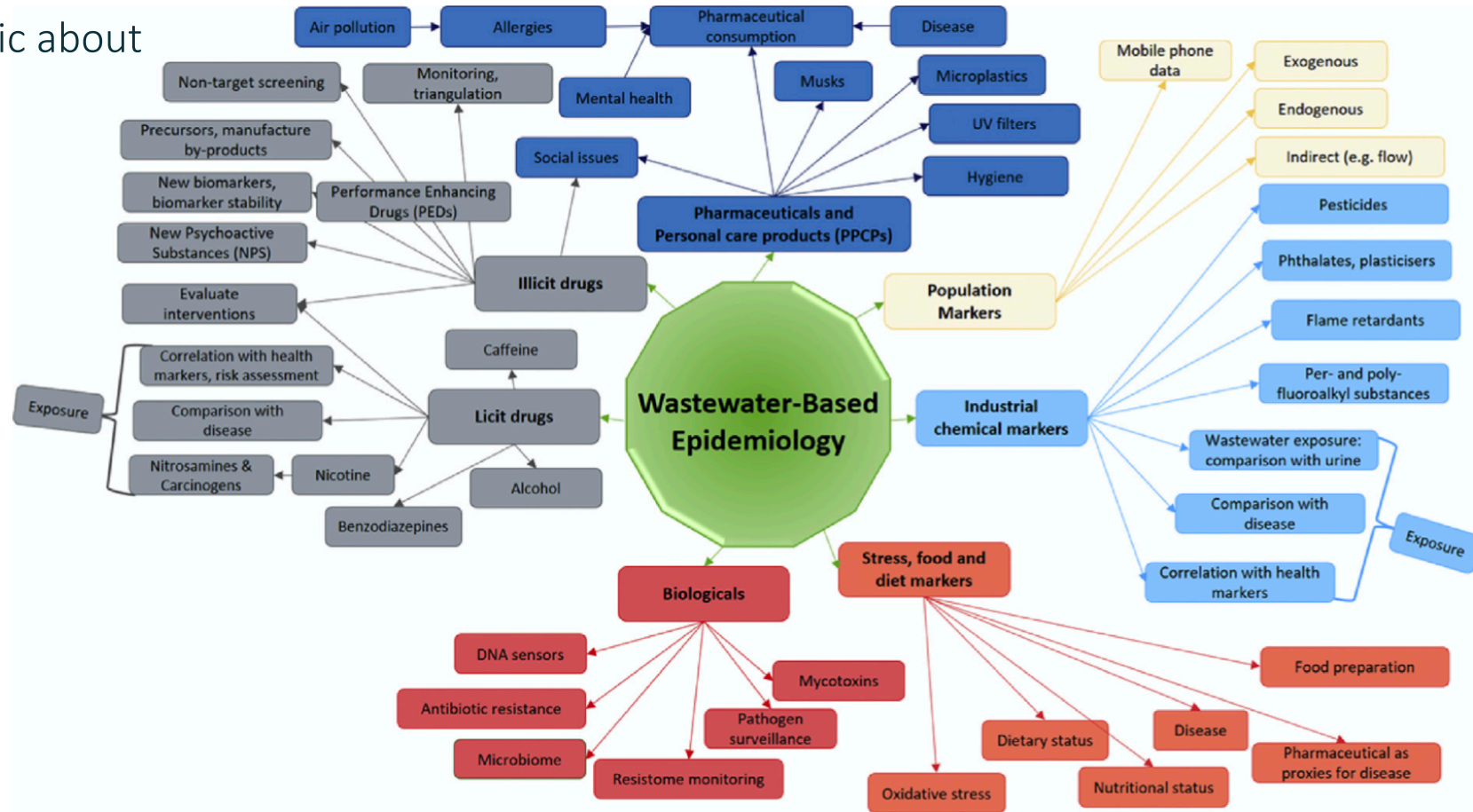
# 5. Antibiotic resistance

- Metagenomic analysis
- AMR genes
- Link with other socio-economical covariates
  - Antibiotic use
  - Sanitation
  - Health
  - ...



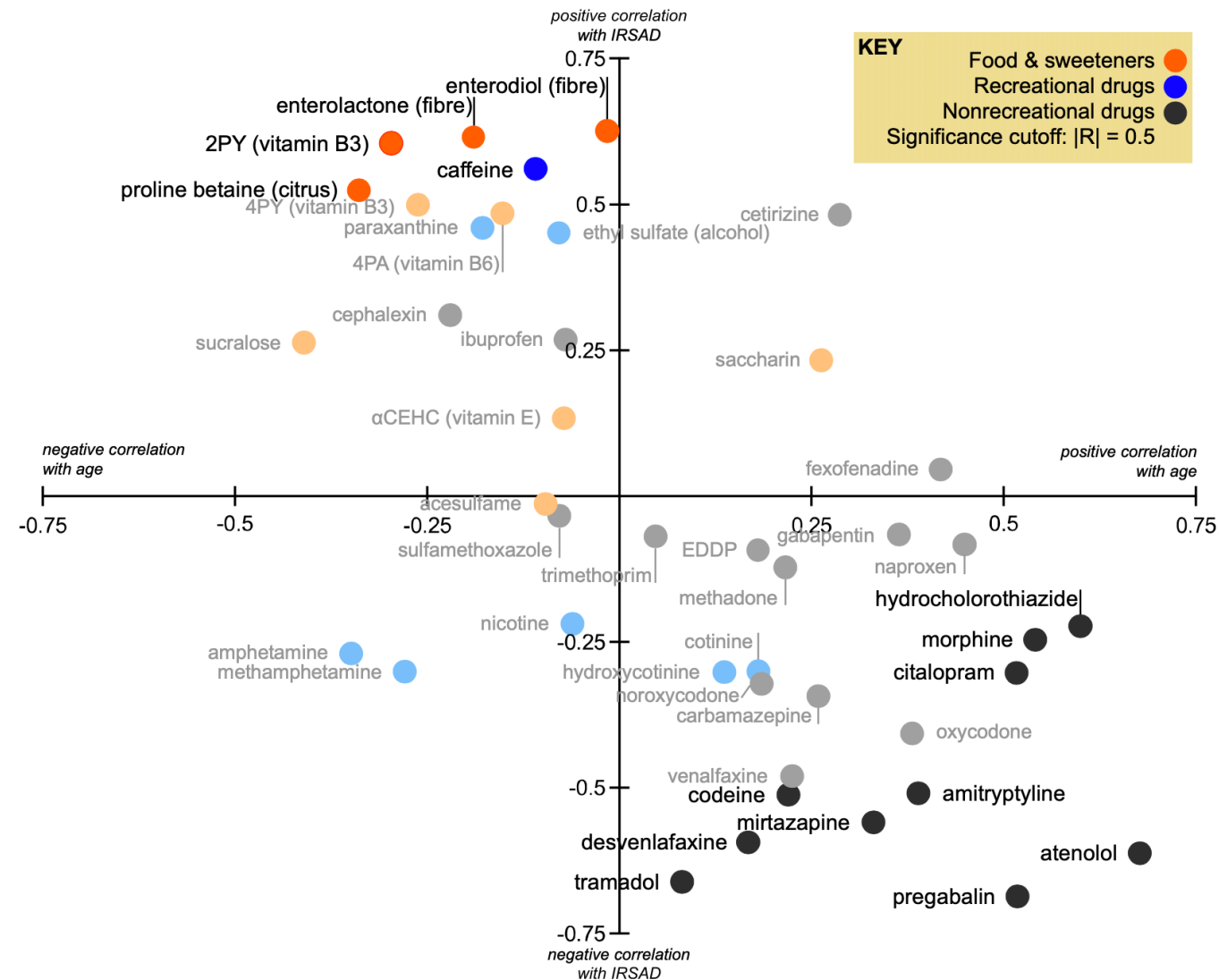
# 6. Health biomarkers

- The holy grail of WBE
- Measure biomarkers diagnostic about community-wide disease prevalence/incidence
- Endogenous biomarkers
- Metabolites
- Proteins



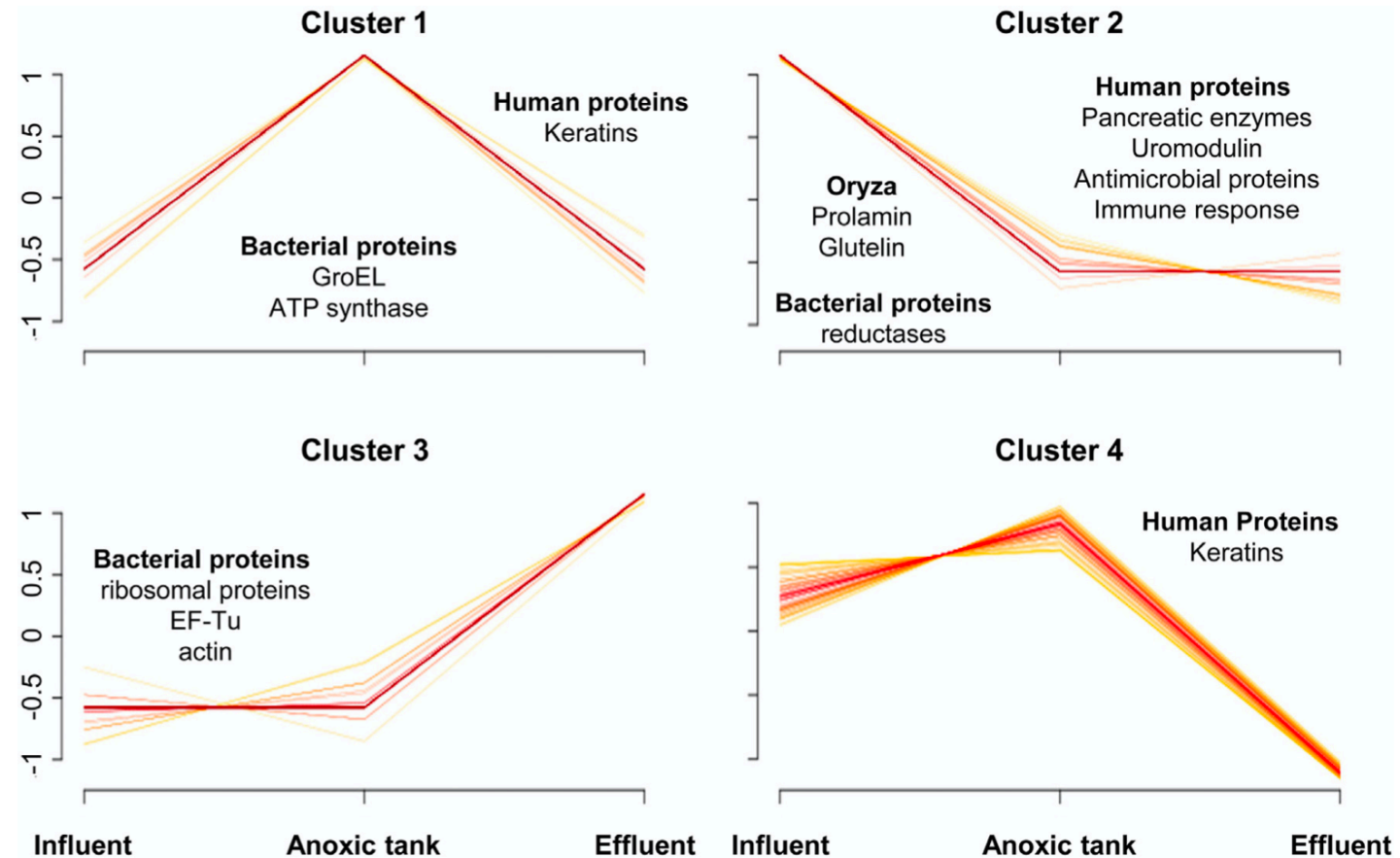
# 6. Health biomarkers

- Monitoring a broad range of (endogenous) biomarkers and correlate to socio-economical covariates



## 6. Health biomarkers

- First steps in the field of “wasteomics”
- Use of polymeric probes to analyse 690 bacterial, plant and animal proteins
  - Identified 57 human proteins
    - S100A8
    - Uromodulin
    - defensins
    - ...

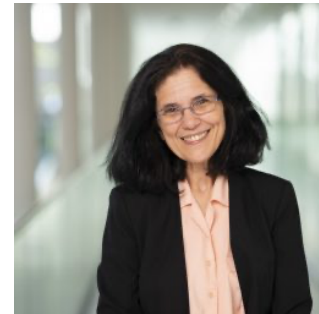






## 7. Future

- Additional (fundamental) research needed in many areas
- Need for collaboration and harmonization
- Stronger links with clinical studies
- How do we translate/interpret wastewater data
- Involvement of health authorities and stakeholders
- But the future is bright





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