Sources of Water Pollution:
A Multi-pollutant Perspective

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Water Quality (in development)

Messages

- A need for multi-pollutant approaches

- Agriculture and sewage are common sources of pollutants

- At least 50% of global population experience multi-pollutant issues

Eutrophication

Nitrogen

Phosphorus

Eutrophication

Nitrogen

Phosphorus
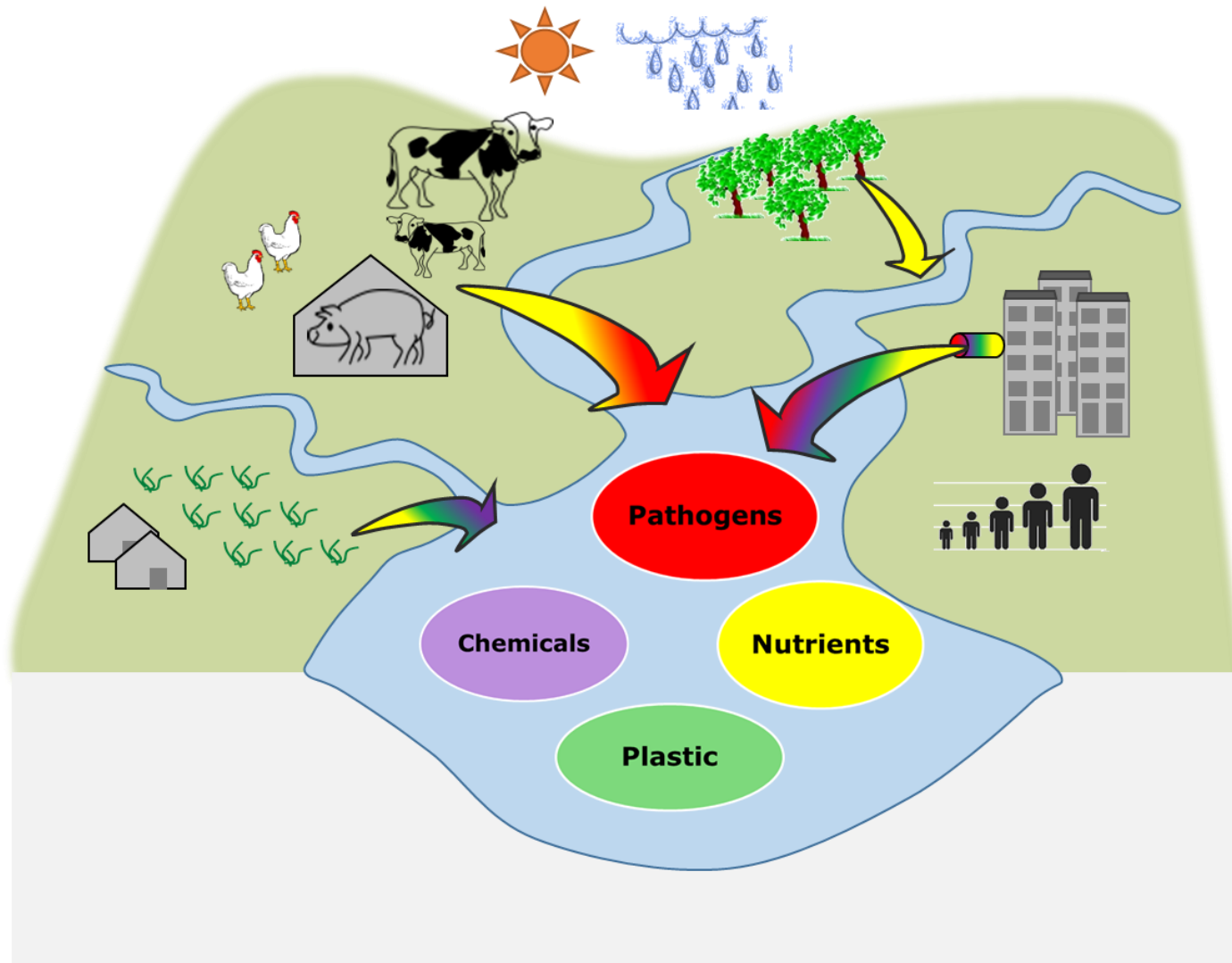
Eutrophication

Nitrogen

Phosphorus

Eutrophication

Nitrogen

Phosphorus

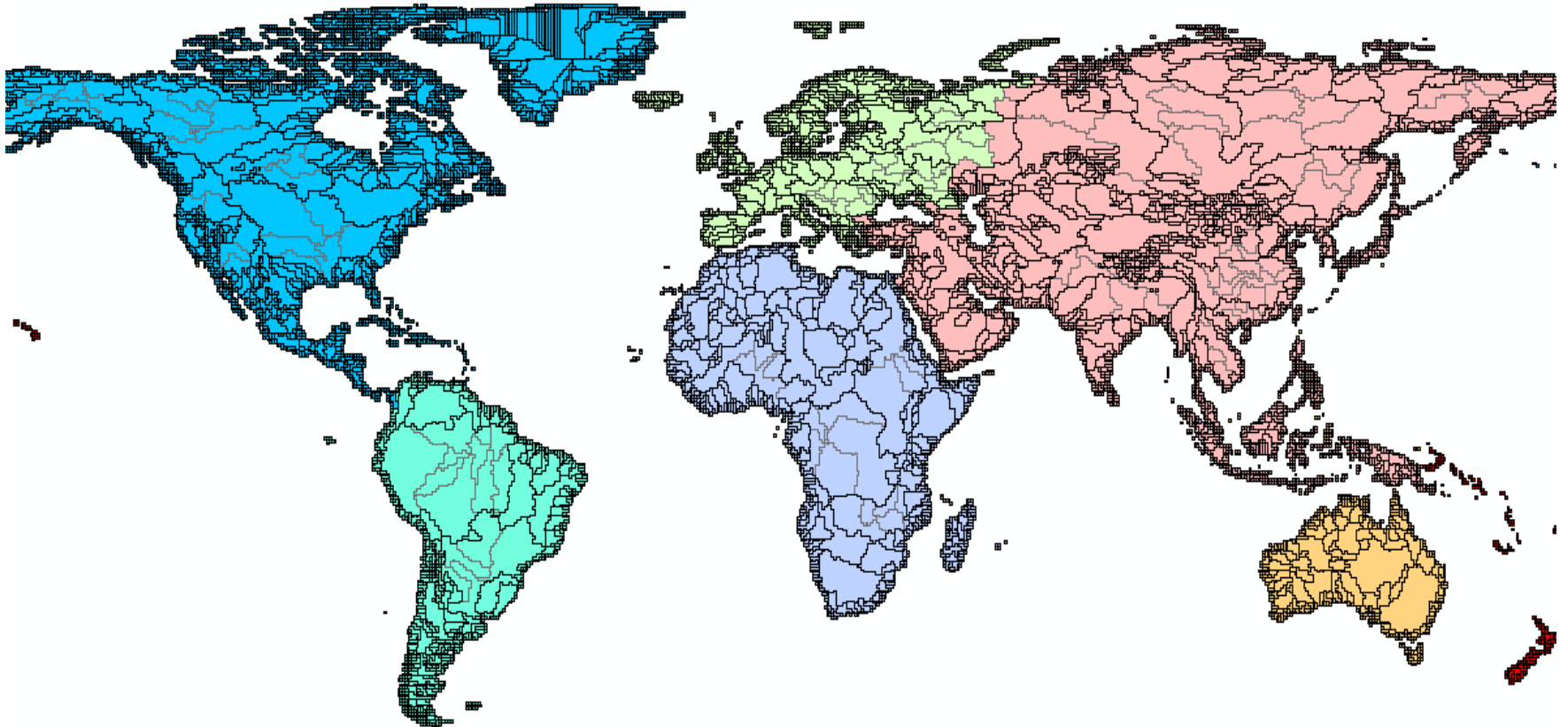# A need for multi-pollutant approaches

- Multiple impacts
- Diverse interactions
- **Common sources**
- Effective solutions

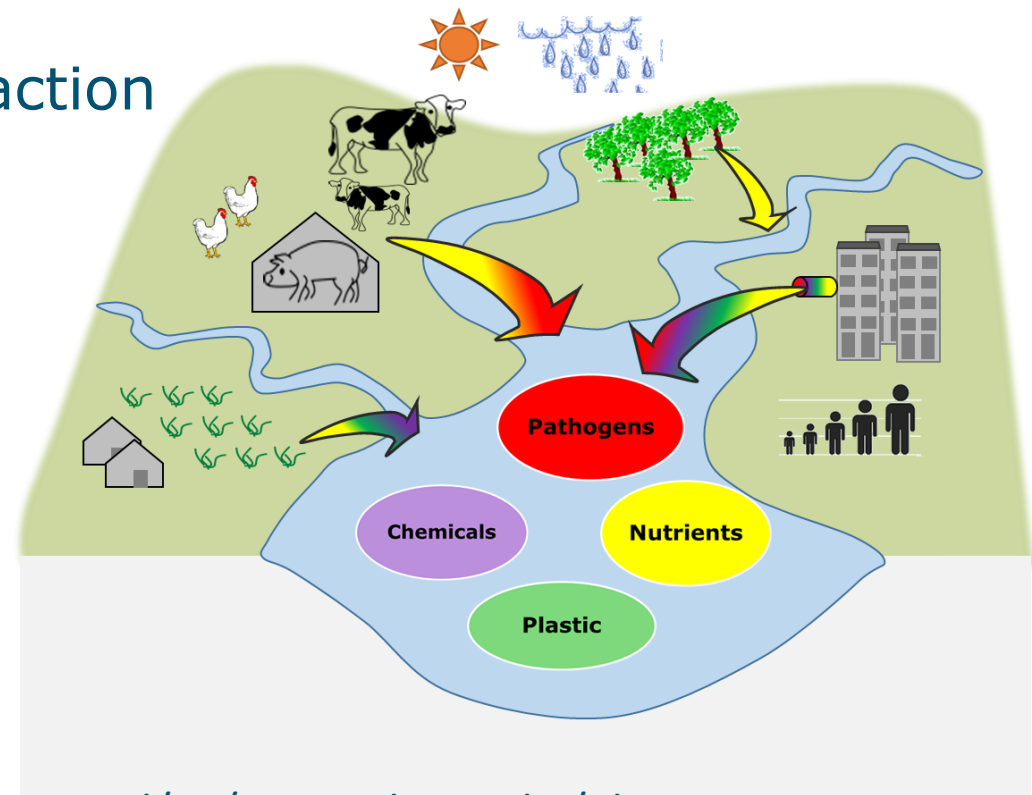# Common sources of water pollution

Common sources for > 10,000 rivers

MARINA models:
Model to Assess River Inputs of pollutaNts to seA

- Integration of processes
- Food-water-climate interaction
- Animal-crop interaction
- Spatially explicit
- Past, present and future

https://www.wur.nl/en/Research-Results/Chair-groups/Environmental-Sciences/Water-Systems-and-Global-Change-Group/MARINA-2.htm

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MARINA website: will be available soon

MARINA Family

In short, MARINA is a **M**odel to **A**ssess **R**iver **I**nputs of polluta**N**ts to se**A**s.

We develop the MARINA family consisting of interdisciplinary, sub-basin scale models. Our MARINA models focus on multi-pollutant issues under global change. The models aim to quantify the levels of multiple pollutants in water, their sources, and trends in relation to interactions between climate and socio-economic systems at different scales in time (annual, seasonal) and space (past, present and future). The models are used to explore effective solutions under global change.
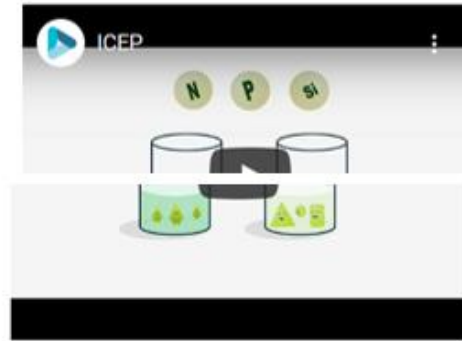
MARINA sub-themes

Our MARINA models are developed along the four pollution sub-themes: Nutrients, Plastics, Antibiotics and Multiple Pollutants. These sub-themes consist of specific versions of the models. We invite you to visit the sub-themes that illustrate the model descriptions and examples of the modelling outcomes.

Nutrients

Plastics

Antibiotics

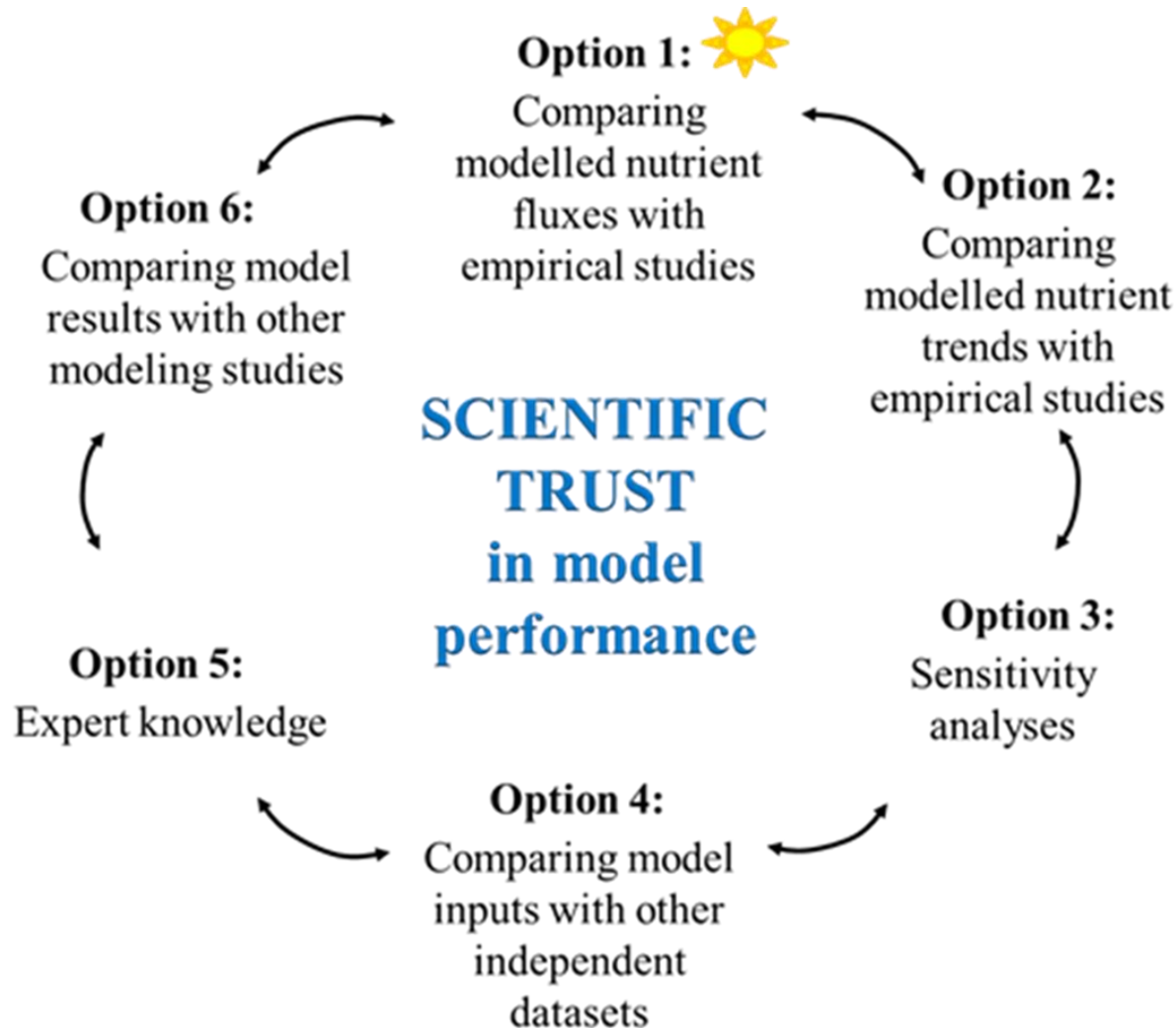Multiple pollutants
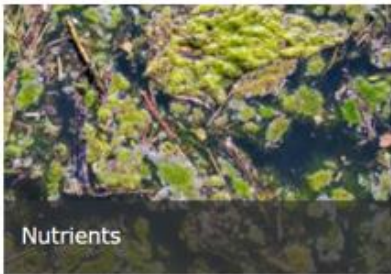
MARINA video's

Curious to learn more about water pollution in general and on how to use the MARINA models? We invite you to take a look at our MARINA video channel.
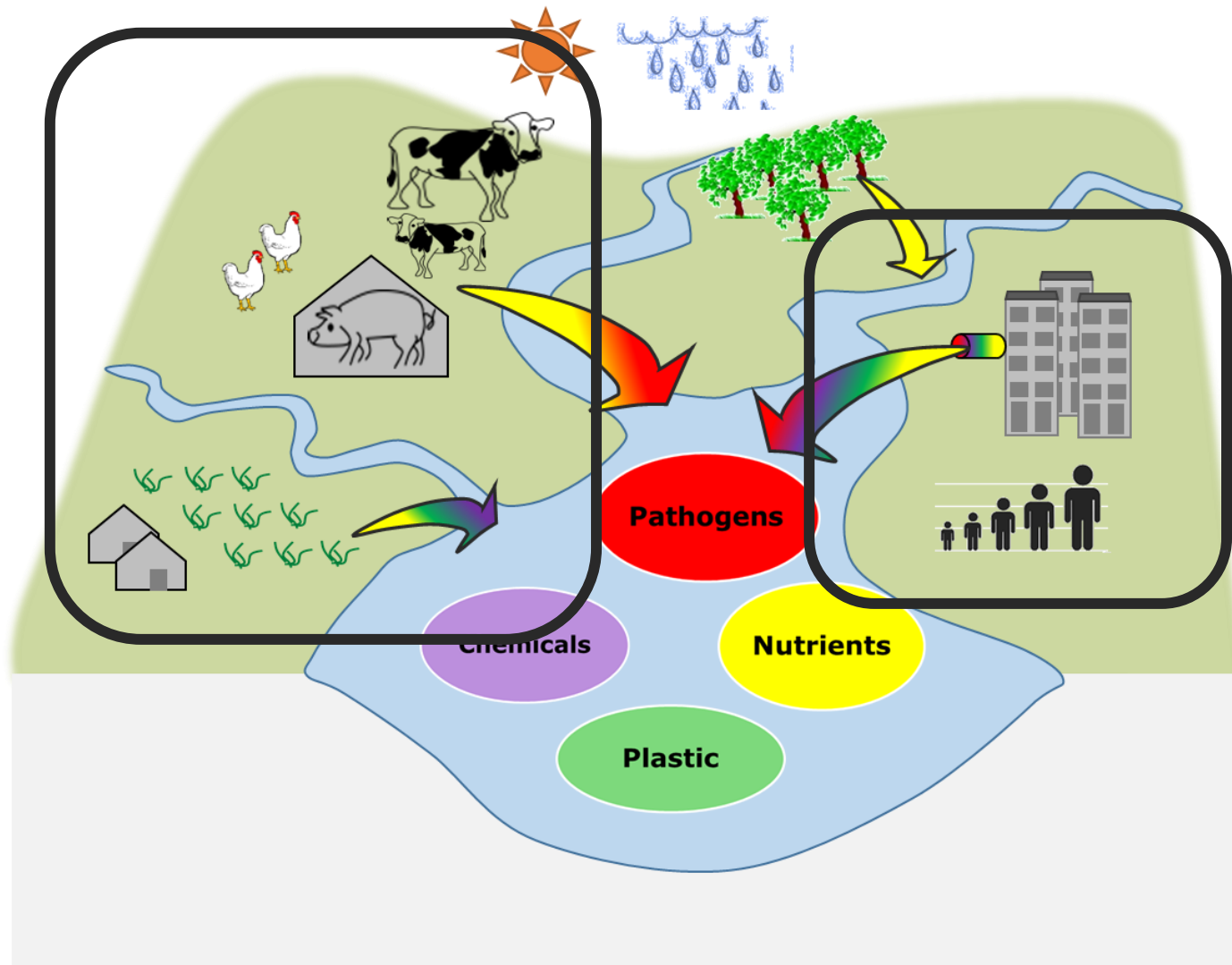
MARINA video channel

https://www.wur.nl/en/Research-Results/Chair-groups/Environmental-Sciences/Water-Systems-and-Global-Change-Group/MARINA-2.htm

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Model evaluation – "building trust" approach

Option 1: ☀️ Comparing modelled nutrient fluxes with empirical studies

Option 2: Comparing modelled nutrient trends with empirical studies

Option 3: Sensitivity analyses

Option 4: Comparing model inputs with other independent datasets

Option 5: Expert knowledge

Option 6: Comparing model results with other modeling studies

SCIENTIFIC TRUST in model performance

Strokal et al. (2016), (2021)
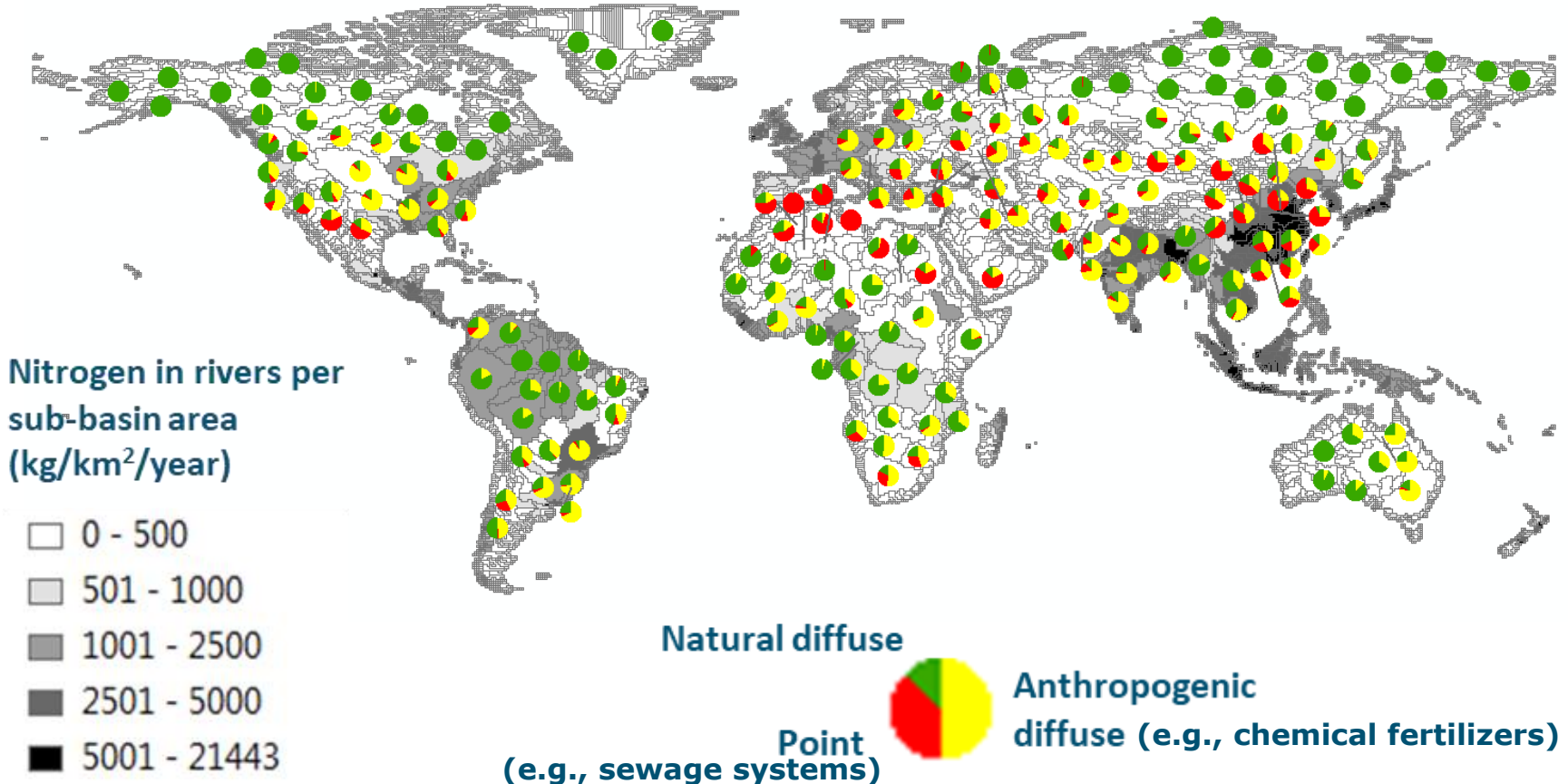
Common sources of water pollution

Agriculture:
a source of nutrients, pathogens, and antibiotics

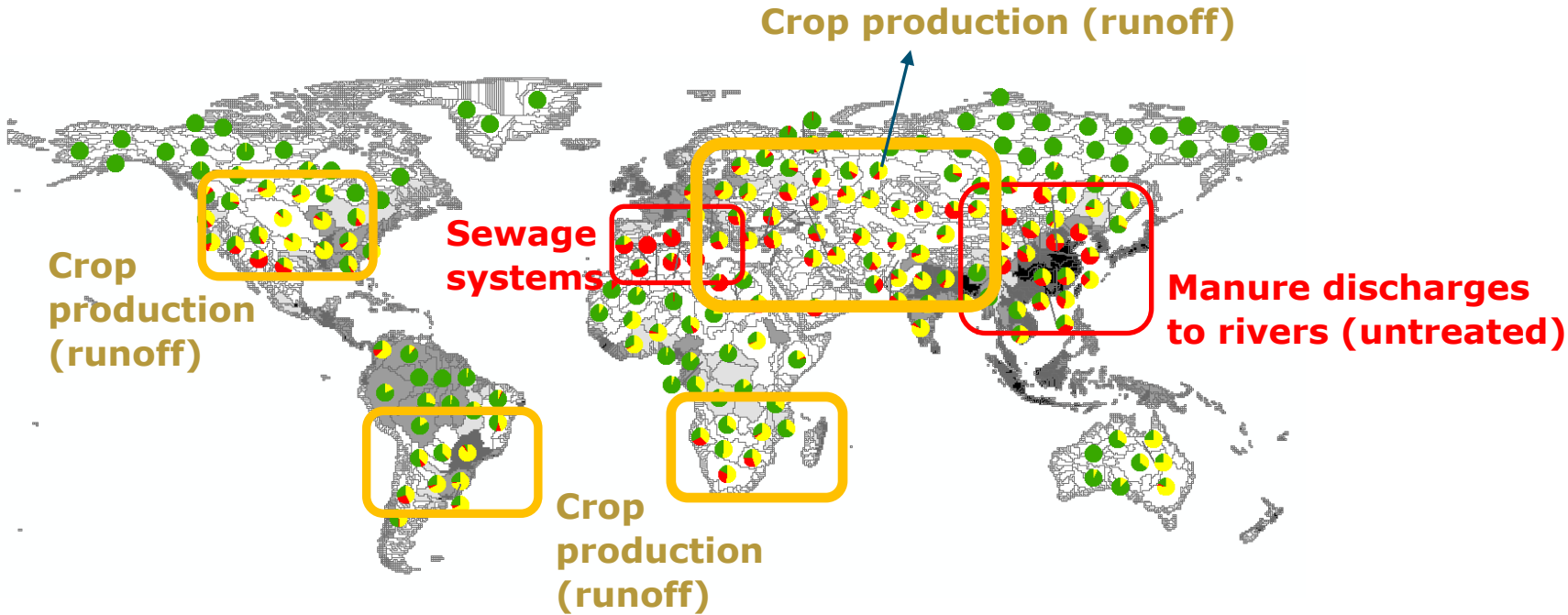# Agriculture:
a source of **nutrients**, pathogens, and antibiotics

Preliminary results

Nitrogen in rivers per sub-basin area (kg/km²/year)

□ 0 - 500
□ 501 - 1000
▨ 1001 - 2500
▨ 2501 - 5000
■ 5001 - 21443

Natural diffuse

Point (e.g., sewage systems)

Anthropogenic diffuse (e.g., chemical fertilizers)

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Wang et al (in prep)

Agriculture:
a source of **nutrients**, pathogens, and antibiotics

Preliminary results

Crop production (runoff)

Crop production (runoff)

Sewage systems

Manure discharges to rivers (untreated)

Crop production (runoff)

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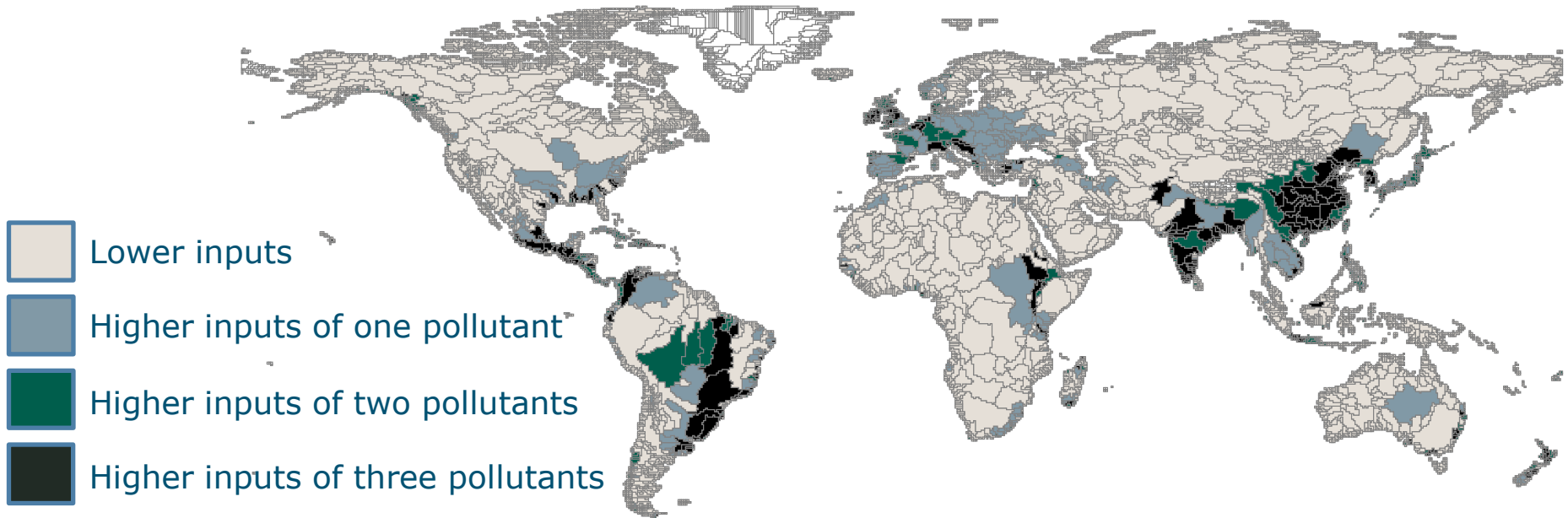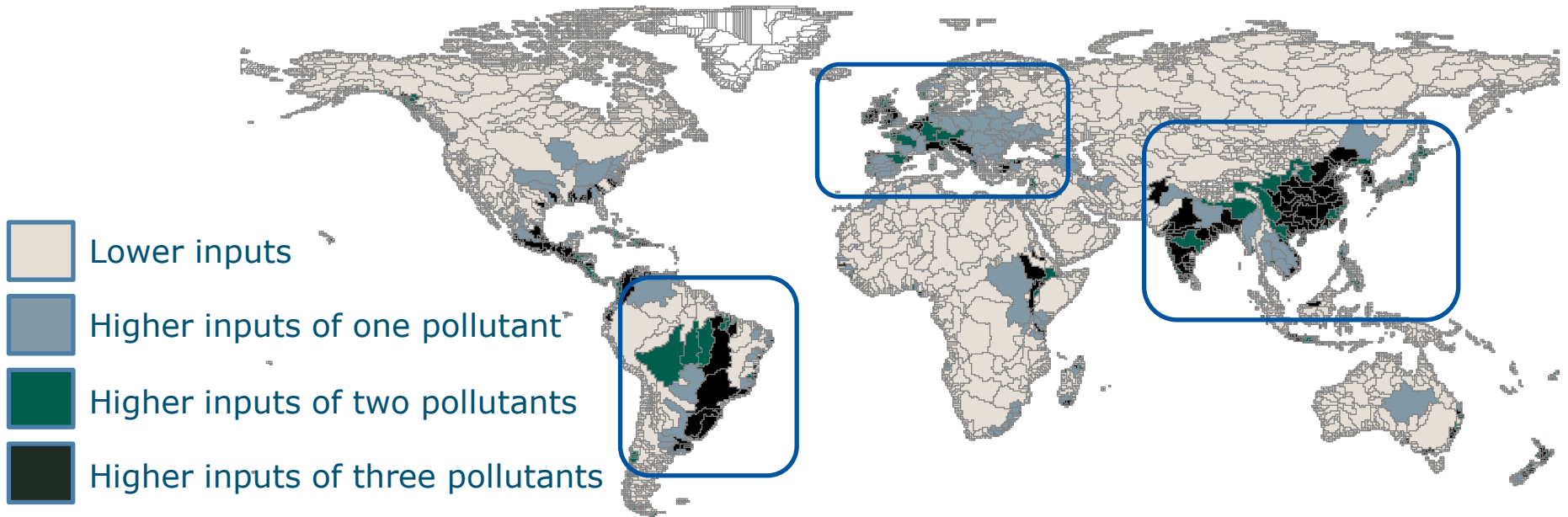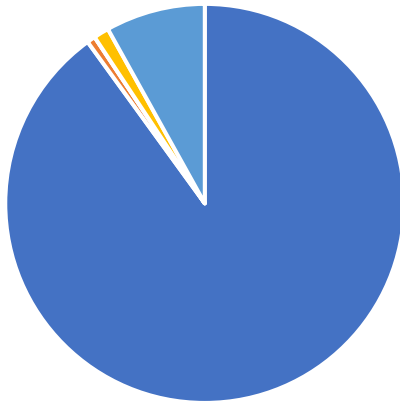
Agriculture:
a source of **nutrients**, **pathogens**, and antibiotics

Inputs of nitrogen, phosphorus and pathogen to rivers from livestock in 2010

- Lower inputs
- Higher inputs of one pollutant
- Higher inputs of two pollutants
- Higher inputs of three pollutants

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Agriculture:
a source of **nutrients**, **pathogens**, and antibiotics

Inputs of nitrogen, phosphorus and pathogen to rivers from livestock in 2010

Lower inputs

Higher inputs of one pollutant

Higher inputs of two pollutants

Higher inputs of three pollutants

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Agriculture:
a source of **nutrients**, **pathogens**, **and antibiotics**

Preliminary results

Shares of 5 classes of antibiotics in **Tetracyclines group** (%)

- Chlortetracycline
- Tetracycline
- Methacycline
- Docycycline
- Oxytetracycline
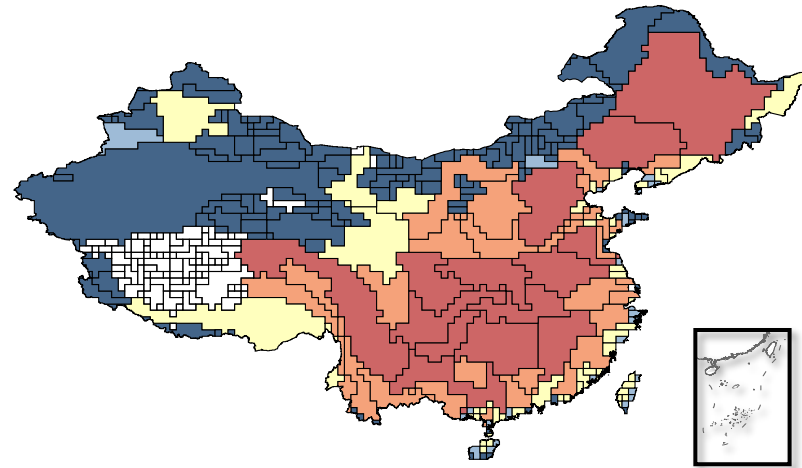
Excretion of tetracyclines in pig manure in sub-basin (kg/year)
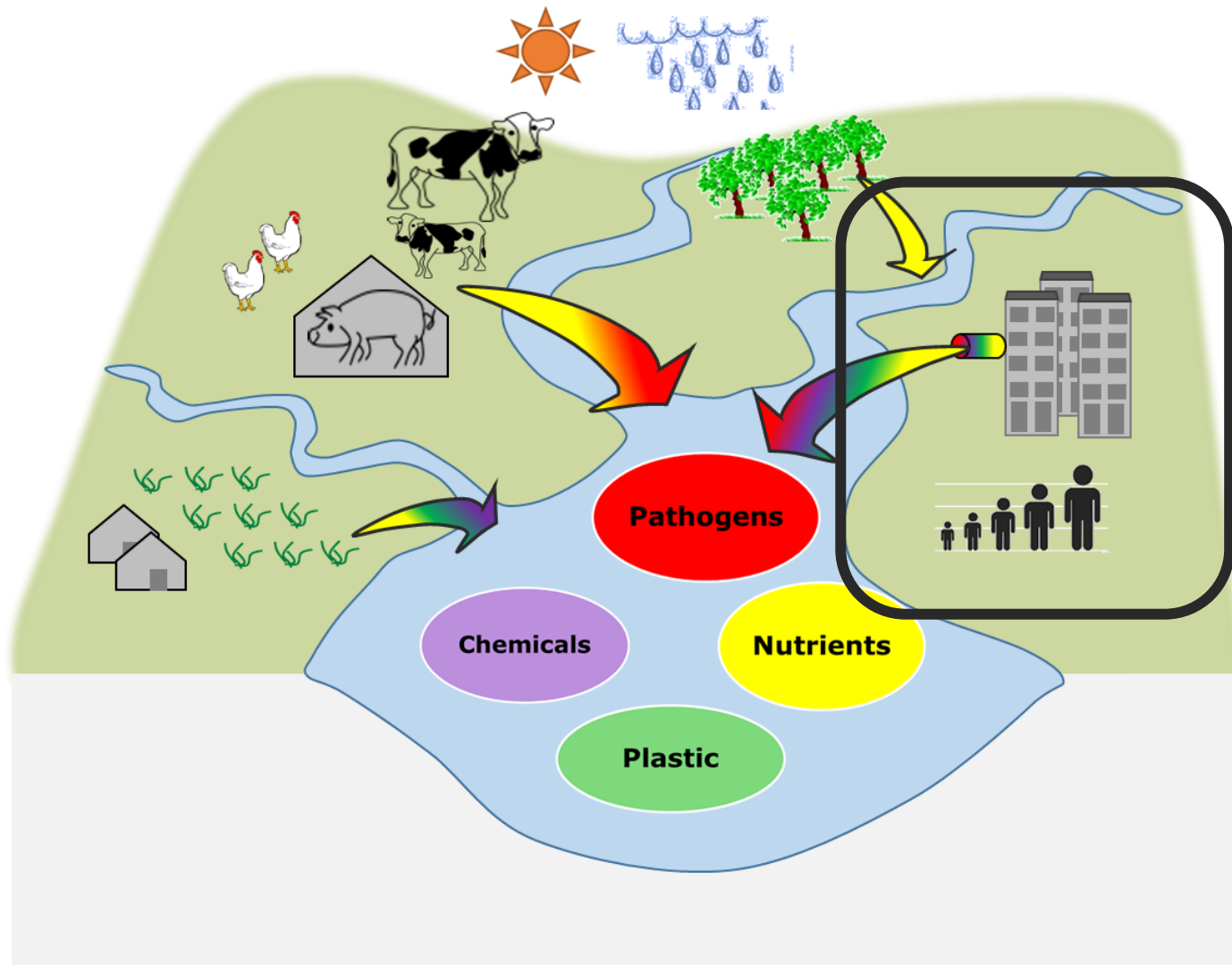
Low

High

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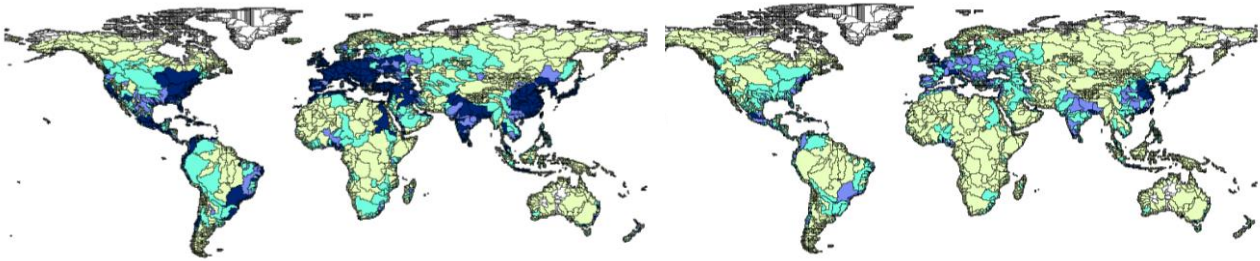UNIVERSITY & RESEARCH

Qi Zhang et al (unpublished)

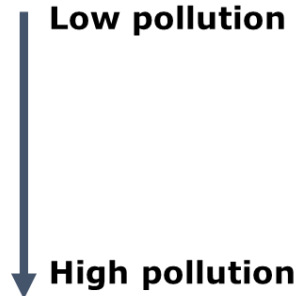# Common sources of water pollution

Sewage systems:
sources of multiple pollutants in rivers

Nitrogen (kgN/km²/year)

Phosphorus (kgP/km²/year)

Nitrogen		Phosphorus
☐	0	0
☐	0-10	0-5
☐	10-50	5-30
☐	50-100	30-100
■ →100	>100	>100

Low pollution

High pollution

Strokal et al (2019)

Sewage systems:
sources of multiple pollutants in rivers
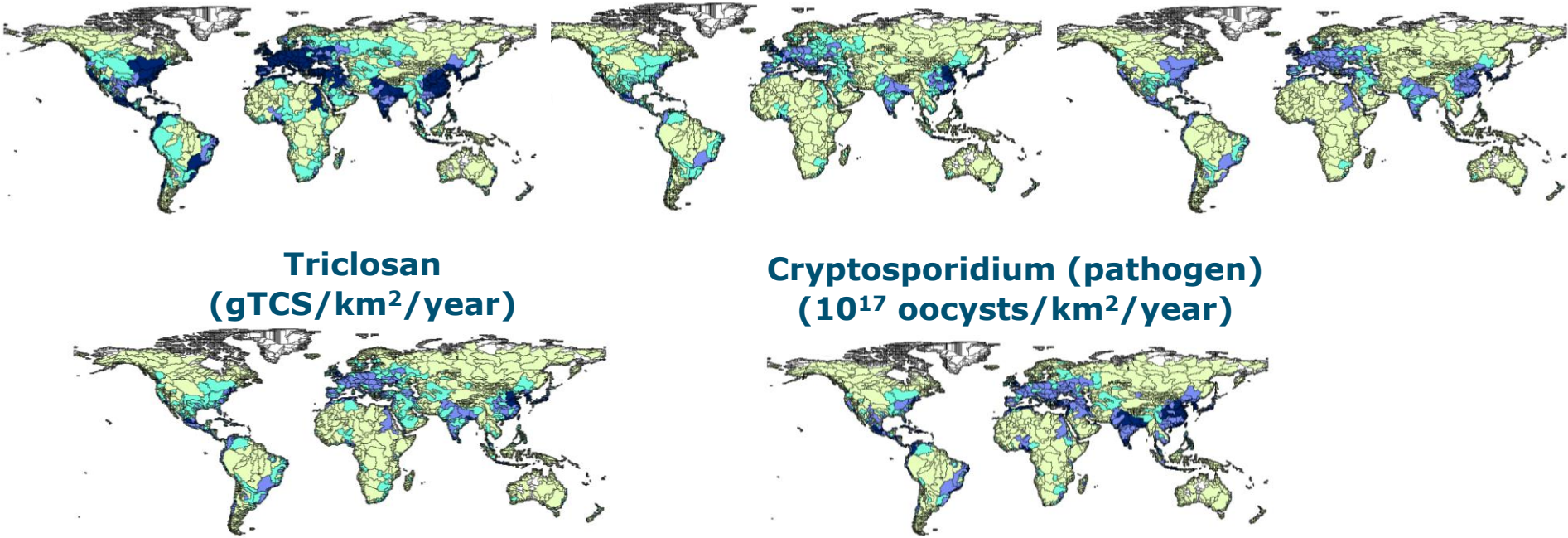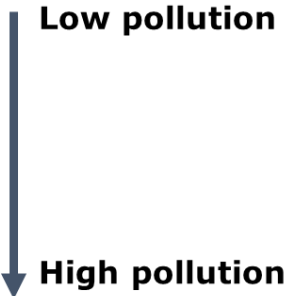

Nitrogen (kgN/km²/year)

Phosphorus (kgP/km²/year)

Microplastic (kgMP/km²/year)

Triclosan (gTCS/km²/year)

Cryptosporidium (pathogen) (10¹⁷ oocysts/km²/year)

Nitrogen	Phosphorus	Triclosan	Microplastics	Cryptosporidium	
0	0	0	0	0	Low pollution
0-10	0-5	0-2	0-2	0-50	
10-50	5-30	2-10	2-5	50-100	
50-100	30-100	10-50	5-50	100-500	
>100	>100	>50	>50	>500	High pollution

Strokal et al (2019)

Sewage systems:
sources of multiple pollutants in rivers
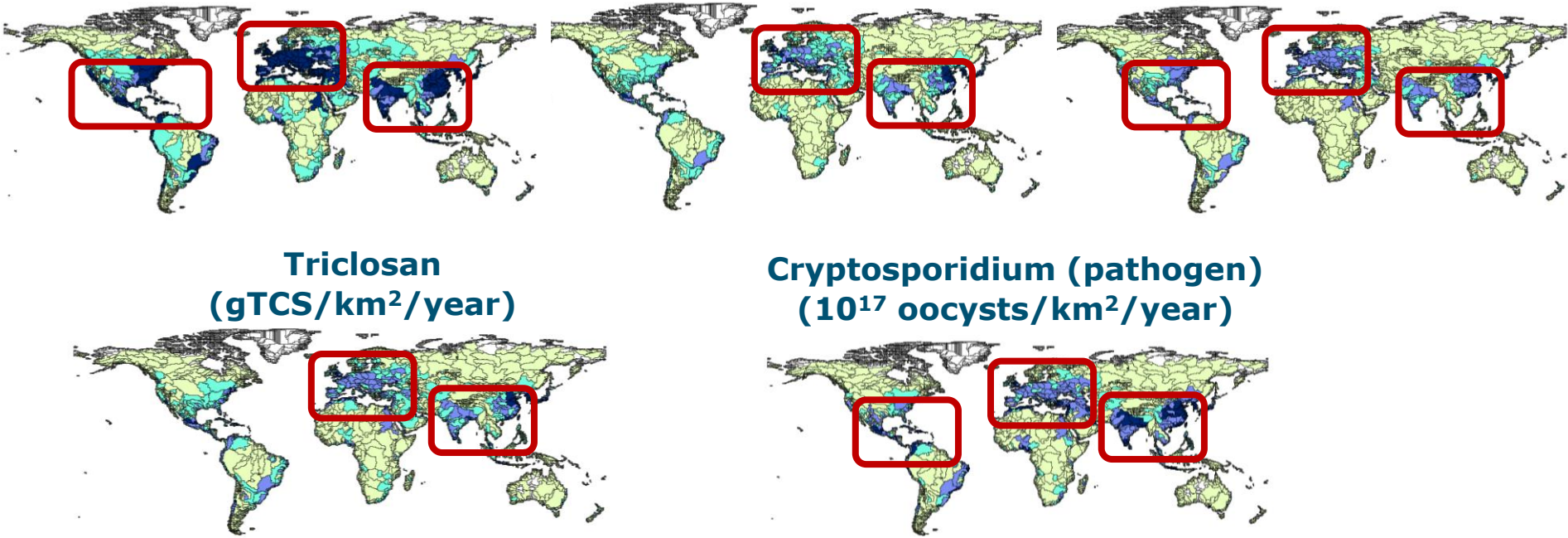

Nitrogen (kgN/km²/year)

Phosphorus (kgP/km²/year)

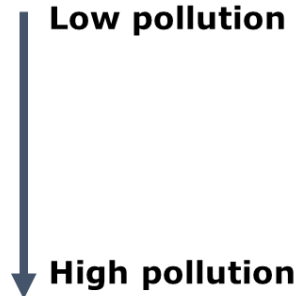**Microplastic (kgMP/km²/year)**

Triclosan (gTCS/km²/year)

Cryptosporidium (pathogen) (10^{17} oocysts/km²/year)

Nitrogen	Phosphorus	Triclosan	Microplastics	Cryptosporidium	
0	0	0	0	0	Low pollution
0-10	0-5	0-2	0-2	0-50	
10-50	5-30	2-10	2-5	50-100	
50-100	30-100	10-50	5-50	100-500	
>100	>100	>50	>50	>500	High pollution

Strokal et al (2019)

Messages

- A need for multi-pollutant approaches

- Agriculture and sewage are common sources of pollutants

- At least 50% of global population experience multi-pollutant issues today

Messages

- "**A multi-pollutant perspective** matters for water quality and its pollution **sources**"

Webinar 2

Water quality drivers
Perspectives on climate and pollution sources

Dr. Michelle van Vliet

Associate professor

Geosciences

Hydrology and quality

Pollution drivers

Universiteit Utrecht

Dr. Maryna Strokal

Assistant professor

Multi-pollutant modelling

Water pollution

Sources and trends

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Webinar 2: discussion

- **Which tools (approaches) can we use to analyze drivers of water quality and water scarcity?**

- **www.menti.com**
- **41 95 59 8**

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Highlights

Webinar series

Water quality in a changing world: status, drivers, impacts and optimistic futures

1. **Water quality status | June 28**
   Perspectives on lakes and surface waters

2. **Water quality drivers | July 5**
   Perspectives on climate change and pollution sources

3. **Water quality impacts | September 14**
   Perspectives on food and health

4. **Water quality impacts | October 4**
   Perspectives on optimistic futures with effective solutions

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Webinars 1 (status)

Dr. Arthur Beusen
Researcher

Geosciences
Earth Sciences
Geochemistry

Dr. ABG (Annette) Janssen
Researcher

Lakes, algae
Nutrient pollution
Critical loadings

- "To explain **nutrient pollution** in water we need to better understand what is happening on the land"
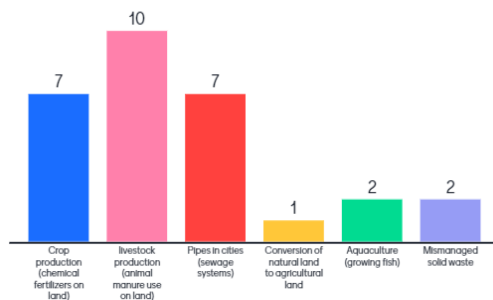
- "Both **rivers and lakes** are important elements of the landscape system"

Go to www.menti.com and use the code 6106 4885

What are sources of water pollution in your own home country?

What great research ideas would we able to work out?

Webinars 2 (drivers & sources)

Dr. Michelle van Vliet
Associate professor
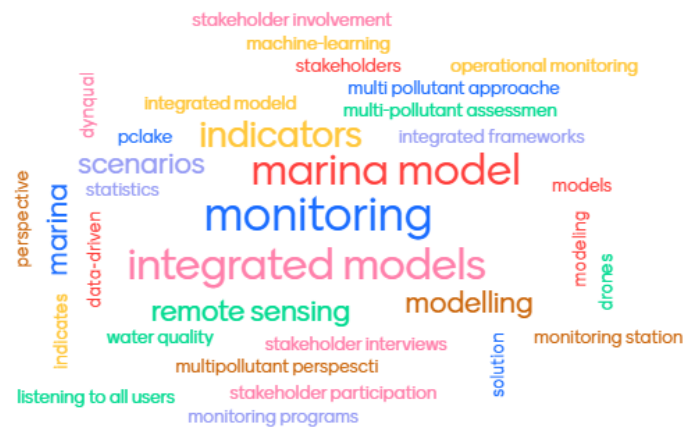Geosciences
Hydrology and quality
Pollution drivers

- "**Quality** matters for water scarcity and its **drivers**"

Dr. Maryna Strokal
Assistant professor
Multi-pollutant modelling
Water pollution
Sources and trends

- "**A multi-pollutant perspective** matters for water quality and its pollution **sources**"

Which tools (approaches) can we use to analyze drivers of water quality and water scarcity?

Mentimeter

stakeholder involvement
machine-learning
stakeholders   operational monitoring
                      multi pollutant approache
dynqual   integrated modeld   multi-pollutant assessmen
pclake   indicators   integrated frameworks
scenarios   marina model   models
perspective marina statistics monitoring
data-driven integrated models   modeling drones
remote sensing   modelling
indicates water quality   monitoring station
listening to all users stakeholder interviews solution
           multipollutant perspescti
           stakeholder participation
           monitoring programs

Webinar 3 on impacts - 14 September