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11^e Conférence internationale

LYON 2023

— L'eau dans la ville | Urban water

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L'eau dans la ville | Urban water

Removal of heavy metals and organic chemicals in nature-based systems: a comprehensive review

Élimination des métaux lourds et des produits chimiques organiques dans les systèmes basés sur la nature : un examen complet

Zhaozhi Zheng*, Pierre Le Clech, Stuart Khan, Baiqian Shi, David McCarthy, Ana Deletic, Tim Fletcher, Marty Hancock, Kefeng Zhang

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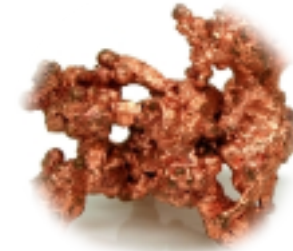


Stormwater runoff

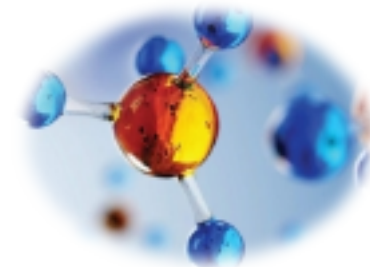


Emerging contaminants

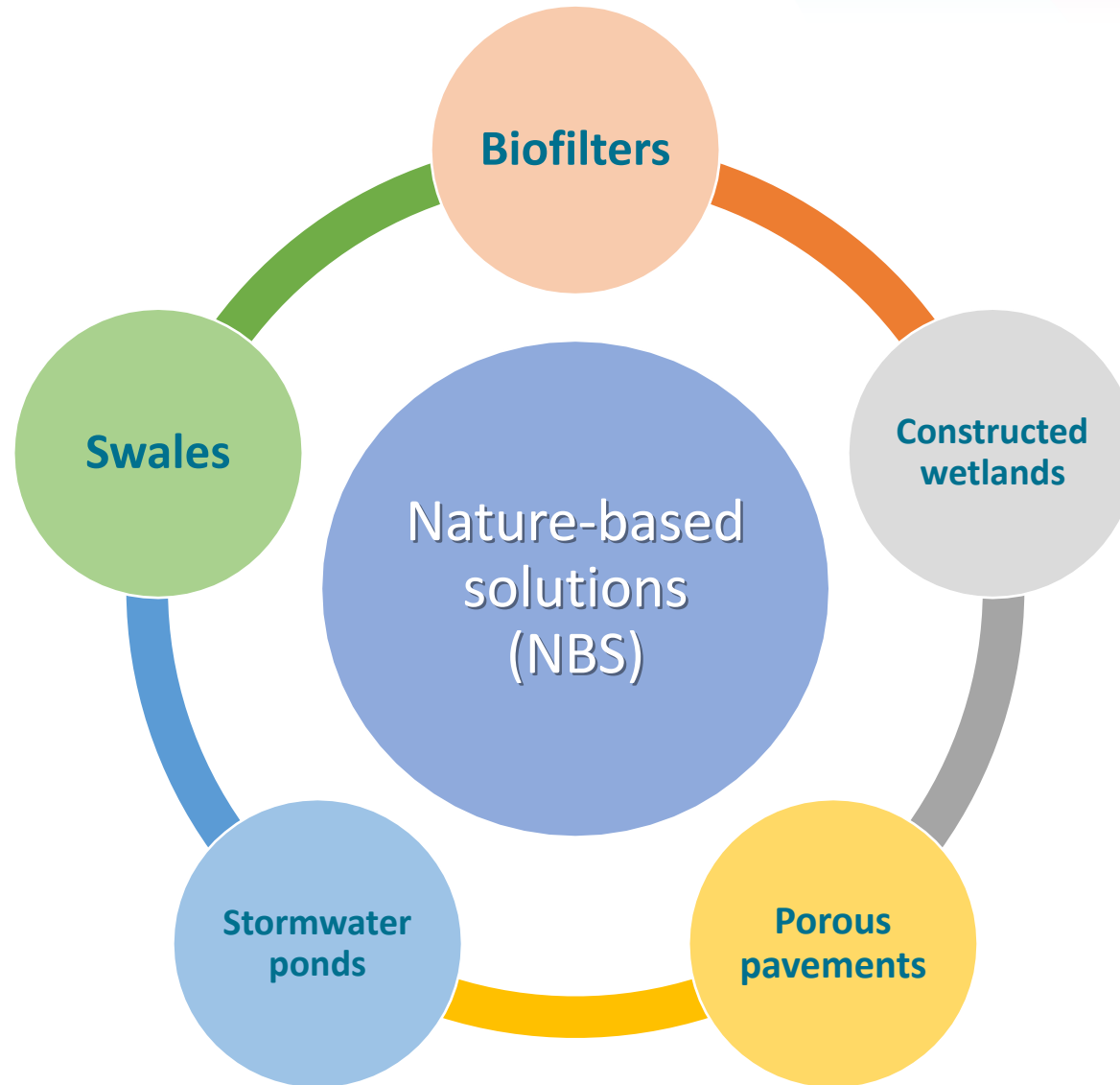
Heavy metals



Organic chemicals



Stormwater treatment



Systematic literature review

Database source from: **Scopus and Web of Science**

Heavy metals	<i>Initial search</i> on Scopus and Web of Science database: 2,999 papers/reports
Organic chemicals	<i>Initial search</i> on Scopus and Web of Science database: 1,632 papers/reports

Overview of collected data

Technology	No. of papers	No. of pollutants	No. of sites (designs)
Heavy metals			
Biofilters	68	22	454
Constructed wetlands	44	20	54
Porous pavements	23	18	52
Stormwater ponds	21	19	47
Swales	7	5	23
Sub-total	163	25	630
Organic chemicals			
Biofilters	32	168	67
Constructed wetlands	10	43	15
Porous pavements	3	8	5
Stormwater Pond	4	11	5
Swales	8	41	19
Advanced technologies	10	19	10
Sub-total	67	181	121

Data analysis

Statistical Summary

Impact of system design

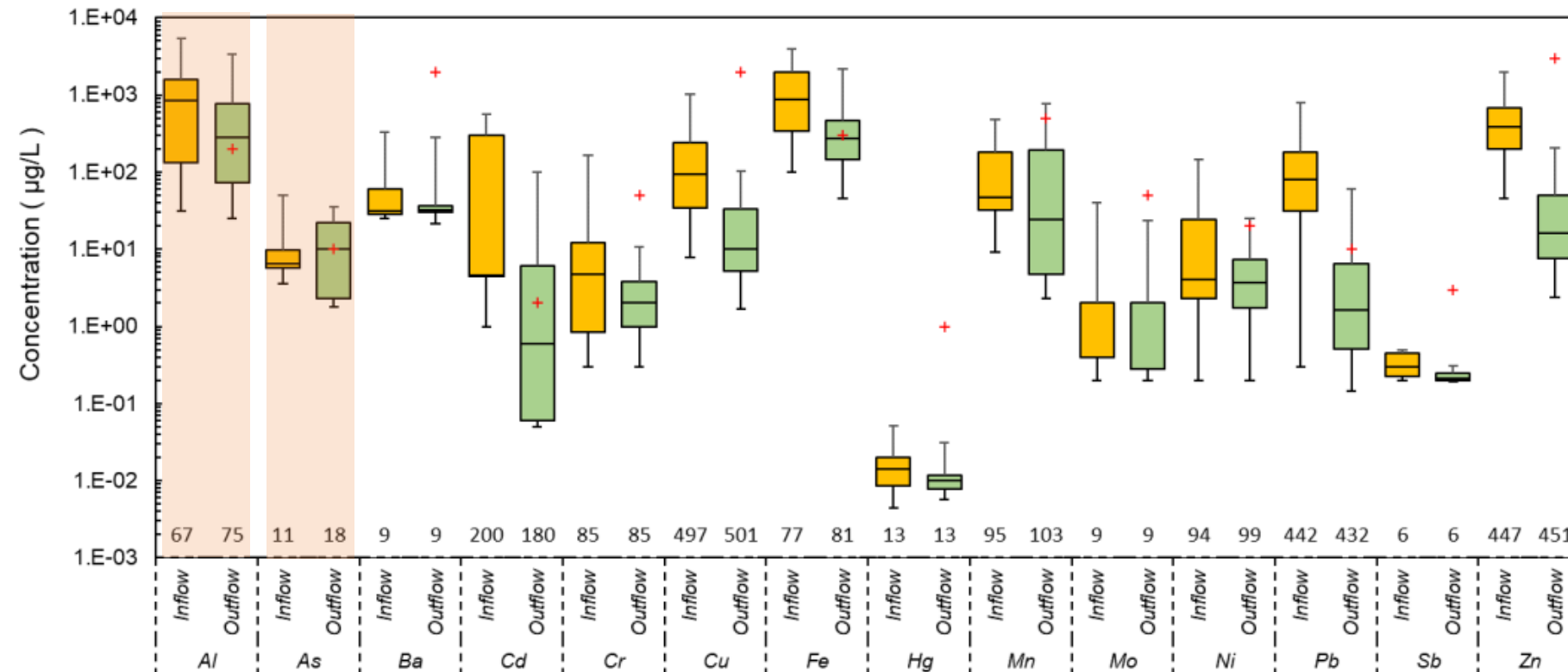
Impact of operational
parameters

Biofilters

Overview of treatment performance

Heavy metals

“+” represents ADWG values



Inflow and outflow concentrations boxplots of the metals

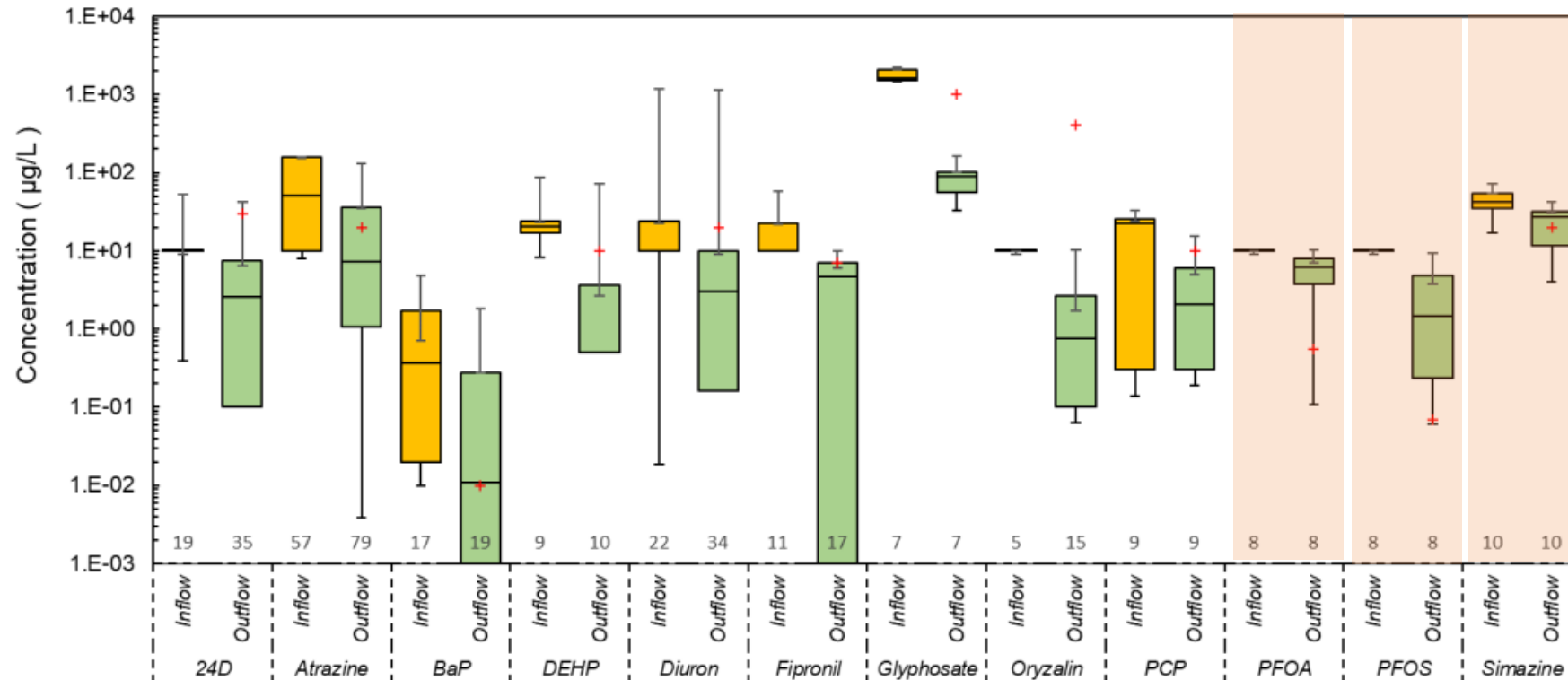
- **Less concern:**
 - Ba, Cr, Cu, Hg, Mo, Sb, Zn
- **Moderate concern**
 - Cd, Fe, Mn, Ni, Pb
- **High concern**
 - Al (aesthetic), As

Biofilters

Overview of treatment performance

Organic chemicals

“+” represents ADWG values



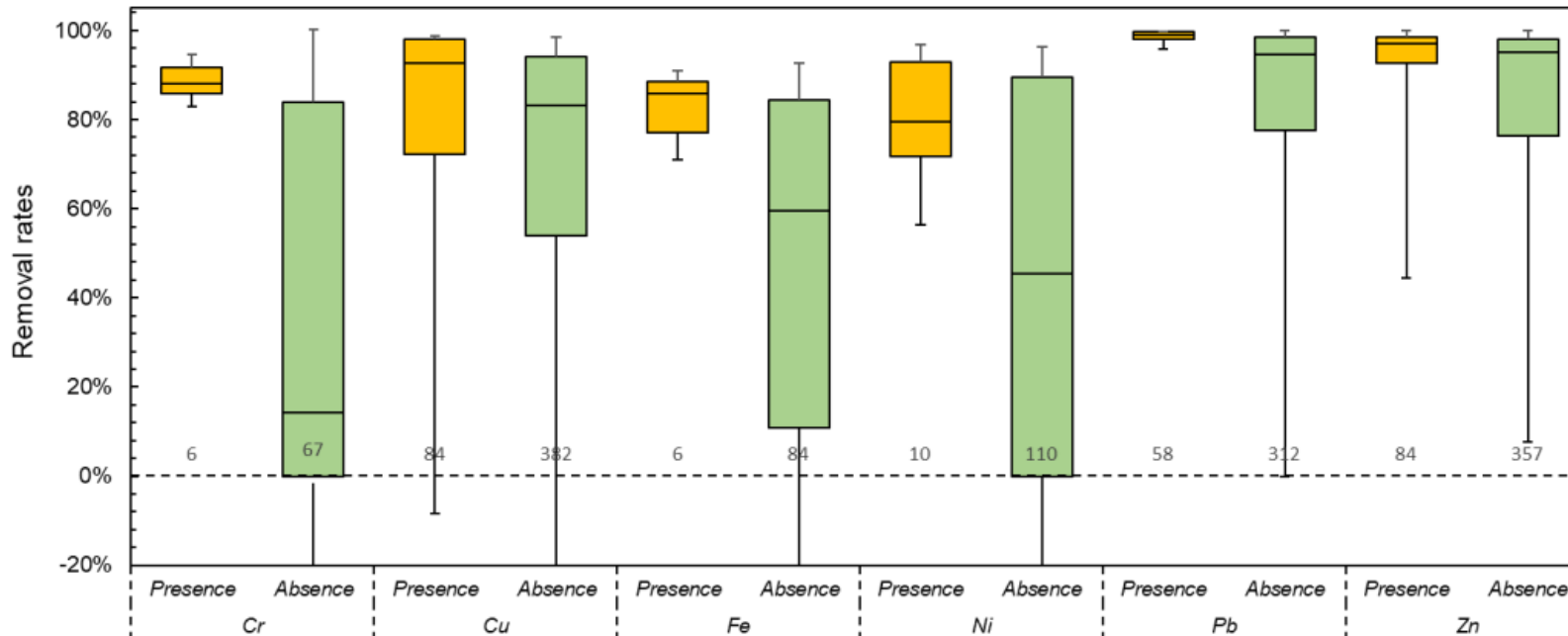
Inflow and outflow concentrations boxplots of the organic chemicals

- **Less concern:**
 - Glyphosate and oryzalin
- **Moderate concern**
 - 2,4-D, atrazine, BaP, diuron, fipronil, PCP and DEHP
- **High concern**
 - Simazine, PFOA and PFOS

Biofilters

Submerged zone (SZ) presence

Heavy metals as example



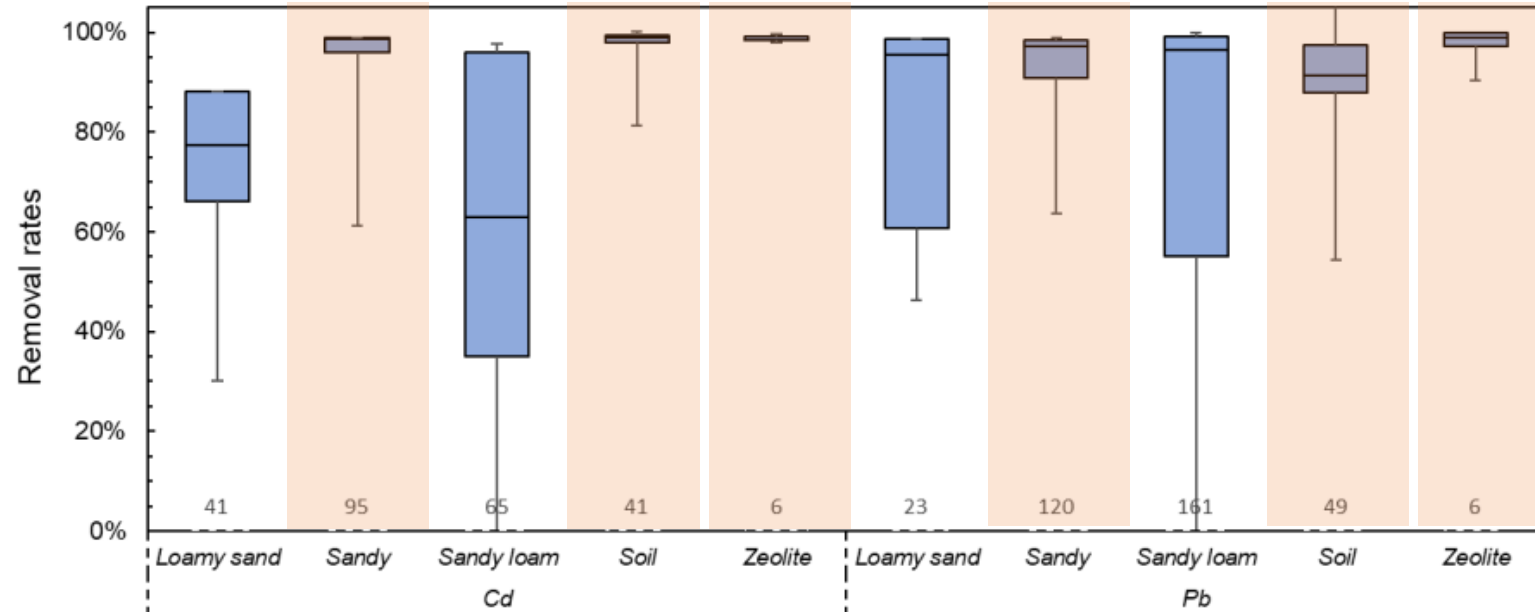
- A **clear positive impact** observed for both metals and organic chemicals
 - higher removal
 - less variability

'Presence' – presence of SZ; 'Absence' – absence of SZ

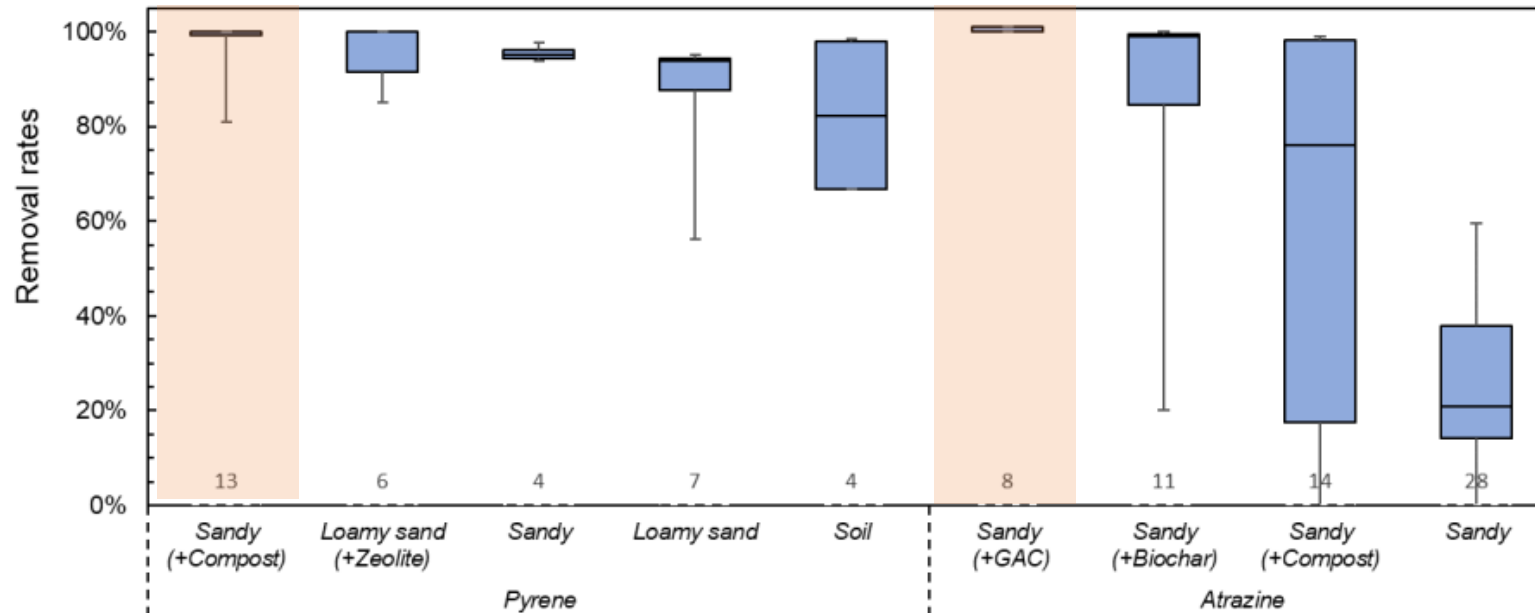
Biofilters

Media type impact

Heavy
metals



Organic
chemicals

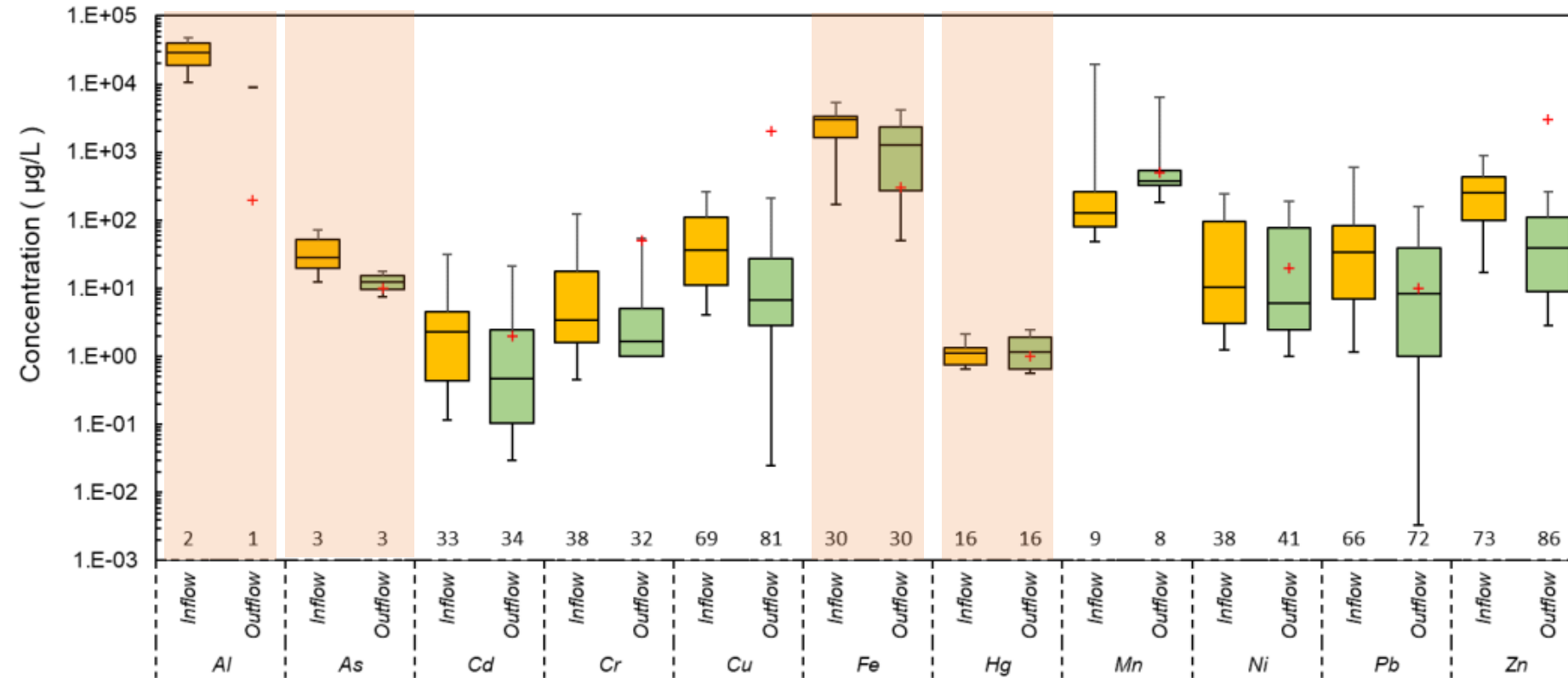


Constructed wetland

Overview of treatment performance

Heavy metals

"+" indicates ADWG values



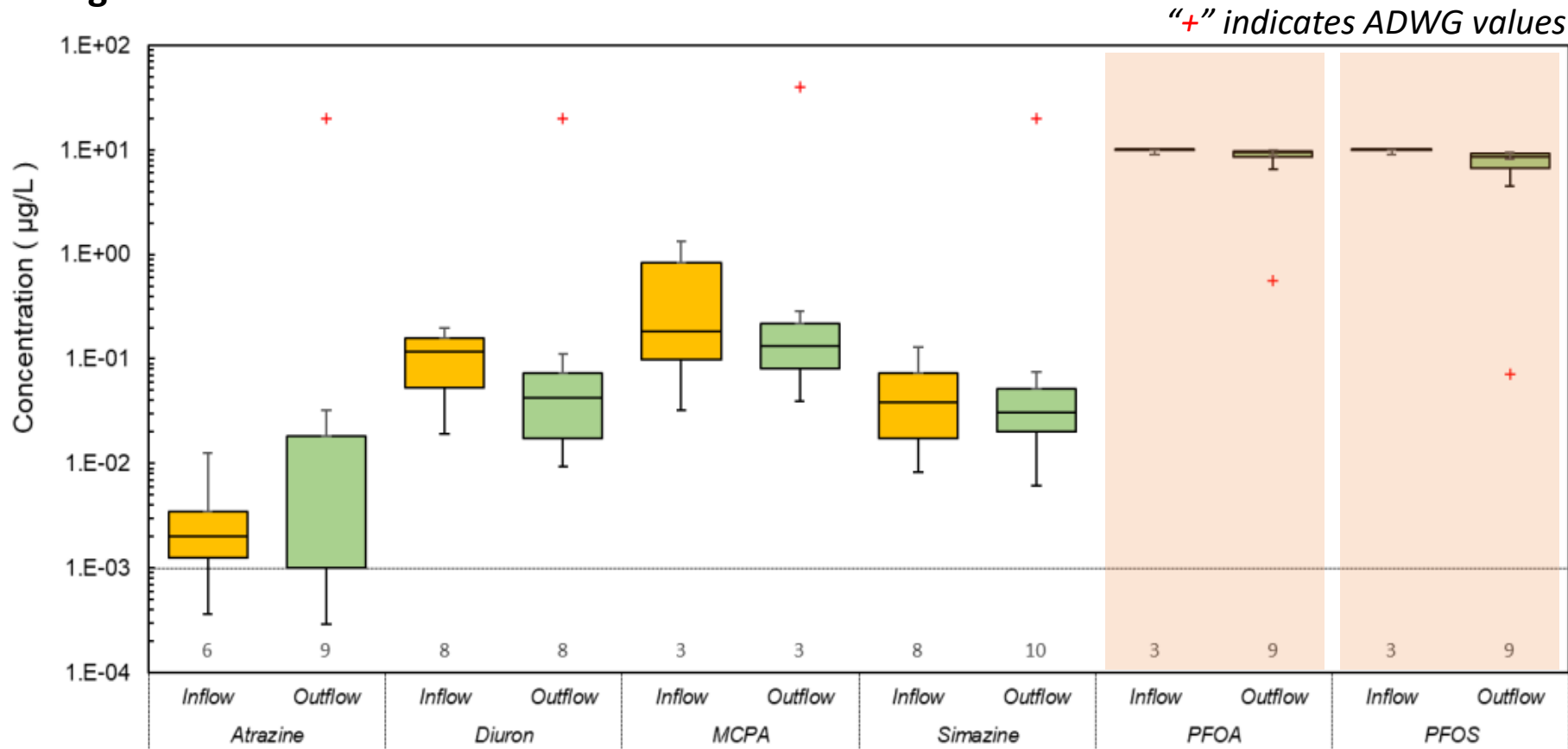
- **Less concern:**
 - Cr, Cu, Zn
- **Moderate concern**
 - Cd, Mn, Ni, Pb
- **High concern**
 - As, Fe, Hg
- **Critical concern**
 - Al

Inflow and outflow concentrations boxplots of the metals

Constructed wetland

Overview of treatment performance

Organic chemicals



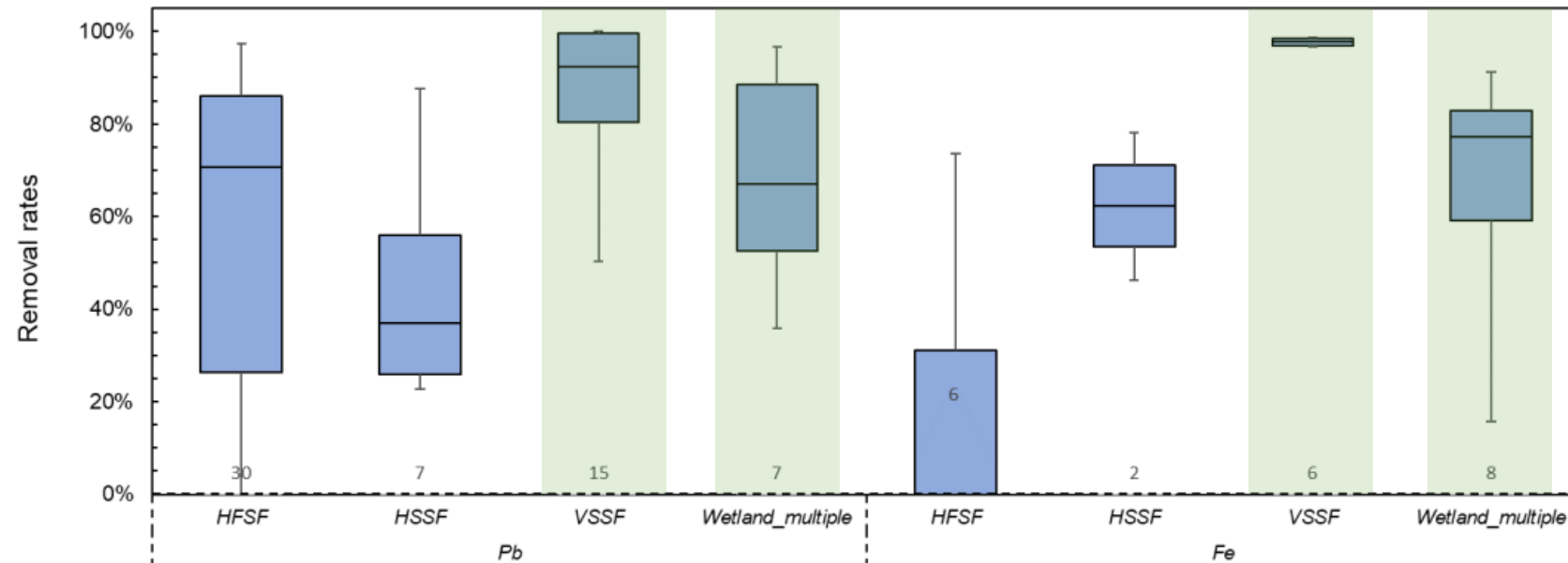
- **Less concern:**
 - Diuron, MCPA, Simazine
- **Critical concern**
 - PFOA, PFOS

Inflow and outflow concentrations boxplots of the organic chemicals

Constructed wetland

Wetland design impact

Heavy metals



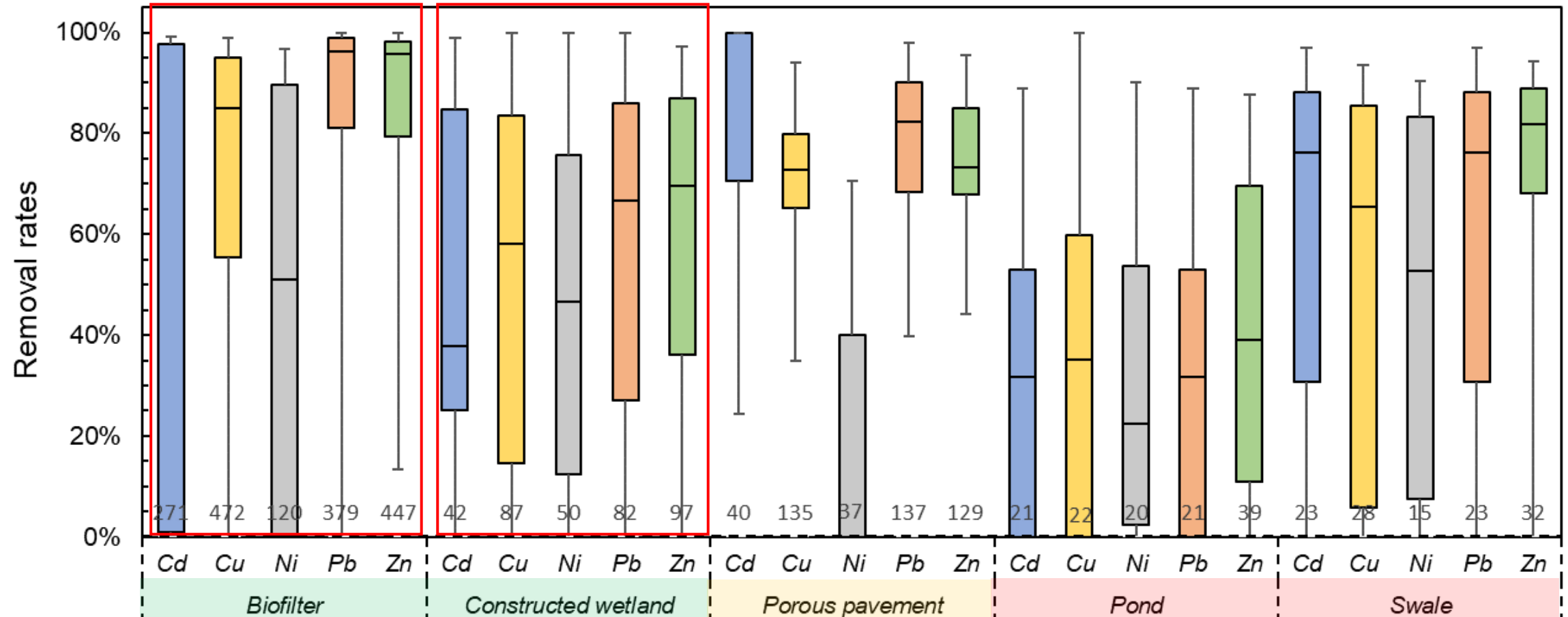
*Note: HFSF- Horizontal free surface flow wetlands; HSSF- Horizontal subsurface flow wetlands; VSSF- vertical subsurface flow wetlands; Wetland_multiple- wetlands applied in series

- **Better performance:**
 - VSSF: vertical subsurface flow wetlands
 - Wetland multiple: different-design wetland in series
- **Variable and lower performance:**
 - Horizontal surface/subsurface flow wetlands

Comparison technologies

Nature-based systems

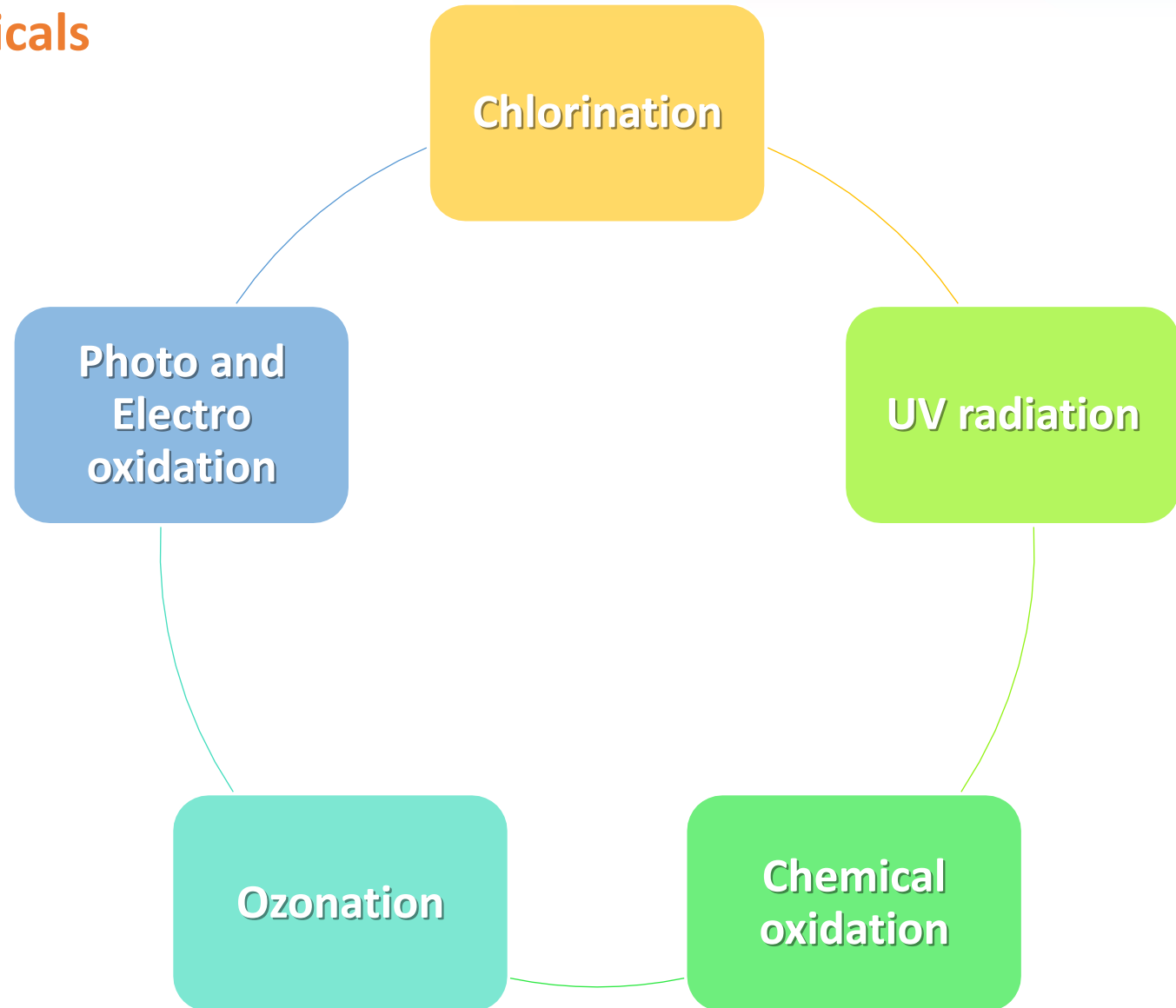
Heavy metals as example



Advanced technologies

Mainly target on organic chemicals

- **Excellent performance** (over 80% removal within mins)
- Mostly within **laboratory scale**
- Great potential as **post-treatment options** in stormwater harvesting



Take-home message

- ❑ Biofilter → #1; Constructed wetlands → #2
- ❑ Porous pavement, swale and pond → Based on local conditions
- ❑ Design parameters impact system performance
- ❑ Advanced technologies → Promising approach as post-treatment in stormwater harvesting



Partners



Research Team



Thank you for your listening
Merci pour votre écoute

Any questions?

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