River plastic monitoring strategy design

Tim H.M. van Emmerik[1], Sabrina Kirschke[2], Christian Schmidt[3]

[1]Wageningen University, the Netherlands

[2]Museum für Naturkunde, Germany

[3]UFZ, Leipzig, Germany

Contact: tim.vanemmerik@wur.nl

WAGENINGEN UNIVERSITY & RESEARCH

UFZ HELMHOLTZ Centre for Environmental Research

MUSEUM FÜR NATURKUNDE BERLIN

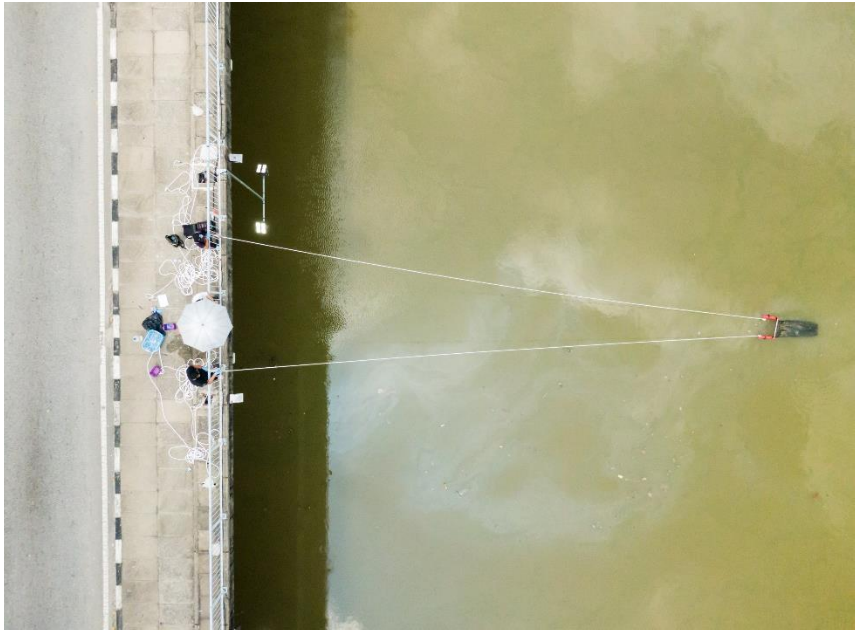
WWQA World Water Quality Alliance

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

NILE BASIN INITIATIVE INITIATIVE DU BASSIN DU NIL

What you should remember

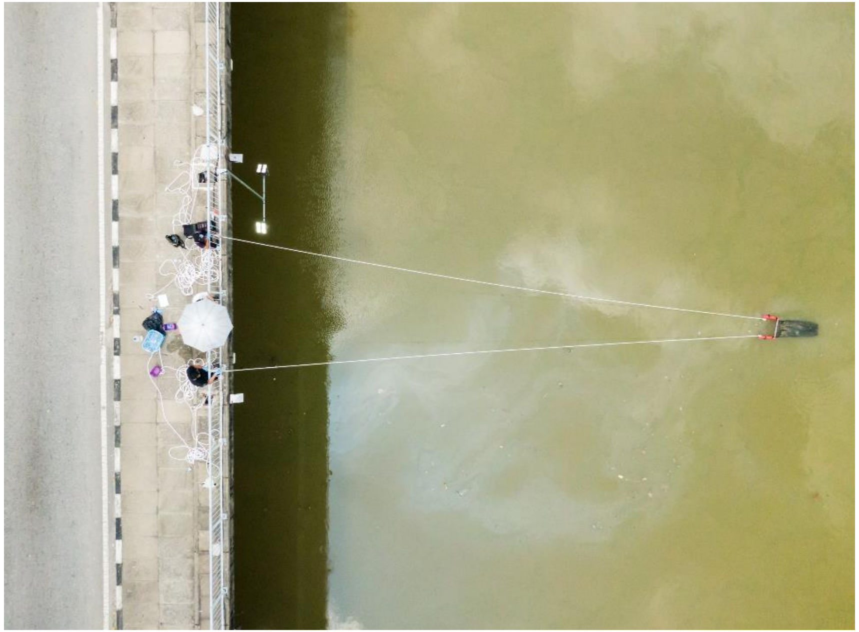
- Monitoring is crucial for effective solutions against plastic
- UNEP guidelines provide framework for monitoring
- No one-size-fits-all



WAGENINGEN UNIVERSITY & RESEARCH

Why plastic monitoring matters

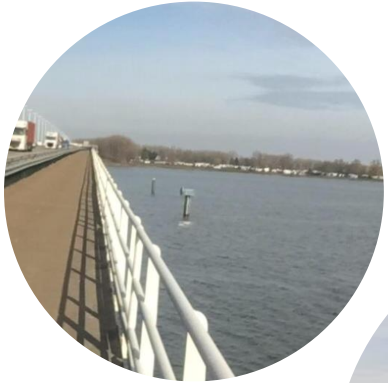
- Identify and quantify sources, sinks, tranport and emission
- Establish baseline values
- Evaluate efficacy of prevention and reduction solutions



WAGENINGEN UNIVERSITY & RESEARCH

How to start monitoring?

- What method to choose?
- What is the goal?
- What are the river characteristics?
- What resources are available?



WAGENINGEN
UNIVERSITY & RESEARCH

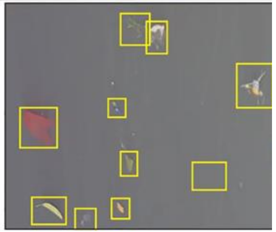
Measuring macroplastics

1. Collection

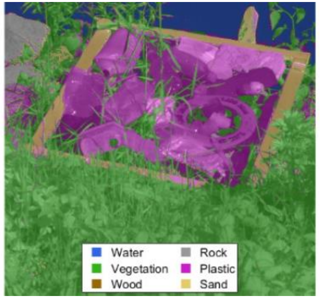
2. Counting

3. Drones

4. Cameras



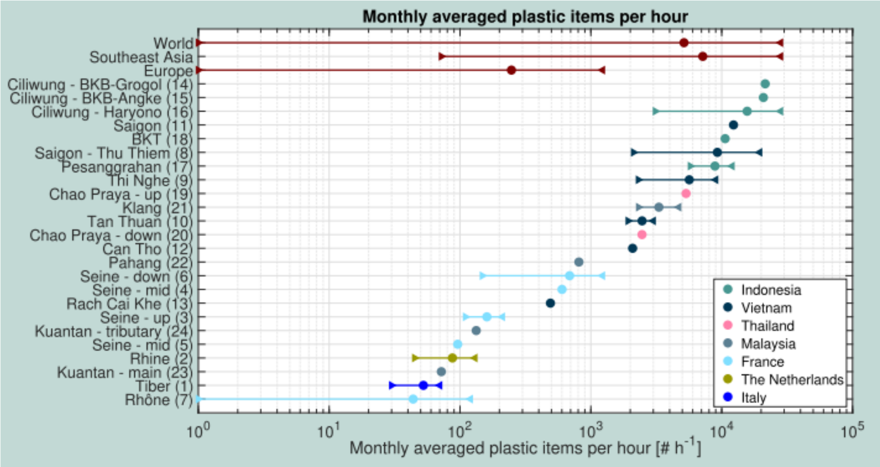
5. Remote Sensing

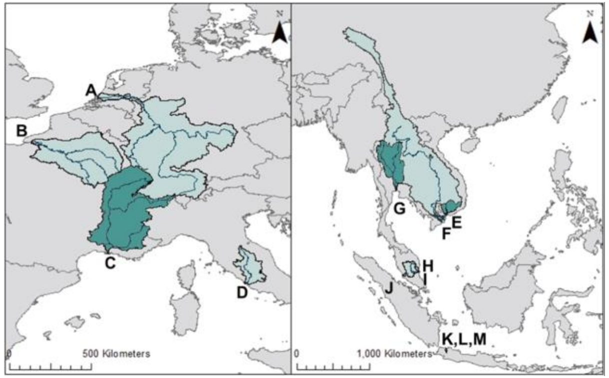


(Schone Rivieren, 2020; van Lieshout et al., 2020)

Why harmonization matters

- Comparative studies to set priorities and baselines
- Basin-scale assessments
- Basis for answering fundamental questions





(van Calcar & van Emmerik, 2019)

WAGENINGEN
UNIVERSITY & RESEARCH

MONITORING PLASTICS IN RIVERS AND LAKES

Guidelines for the Harmonization of Methodologies

Acknowledgements

UNEP would like to thank the authors, reviewers and the Secretariat for their contribution to the preparation of this report. The authors and reviewers have contributed to the report in their individual capacities.

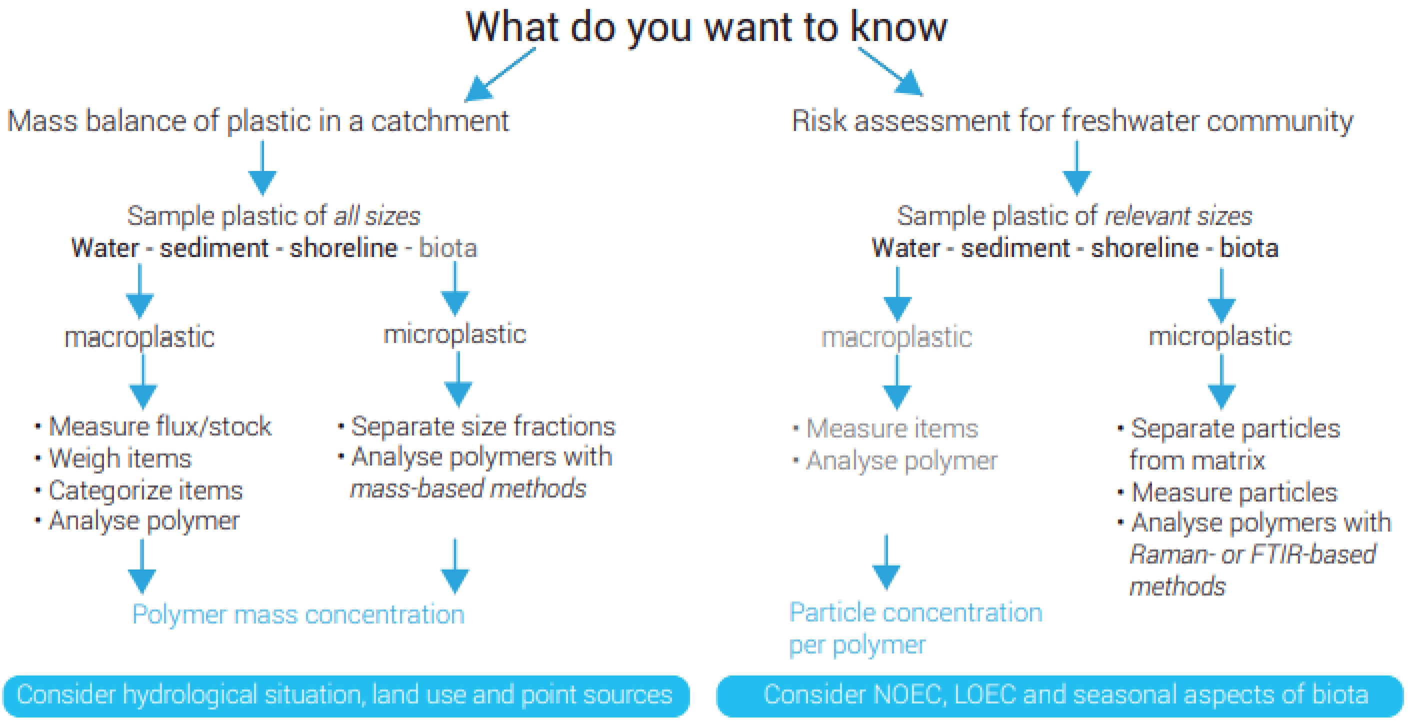
Authors

Katrin Wendt-Potthoff, Helmholtz Centre for Environmental Research (UFZ), Magdeburg, Germany; Tamara Avellán, United Nations University – Institute for Integrated Management of Material Fluxes and of Resources (UNU-FLORES), Dresden, Germany; Tim van Emmerik, Hydrology and Quantitative Water Management Group, Wageningen University and Research, Wageningen, The Netherlands; Meike Hamester, UNU-FLORES, Dresden, Germany; Sabrina Kirschke, UNU-FLORES, Dresden, Germany; Danielle Kitover, T+I Consult, Geschäftsstelle Magdeburg, Magdeburg, Germany; Christian Schmidt, Helmholtz Centre for Environmental Research (UFZ), Leipzig, Germany

UNEP plastic monitoring guidelines

- Micro and macro
- Rivers, reservoirs, lakes, drinking water
- Summary of methods, guidelines for strategy design

How to start



WAGENINGEN UNIVERSITY & RESEARCH

Step-wise approach

Develop the monitoring programme

Identify objectives

Typical examples:
- Quantify export from river catchments
- Quantify abundance of plastic in river systems, lakes, or biota
- Abundance of specific items for policy-making
- Quantify removal efficiencies in wastewater treatment facilities
- Exposure of aquatic life to microplastic

Available resources

- Gender-balanced pool of skilled personnel for sampling (simple) and lab analysis (complex)
- Sampling equipment
- Laboratory facilities
- IT infrastructure for automated monitoring

Design the monitoring programme

Compartments and location

Compartments:
- Water surface, water column, sediments, shorelines, biota

Locations:
- Select according to objectives, accessibility and safety
- Easily accessible locations, e.g. small wadable rivers may reduce monitoring costs

Temporal resolutions

- Frequency should be adapted to the variability of the system
- Regular monitoring interval should be refined during events (e.g. high flows in rivers)

Particle size

- Adjust the size classes considered to the objectives and the available resources for sampling and analysis
- Smaller particle sizes are typically associated with higher sampling and analysis efforts

Analysis methods

- Select observation and sampling methods according to the compartments and size classes
- Select analysis methods according to the monitoring objective and resources, e.g., for particle counts it may be necessary to identify the polymer type

Implement the monitoring programme

Establish, evaluate, refine

- Apply established sampling and analysis protocols
- Establish locations and a workflow of sampling and analysis
- Conduct the monitoring as planned for an initial period (e.g. one year)
- Collect the required meta data
- Evaluate the data, refine design of the monitoring if needed

Analysis methods

- Data sharing will add value to the data, making data available to the public is highly recommended
- Comply with metadata standards

Develop the monitoring programme

Identify objectives

Typical examples:
- Quantify export from river catchments
- Quantify abundance of plastic in river systems, lakes, or biota
- Abundance of specific items for policy-making
- Quantify removal efficiencies in wastewater treatment facilities
- Exposure of aquatic life to microplastic

Available resources

- Gender-balanced pool of skilled personnel for sampling (simple) and lab analysis (complex)
- Sampling equipment
- Laboratory facilities
- IT infrastructure for automated monitoring

Step-wise approach

Develop the monitoring programme

Identify objectives

Typical examples:
- Quantify export from river catchments
- Quantify abundance of plastic in river systems, lakes, or biota
- Abundance of specific items for policy-making
- Quantify removal efficiencies in wastewater treatment facilities
- Exposure of aquatic life to microplastic

Available resources
- Gender-balanced pool of skilled personnel for sampling (simple) and lab analysis (complex)
- Sampling equipment
- Laboratory facilities
- IT infrastructure for automated monitoring

Design the monitoring programme

Compartments and location

Compartments:
- Water surface, water column, sediments, shorelines, biota

Locations:
- Select according to objectives, accessibility and safety
- Easily accessible locations, e.g. small wadable rivers may reduce monitoring costs

Temporal resolutions
- Frequency should be adapted to the variability of the system
- Regular monitoring interval should be refined during events (e.g. high flows in rivers)

Particle size
- Adjust the size classes considered to the objectives and the available resources for sampling and analysis
- Smaller particle sizes are typically associated with higher sampling and analysis efforts

Analysis methods
- Select observation and sampling methods according to the compartments and size classes
- Select analysis methods according to the monitoring objective and resources, e.g., for particle counts it may be necessary to identify the polymer type

Implement the monitoring programme

Establish, evaluate, refine
- Apply established sampling and analysis protocols
- Establish locations and a workflow of sampling and analysis
- Conduct the monitoring as planned for an initial period (e.g. one year)
- Collect the required meta data
- Evaluate the data, refine design of the monitoring if needed

Analysis methods
- Data sharing will add value to the data, making data available to the public is highly recommended
- Comply with metadata standards

Design the monitoring programme

Compartments and location

Compartments:
- Water surface, water column, sediments, shorelines, biota

Locations:
- Select according to objectives, accessibility and safety
- Easily accessible locations, e.g. small wadable rivers may reduce monitoring costs

Temporal resolutions
- Frequency should be adapted to the variability of the system
- Regular monitoring interval should be refined during events (e.g. high flows in rivers)

Particle size
- Adjust the size classes considered to the objectives and the available resources for sampling and analysis
- Smaller particle sizes are typically associated with higher sampling and analysis efforts

Analysis methods
- Select observation and sampling methods according to the compartments and size classes
- Select analysis methods according to the monitoring objective and resources, e.g., for particle counts it may be necessary to identify the polymer type

Step-wise approach

Develop the monitoring programme

Identify objectives

Typical examples:
- Quantify export from river catchments
- Quantify abundance of plastic in river systems, lakes, or biota
- Abundance of specific items for policy-making
- Quantify removal efficiencies in wastewater treatment facilities
- Exposure of aquatic life to microplastic

Available resources

- Gender-balanced pool of skilled personnel for sampling (simple) and lab analysis (complex)
- Sampling equipment
- Laboratory facilities
- IT infrastructure for automated monitoring

Design the monitoring programme

Compartments and location

Compartments:
- Water surface, water column, sediments, shorelines, biota

Locations:
- Select according to objectives, accessibility and safety
- Easily accessible locations, e.g. small wadable rivers may reduce monitoring costs

Temporal resolutions

- Frequency should be adapted to the variability of the system
- Regular monitoring interval should be refined during events (e.g. high flows in rivers)

Particle size

- Adjust the size classes considered to the objectives and the available resources for sampling and analysis
- Smaller particle sizes are typically associated with higher sampling and analysis efforts

Analysis methods

- Select observation and sampling methods according to the compartments and size classes
- Select analysis methods according to the monitoring objective and resources, e.g., for particle counts it may be necessary to identify the polymer type

Implement the monitoring programme

Establish, evaluate, refine

- Apply established sampling and analysis protocols
- Establish locations and a workflow of sampling and analysis
- Conduct the monitoring as planned for an initial period (e.g. one year)
- Collect the required meta data
- Evaluate the data, refine design of the monitoring if needed

Analysis methods

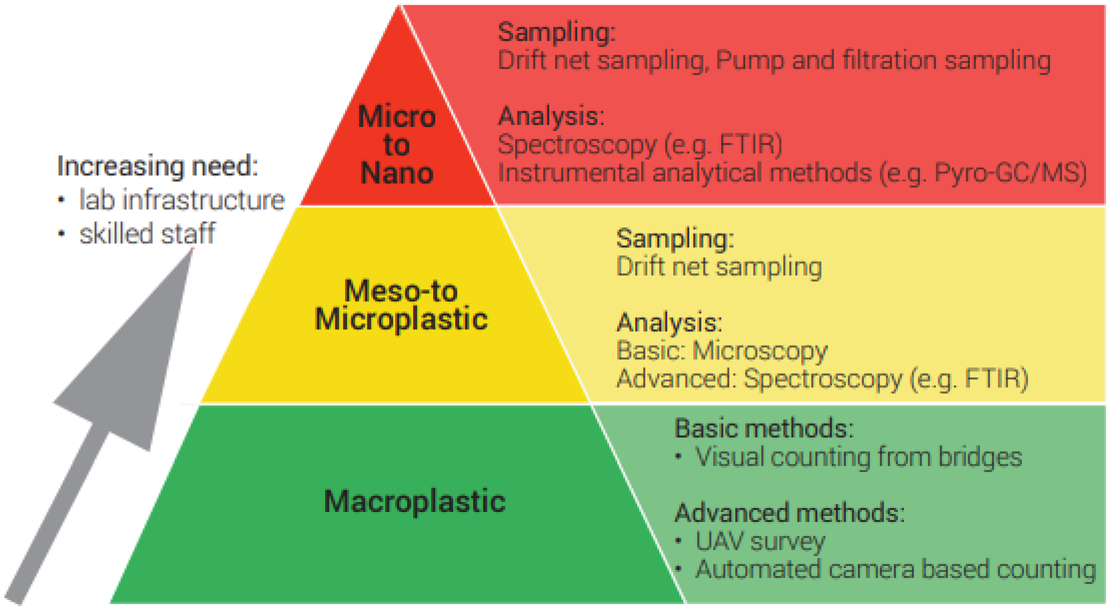
- Data sharing will add value to the data, making data available to the public is highly recommended
- Comply with metadata standards

Implement the monitoring programme

Establish, evaluate, refine
- Apply established sampling and analysis protocols
- Establish locations and a workflow of sampling and analysis
- Conduct the monitoring as planned for an initial period (e.g. one year)
- Collect the required meta data
- Evaluate the data, refine design of the monitoring if needed

Analysis methods
- Data sharing will add value to the data, making data available to the public is highly recommended
- Comply with metadata standards

Start simple



Comparing methods

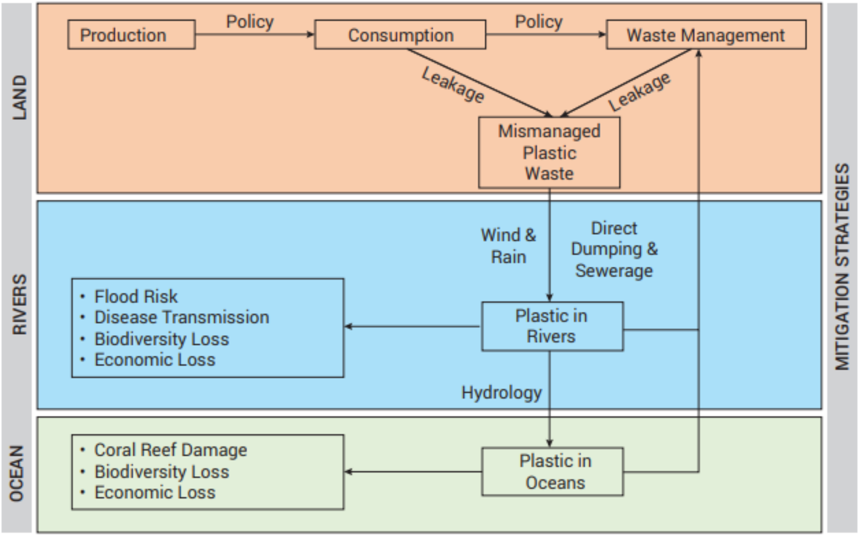
	Macro	Equipment cost	Infrastructure	Staff training level	Installation effort	Comments
Sampling						
River Water Surface	Visual counting	1	1	1.5	1	
	Camera automated camera counting	2.5	2.5	2.5	2	Bridge mounted or via UAV
	Drift net	1.5	2	2	2.5	
River Water Column	Drift net	1.5	2	2	2.5	
River sediment	Grab sampling	1.5	1	1	1	
Shorelines (Lake + River)	Grab sampling	1	1	1	1	
Lake surface	Trawl net and vessel	2	2.5	2.5	2	
Lake water column	Trawl net and vessel	2	2.5	2.5	2	
Biota	Collect or catch with nets/electro-fishing					Only very large organisms will contain macroplatics, it will be challenging to sample these
Analysis						
Visual observation		1	1	2	1	
Spectroscopy (FTIR, Raman)		3	3	3	3	For polymer identification

1	Low
1.5	Low-Medium
2	Medium
2.5	Medium - High
3	High

WAGENINGEN
UNIVERSITY & RESEARCH

There's more than just plastic

- Stakeholder involvement is key
- Questions/goals need to be relevant
- Interventions need embedding



WAGENINGEN UNIVERSITY & RESEARCH

WORKFLOW FOR MACROPLASTIC MONITORING

QUESTIONS

- Emission to ocean?
- Top 10-20 items?
- Hotspots in time/space?

RIVER CHARACTERISTICS

- Wide (>500 m) or narrow (<100 m)?
- Safe bridges available?
- River mouth or upstream?

AVAILABLE RESOURCES

- How many observers?
- High-tech or low-tech equipment?
- Available budget?

DATA

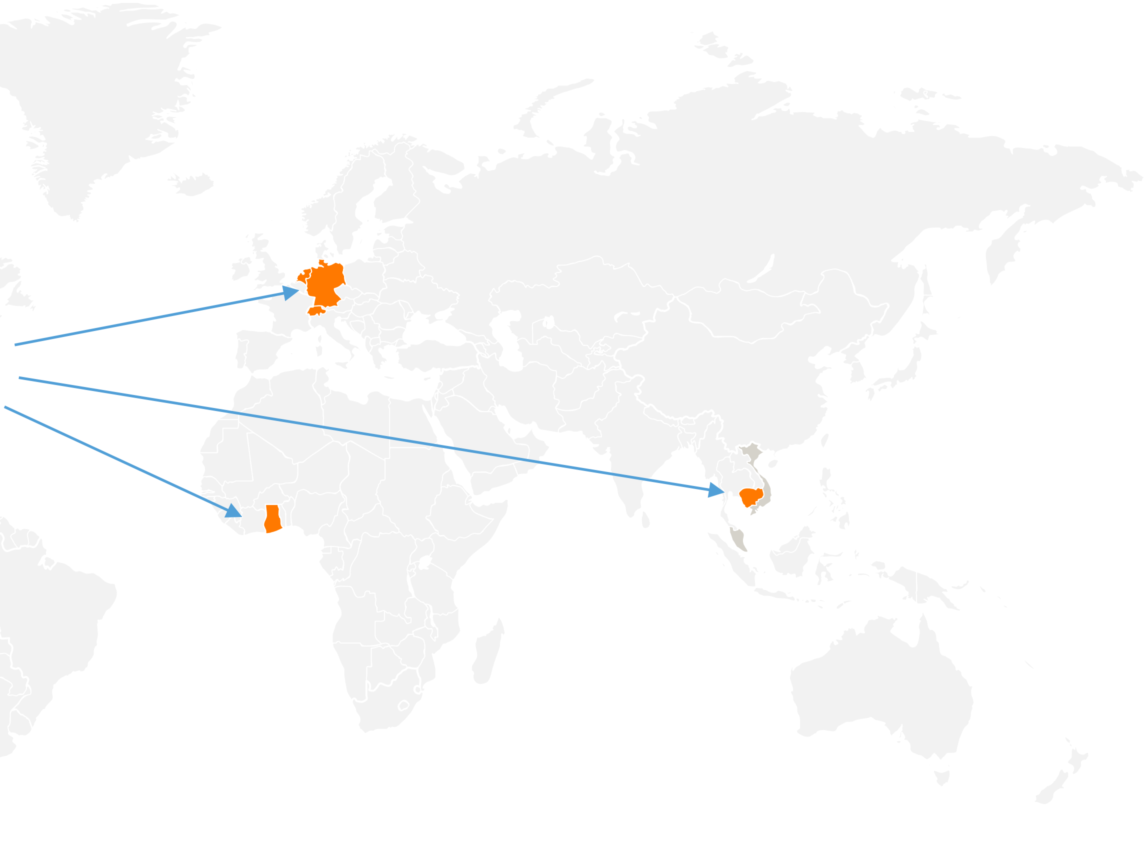
- Normalize to standard units
- Consistent with questions

ANALYSIS & DISSEMINATION

- Clear visualization
- Consider the stakeholders
- Are questions answered?

Applying the guidelines: A workflow

THREE EXAMPLES



RIVER PLASTIC MONITORING

Rhine, Europe
Mekong, Asia
Odaw, Africa

WAGENINGEN
UNIVERSITY & RESEARCH

1. Rhine (Netherlands, Germany, Switzerland)

1. Goal/research question:

Identify entry locations of plastic into the Rhine

2. River characteristics:

1200 km long; width ranges between 50 and 500 m; accessible bridges around urban areas

3. Available funding:

Limited (1000 EUR); no sampling equipment; collaboration with university

4. Method design:

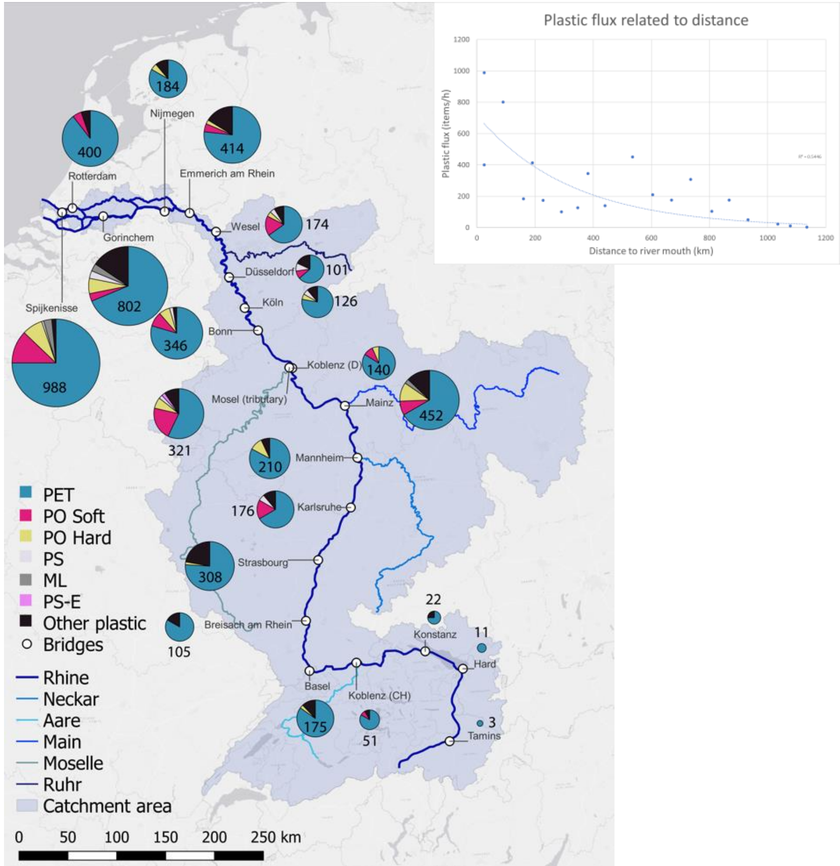
Visual counting at 20 bridges from source to mouth

5. Dissemination and check:

Longitudinal profile of floating plastic [items/hour]

1. Rhine (Netherlands, Germany, Switzerland)

- Increase from upstream to downstream
- Clear effect of river tributaries and/or urban areas
- High values downstream may be caused by the tide



WAGENINGEN
UNIVERSITY & RESEARCH

2. Odaw (Ghana)

1. Goal/research question:

Identify sources of plastic pollution across the catchment

2. River characteristics:

30 km long; width between 10-50 m; heavily urbanized catchment

3. Available funding:

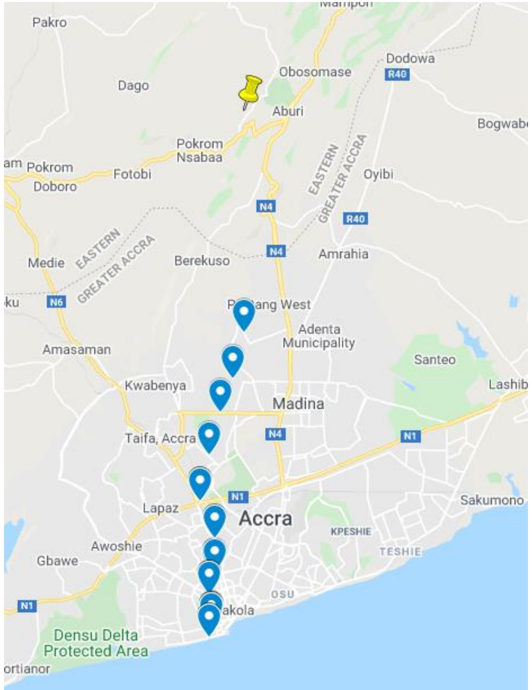
Limited (2000 EUR); no sampling equipment; collaboration with NGO and university

4. Method design:

Visual counting at 10 bridges from source to mouth; manual sampling on riverbanks and on land

5. Dissemination and check:

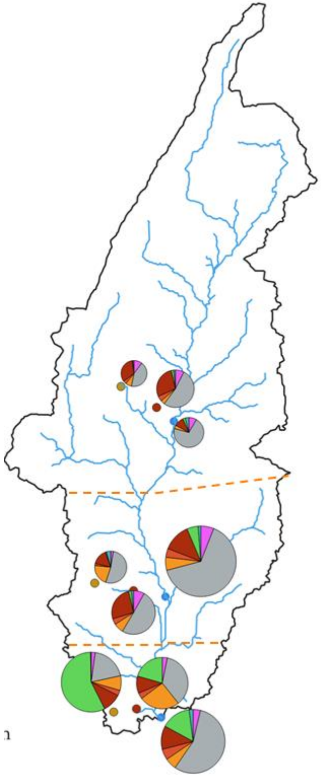
Longitudinal profile of floating plastic [items/hour] and plastic density on riverbank and land [items/m^2]

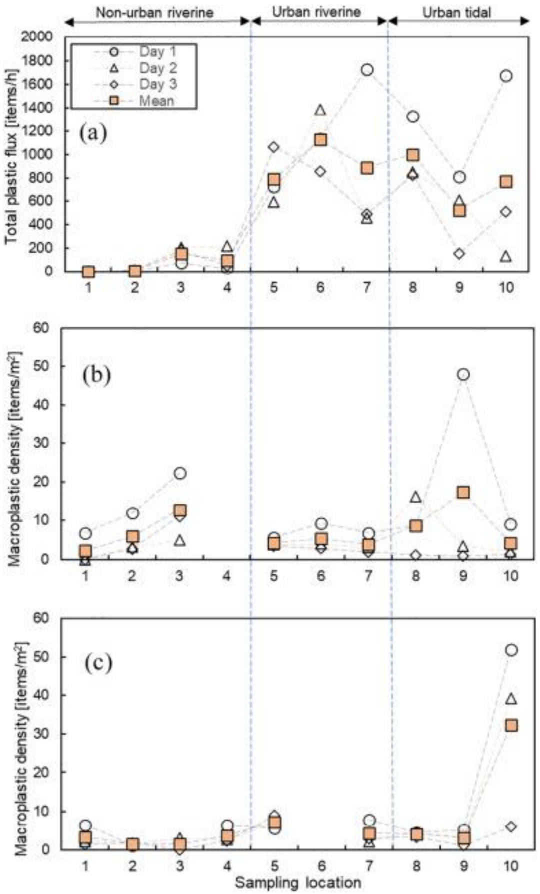


WAGENINGEN
UNIVERSITY & RESEARCH

2. Odaw (Ghana)

- Increase in urban area, decrease at the mouth
- Profiles of floating, riverbank and land are different
- Composition across compartments is locally similar





WAGENINGEN
UNIVERSITY & RESEARCH

3. Mekong (Cambodia)

1. Goal/research question:

Floating mass balance around Phnom Penh during dry season

2. River characteristics:

70 km long reach; width 600-650 m; no tidal influence; confluence and bifurcation

3. Available funding:

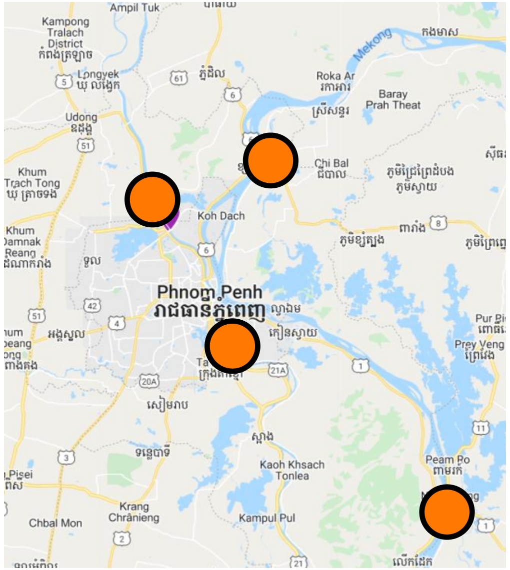
Limited (2000 EUR); no sampling equipment; collaboration with university

4. Method design:

Visual counting at four bridges at confluence and bifurcation; item-to-mass conversion using database

5. Dissemination and check:

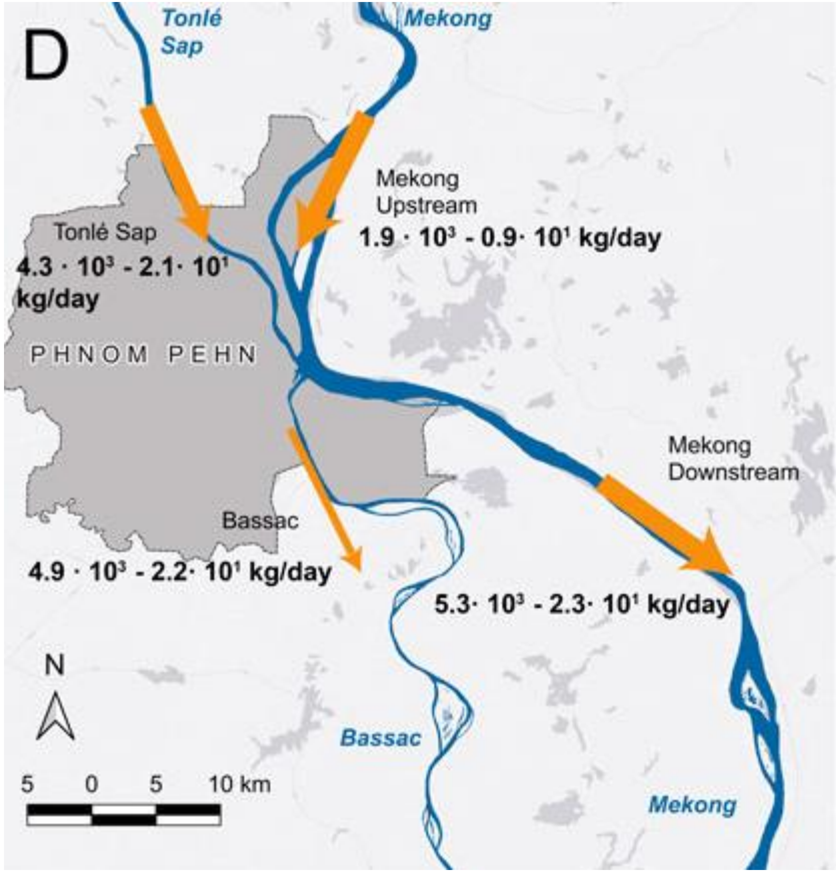
Floating plastic mass estimates at all locations



WAGENINGEN
UNIVERSITY & RESEARCH

3. Mekong (Cambodia)

- Difference between upstream and downstream
- Factor 1000 between dry and wet season
- Emphasizes importance of seasonality



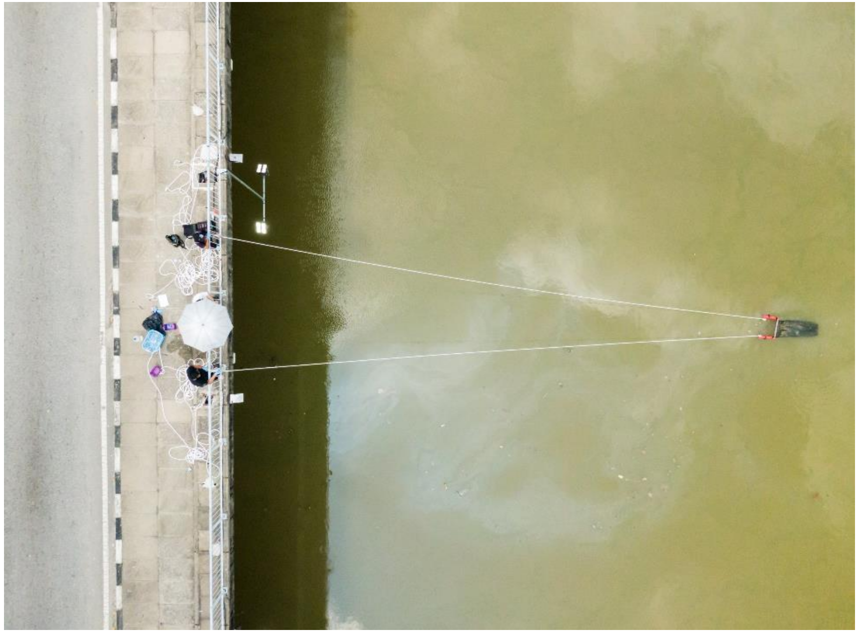
WAGENINGEN UNIVERSITY & RESEARCH

Summary monitoring

River	1. Goal/Research question	2. River characteristics	3. Available resources	4. Strategy design	5. Dissemination and check
Rhine (Netherlands, Germany, Switzerland)	Identify entry locations of plastic into the Rhine	• 1200 km long • Width ranges between 50 and 500 m • Transboundary basin • Acessible bridges around urban and industrial areas • Complex delta	• Limited funding (1000 EUR) • No sampling equipment • Collaboration with university	• Visual counting at bridges at 20 bridges from source to river mouth • Conversion to mass transport using literature	• Longitudinal profile of floating plastic transport [items/hour] and plastic types.
Odaw (Ghana)	Identify sources of plastic pollution in the Odaw basin	• 30 km long • Width ranges between 10 and 50 m • Heavily urbanized catchment and channalized river • Many accessible bridges	• Limited funding (2000 EUR) • No sampling equipment • Collaboration with NGO and university	• Visual counting at 10 bridges from source to river mouth • Manual sampling of plastic on riverbank and on land • Conversion to mass transport and desnsity using sampled material	• Longitudinal profile of floating plastic transport [items/hour] and plastic density on riverbanks and on land [items/m^2] • Reporting results spatially, and per compartment (floating, riverbank, land)
Mekong (Cambodia)	Establish the floating plastic mass balance at a Mekong river section	• 70 km reach total 4350 km length • Width ranges between 600 and 650 m • No tidal influence • Confluence with the Tonle Sap river • Bifurcation that flows into Bassac river • Accessible bridges at upper and lower sections of the study area	• Limited funding (2000 EUR) • No sampling equipment • Collaboration with university	• Visual counting at four bridges at bifurcation and confluence • Manual sampling of plastic on riverbanks • Conversion to mass transport and desnsity using sampled material	• Floating plastic estimates at all measurement locations • Establishing the floating plastic mass balance for the study area

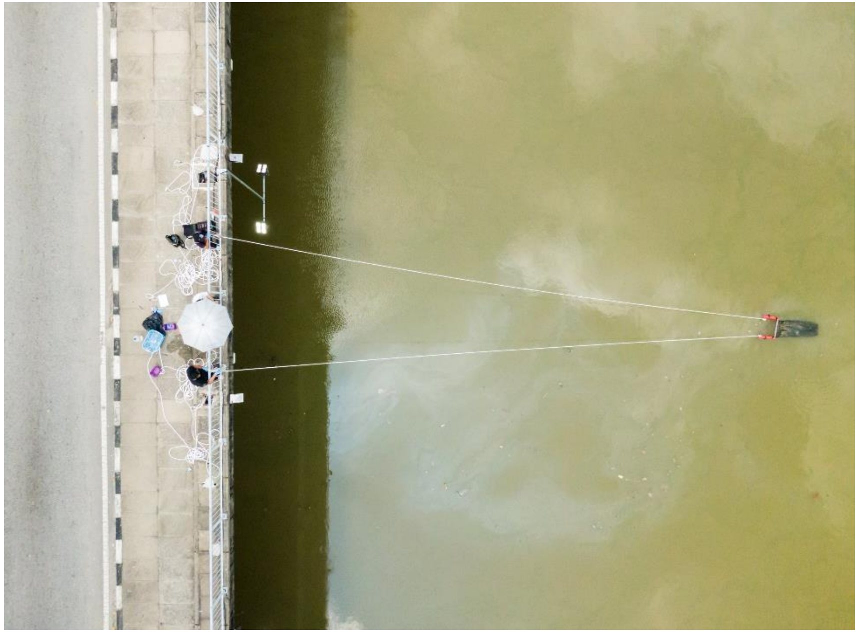
Summary monitoring

- Three successful applications of the UNEP guidelines:
    - Profile floating plastic Rhine
    - Rapid system scan Odaw
    - Mass balance Mekong
- Capacity building through collaboration with local partners
- Future efforts may focus on more complex and long-term goals



What you should remember

- Monitoring is crucial for effective solutions against plastic
- UNEP guidelines provide framework for monitoring
- No one-size-fits-all



Assignment!

- Divide into groups
- Develop a monitoring strategy for your country (5 slides max)
- Estimate the costs/resources
- Upload the presentation
- Link: ...
- At ... you will present in max 5 min

Workflow

- What is the question/goal?
- What are the river characteristics?
- What are the available resources?
- What units are reported?
- Are the results answering the question?

River plastic monitoring strategy design

Tim H.M. van Emmerik[1], Sabrina Kirschke[2], Christian Schmidt[3]

[1]Wageningen University, the Netherlands

[2]Museum für Naturkunde, Germany

[3]UFZ, Leipzig, Germany

Contact: tim.vanemmerik@wur.nl

WAGENINGEN UNIVERSITY & RESEARCH

UFZ HELMHOLTZ Centre for Environmental Research

MUSEUM FÜR NATURKUNDE BERLIN

WWQA World Water Quality Alliance

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

NILE BASIN INITIATIVE
INITIATIVE DU BASSIN DU NIL