EMERGING CONTAMINANTS IN INLAND WATER SEDIMENTS OF ANTHROPOGENICALLY AFFECTED AREAS IN POLAND. A ONE HEALTH PERSPECTIVE

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INTRODUCTION

EMERGING CONTAMINANTS (ECS)

ENVIRONMENTAL RELEASE OF ECS

RISKS OF ECS

EMERGING CONTAMINANTS (ECs)

Heterogeneous group of exogenous substances whose ecological and human health impacts remain largely unknown

Pharmaceuticals and personal care products (PPCPs)

Largest group of ECs (wide array of compounds with diverse chemical and physical properties)

- Pharmaceuticals: antibiotics, hormones, anti-inflammatory and anticancer drugs, antiepileptics, antidepressants, etc.
- Personal care products: chemicals in body lotions, cosmetics, fragrances, UV filters, etc.

Per- and poly-fluoroalkyl substances (PFAS)

Extremely durable and resistant to heat, water, stains; widespread use in industrial and consumer products since the 1950s

- Nonstick cookware, cleaning products, stain-resistant and water-resistant fabrics, firefighting foams

Heavy metals and metaloids (arsenic, lead, chromium, cadmium, zinc, manganese, etc.)

Others: plasticizers (bisphenol A), **pesticides** (atrazine), **micro- and nanomaterials** (microplastics)

ENVIRONMENTAL RELEASE OF ECs

ECs enter the environment through multiple pathways, resulting in the formation of a complex mixture of synthetic chemicals

Domestic, industrial, and hospital wastewater discharge

PPCPs and PFAS are increasingly released into the environment

Wastewater treatment plants (WWTPs) often have limited capacity to fully eliminate many ECs due to their persistence and chemical complexity

Agricultural runoff

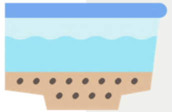
Main source for pesticides and metals, which can leach from treated soils or be carried by rainwater into nearby streams, rivers, and groundwater

Atmospheric deposition

Particulate matter (PM) → transported over long distances, introducing ECs into ecosystems far from their original source

RISKS OF ECs

ECs pose serious risks to environmental quality and human health due to their persistence, bioaccumulation, and mobility across soil, water, and air



SEDIMENTS

Crucial to the structure and function of aquatic ecosystems

Recognized as both a carrier and a potential source of contaminants in aquatic systems

Sediment-associated contaminants are of particular concern for benthic fauna
Physiological stress, reproductive impairment, and mortality → **changes in the structure and function of the benthic community**

Loss of ecosystem processes, such as decomposition of organic matter and water filtration
→ **environmental degradation**

RISKS OF ECs

HUMAN HEALTH

Humans are exposed to ECs via:

- Ingestion of contaminated water or food, (fish or crops grown in or near contaminated areas)
- Dermal contact
- Inhalation of aerosolized particles

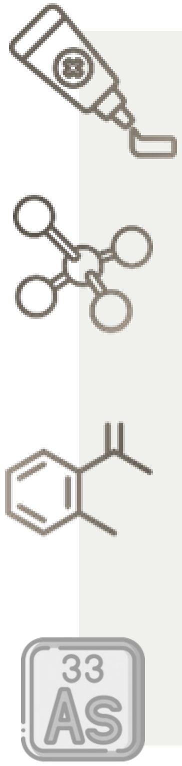
HEALTH ISSUES

- Endocrine disruption
- Metabolic and cardiovascular effects
- Neurotoxicity
- Liver and kidney damage
- Cancer

ONE HEALTH APPROACH

OBJECTIVES

OBJETIVES



- Investigate target ECs contents (selected PFAS, bisphenols, representative PPCPs, and key heavy metals) in various inland water sediments in Poland
- Calculate an individual risk quotient for each EC in each water reservoir
- Determine the related cumulative ecological risk per each water reservoir

METHODOLOGY

STUDY AREA

SAMPLING PROCEDURE

ECS DETERMINATION

ECOLOGICAL RISK ASSESSMENT

STUDY AREA

Fig. 1. Freshwater inland reservoirs selected for investigations in the study a) Kryspinow reservoir, b) Balaton reservoir, c) Chechło reservoir, and d) Dobczyce reservoir. Photos taken by Agata Stolecka

SAMPLING PROCEDURE

Two field campaigns: April & July

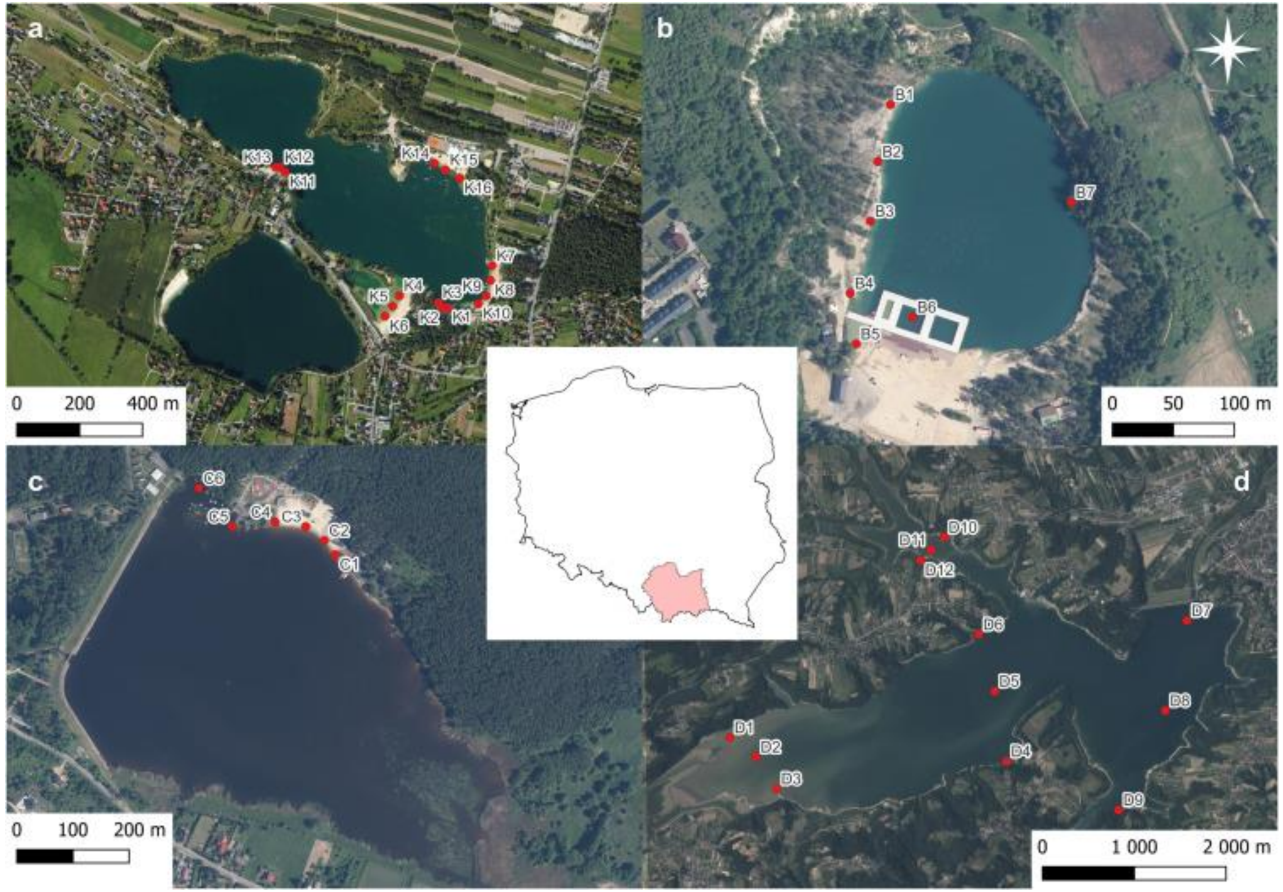


Fig. 2. Sampling points in the four investigated freshwater reservoirs in southern Poland a) Kryspinow, b) Balaton, c) Chechło, d) Dobczyce (Orthophotomap sourced from geoportal.gov.pl and adapted using QGIS 3.36.3 to include sample collection points (Orthophotomap, 2024))

ECs DETERMINATION

Reference materials

PPCPs	Paracetamol, Caffeine, Ibuprofen, Sulfadiazine, Triclosan, Metformine, Ketoprofen, Diclofenac, Valsartan, Carbamazepine, Methyl Paraben, Butyl Paraben	12
PFAS	HFBA, PFPeA, NFBSA, PFHxA, PFHpA, PFHxS, THPFOS, PFOA, PFHpS, PFNA, PFOS, PFUnDA, EtFOSAA, FTriDA	14
Bisphenols	Bisphenol A, Bisphenol B, Bisphenol E, Bisphenol F, Bisphenol S	5
Heavy metals	Arsenic (As), Zinc (Zn), Antimony (Sb), Lead (Pb), Copper (Cu, Cadmium (Cd), Niquel (Ni), Cobalt (Co), Manganese (Mg), Chromium (Cr), Iron (Fe), Tin (Sn), Thallium (Tl)	13

Standard solution

ECs DETERMINATION

SAMPLE SOLUTION

PPCPs

PFAS

BPs

20 g dryed sediment at 20ºC

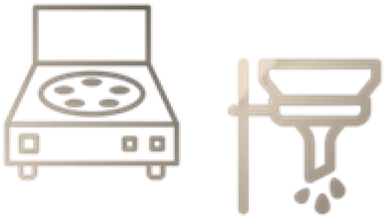
20 µL concentrated formic acid

10 µg/L internal standard (Bisphenol A D16)

30-minute ultrasonic-assisted **extraction** with 20 mL of methanol (MeOH)

Extracts **filtered**, **evaporated** & **reconstituted** in 1 mL of an acetonitrile:water mixture (1:1)

Ultrahigh performance liquid chromatography-mass spectrometry (**UHPLC-MS/MS**)



Heavy metals: external laboratory at AGH → inductively coupled plasma mass spectrometry (**ICP-MS**)

ECOLOGICAL RISK ASSESSMENT

The potential environmental risk posed by the investigated ECs was assessed using the methodology of the US Environmental Protection Agency, based on the **Risk Quotient (RQ)**

$$RQ = \frac{MEC}{PNEC}$$

MEC: measured environmental concentration
PNEC: predicted no-effect concentration

@RISK

ECOLOGICAL CUMULATIVE RISK

Thiele-Bruhn (2019)

$$\mathrm{PNEC_{mix}} = \sum \frac{PNEC_i}{C_i/Cmix}$$

$$\mathrm{RQ_{mix}} = \sum \frac{C_i}{PNEC_{mix}}$$

PNECi: PNEC value of each individual compound
Ci: concentration of each compound
Cmix: total concentration of all

RQ	<0.01	0.01 - 0.1	0.1 - 1.0	>1.0
risk	negligible	low	moderate	high

USEPA 1989. Risk Assessment Guidance for Superfund ,Vol. 1: Human Health Evaluation Manual, Part A. Interim Final.
Thiele-Bruhn, S., Konradi, S., & Vogel, I. *Environmental risks from mixtures of antibiotic pharmaceuticals in soils$aa literature review* (Study completed in: November 2018.)

RESULTS

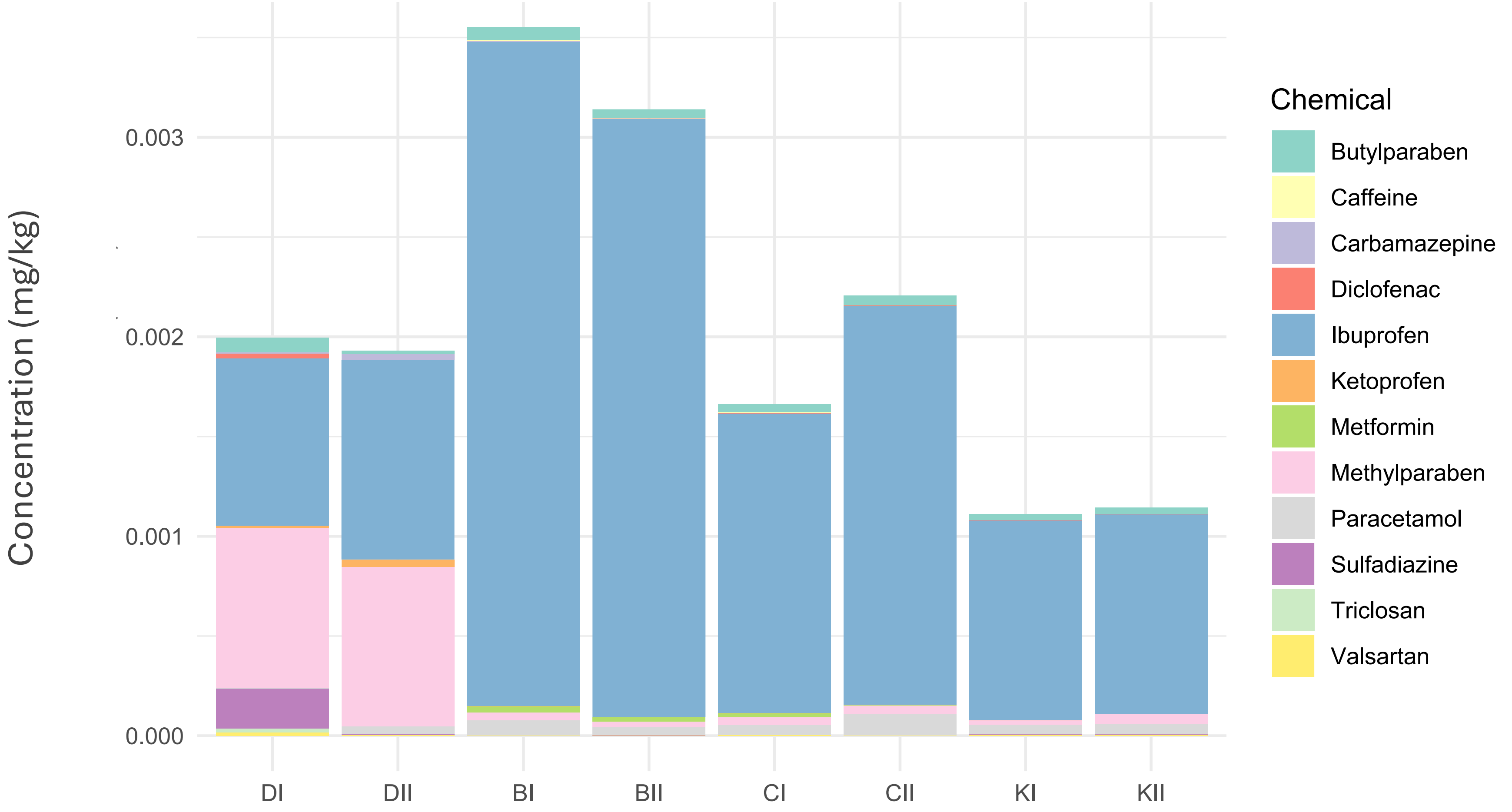
ECS CONCENTRATIONS

RISK ASSESSMENT

CUMULATIVE ECOLOGICAL RISK

ECs CONCENTRATIONS

PPCPs

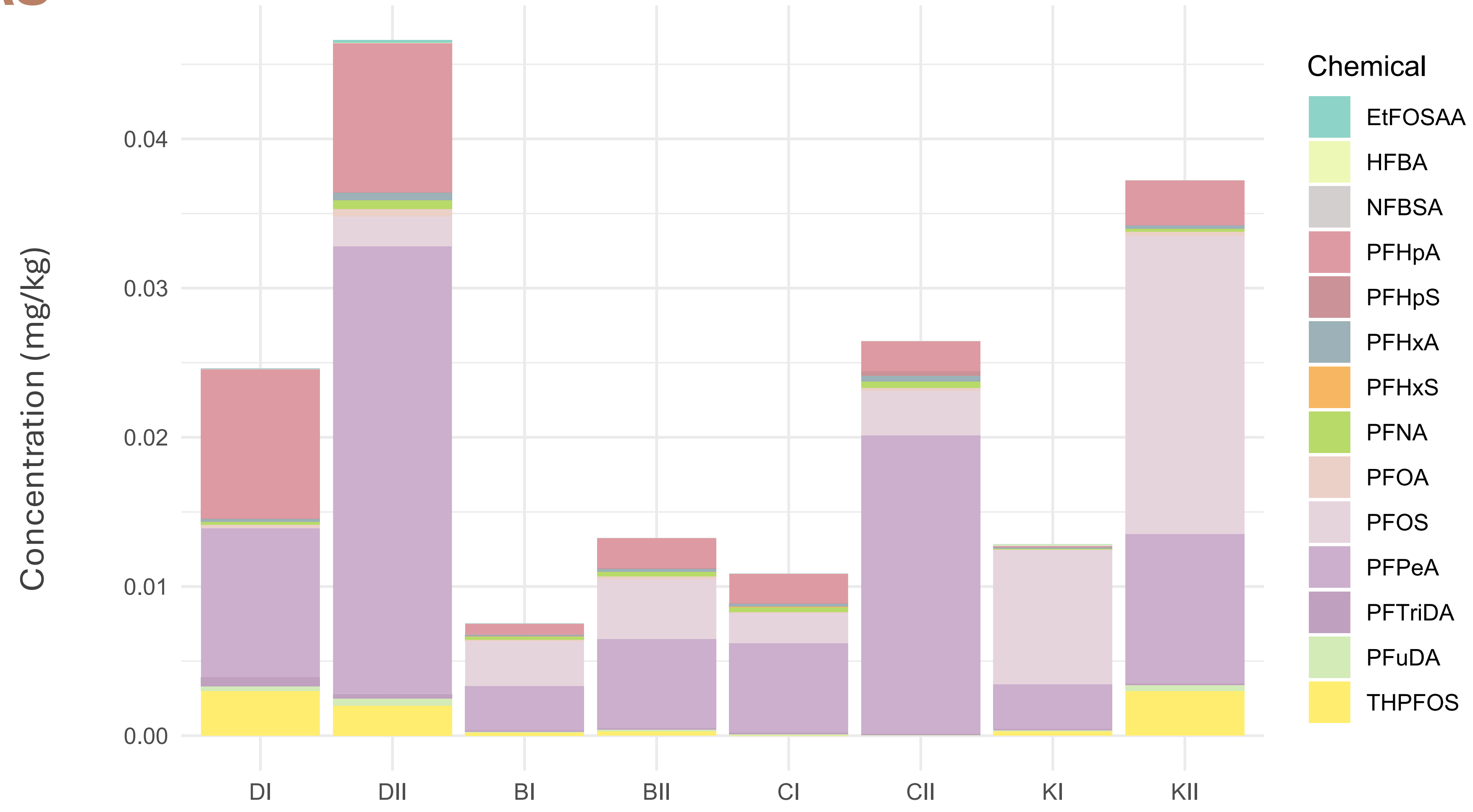


D: Dobczyce
B: Balaton
C: Chechło
K: Kryspinow

I: April
II: July

ECs CONCENTRATIONS

PFAS



D: Dobczyce
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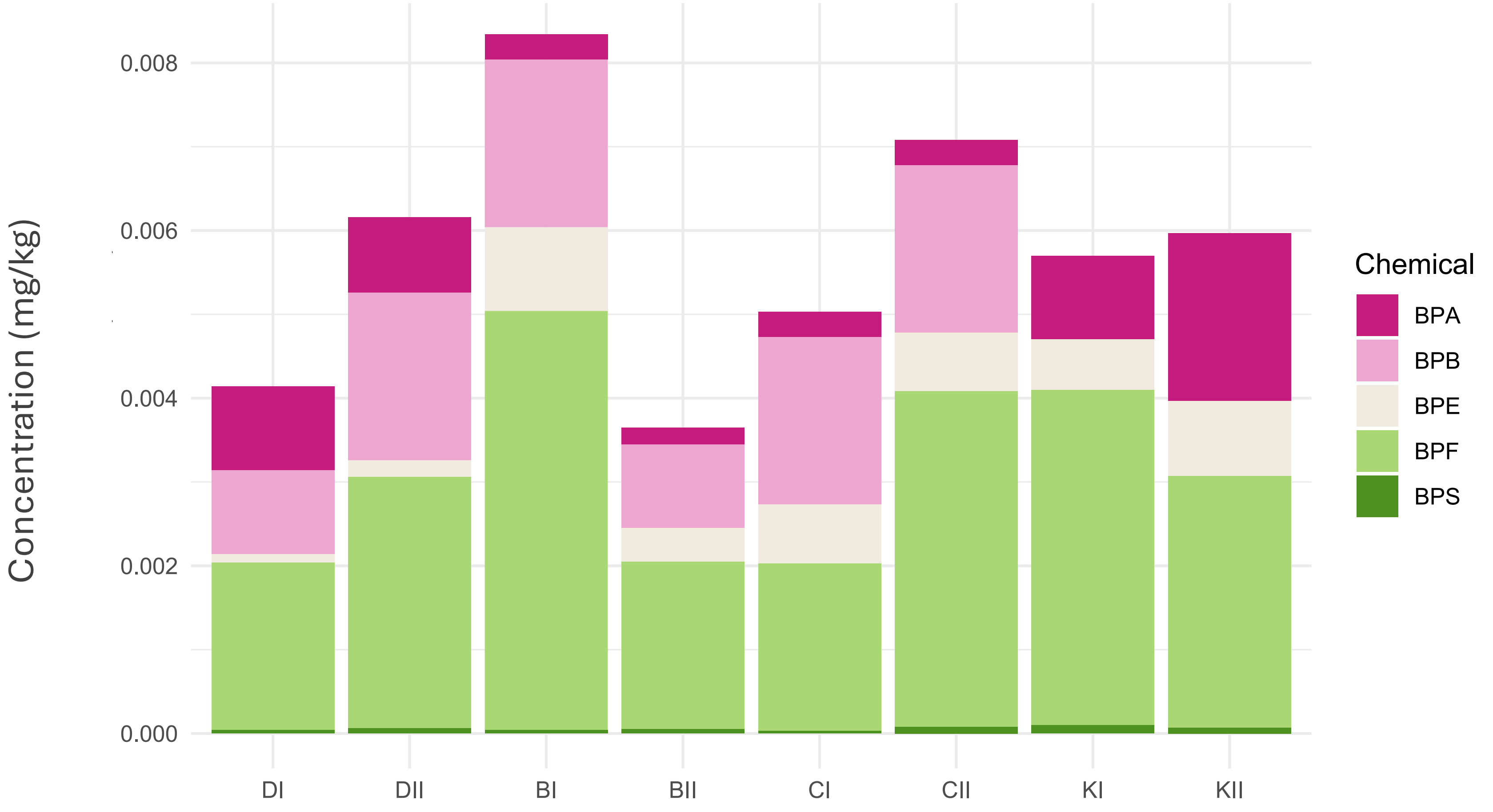
ECs CONCENTRATIONS

BPs

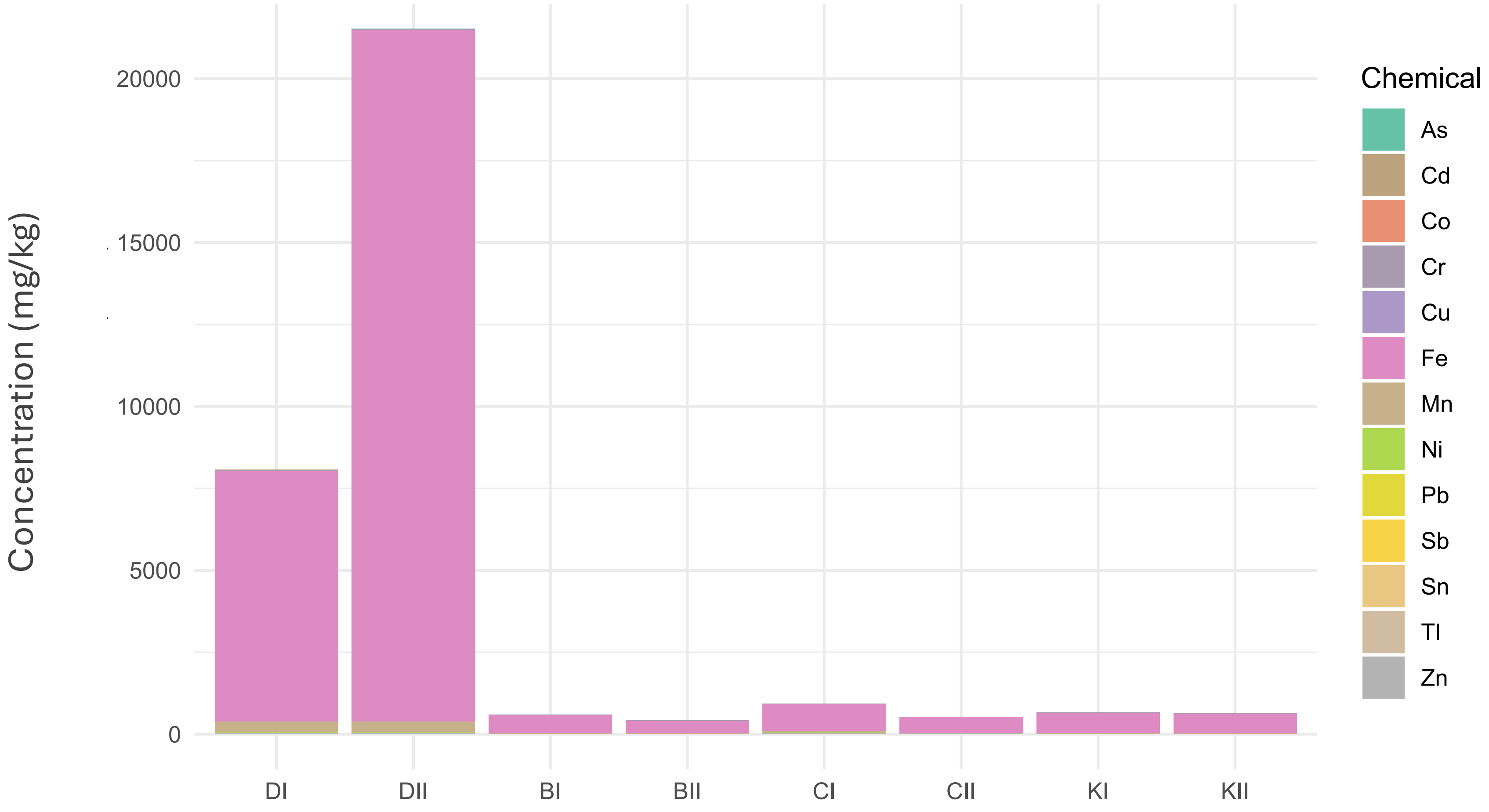


D: Dobczyce
B: Balaton
C: Chechło
K: Kryspinow

I: April
II: July

ECs CONCENTRATIONS

HEAVY METALS

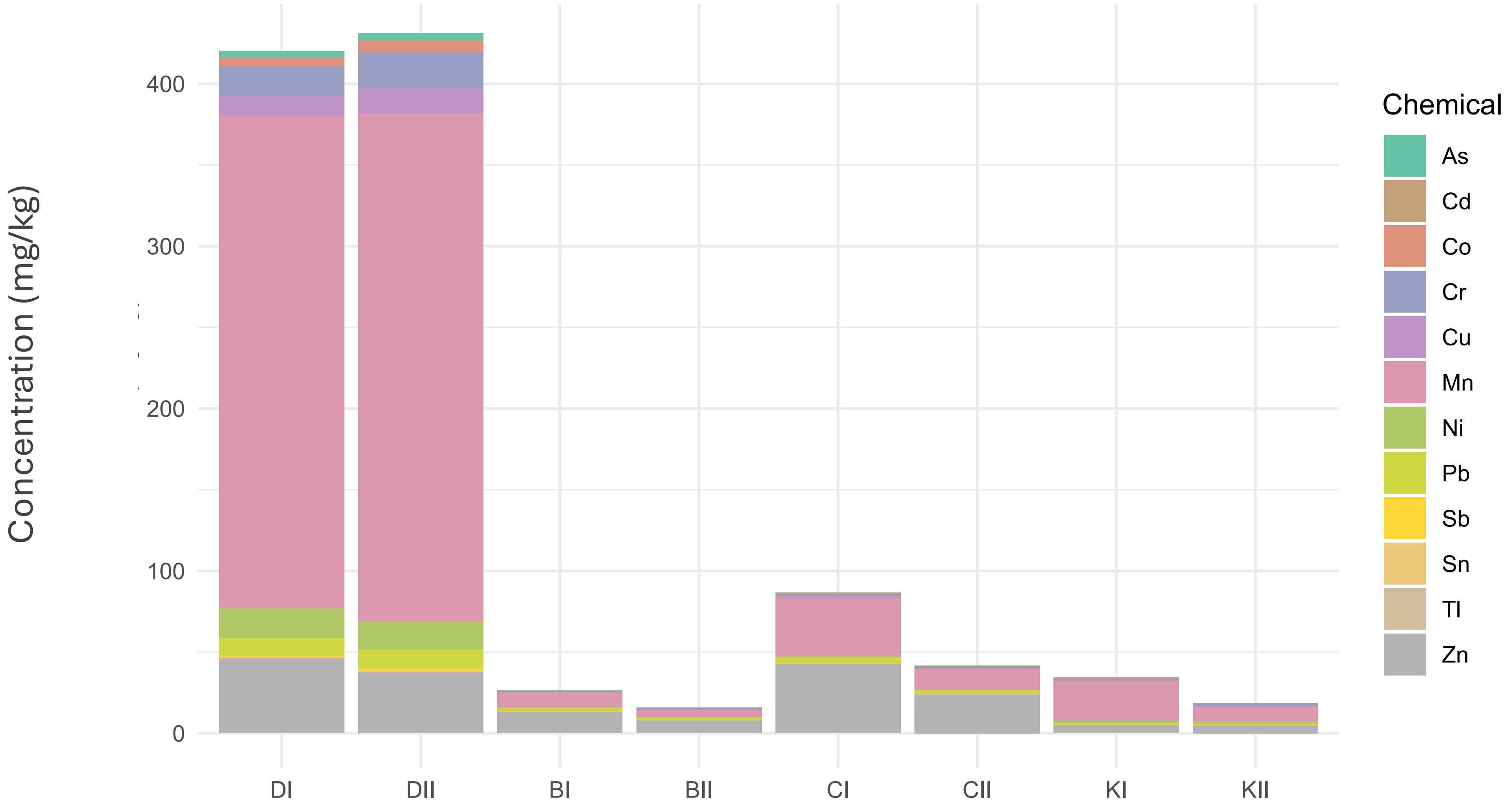


D: Dobczyce
B: Balaton
C: Chechło
K: Kryspinow

I: April
II: July

ECs CONCENTRATIONS

HEAVY METALS (excluding Fe)



D: Dobczyce
B: Balaton
C: Chechło
K: Kryspinow

I: April
II: July

RISK ASSESSMENT

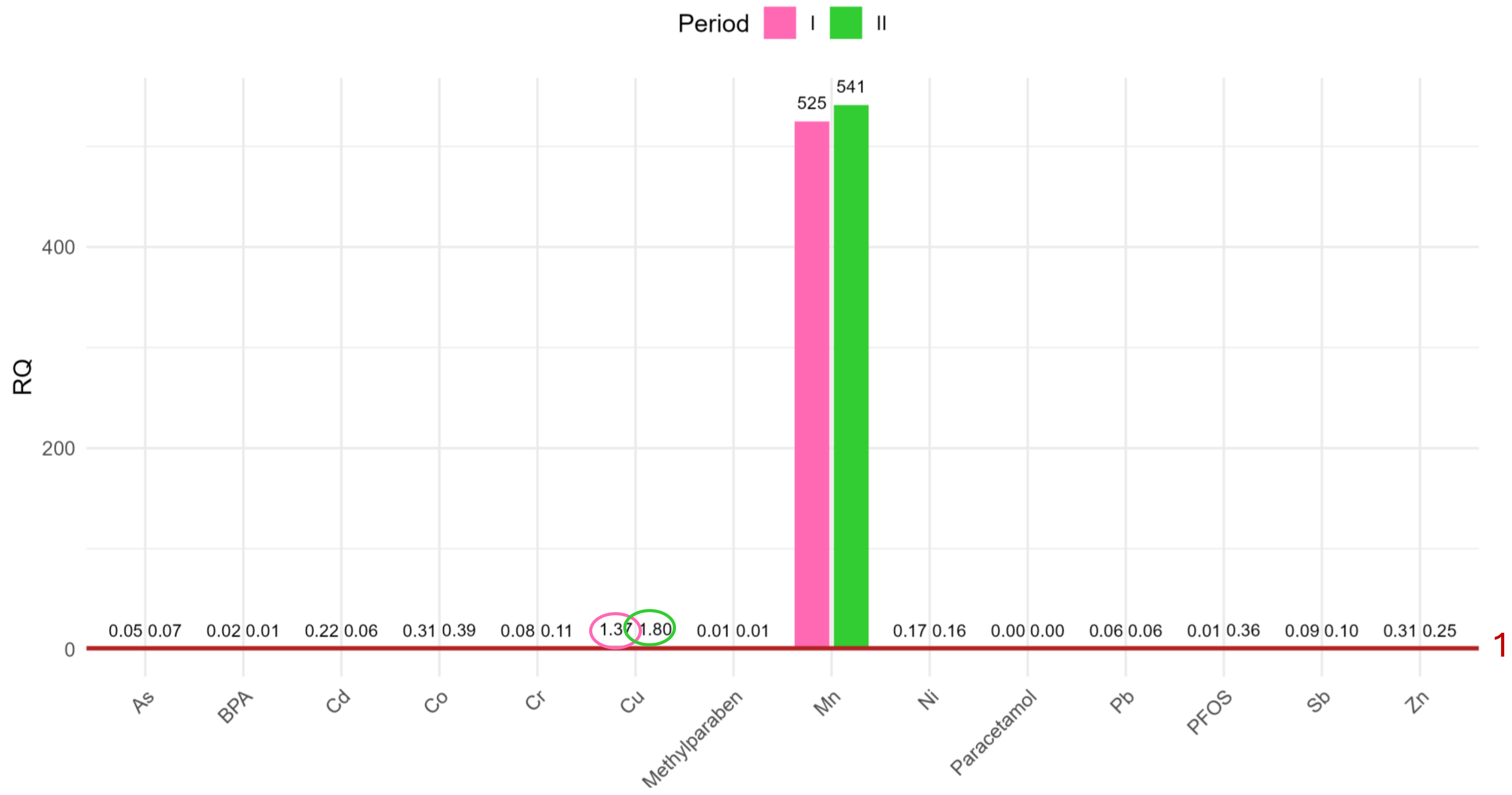
PNECsed

PNEC values in sediments for most of the ECs have not been established yet: insufficient experimental data

PPCPs	**Paracetamol**, Caffeine, Ibuprofen, Sulfadiazine, Triclosan, Metformine, Ketoprofen, Diclofenac, Valsartan, Carbamazepine, **Methylparaben**, Butylparaben	2/12
PFAS	HFBA, PFPeA, NFBSA, PFHxA, PFHpA, PFHxS, THPFOS, PFOA, PFHpS, PFNA, **PFOS**, PFUnDA, EtFOSAA, FTriDA	1/14
Bisphenols	**Bisphenol A**, Bisphenol B, Bisphenol E, Bisphenol F, Bisphenol S	1/5
Heavy metals	**Arsenic (As), Zinc (Zn), Antimony (Sb), Lead (Pb), Copper (Cu, Cadmium (Cd), Niquel (Ni), Cobalt (Co), Manganese (Mg), Chromium (Cr)**, Iron (Fe), Tin (Sn), Thallium (Tl)	10/13

RISK ASSESSMENT

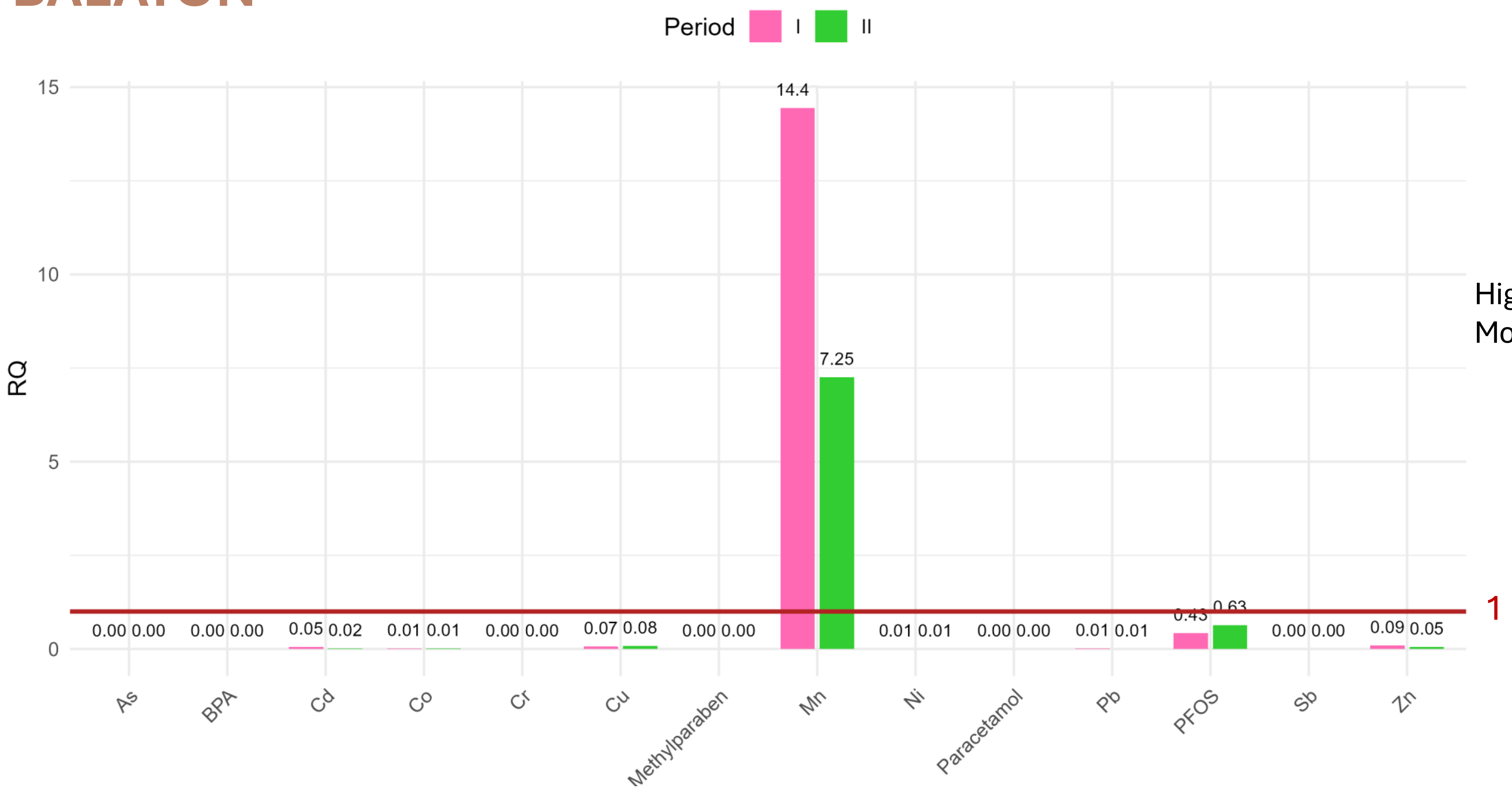
DOBCZYCE



High: Mn, Cu
Moderate: Zn, Ni, Co

RISK ASSESSMENT

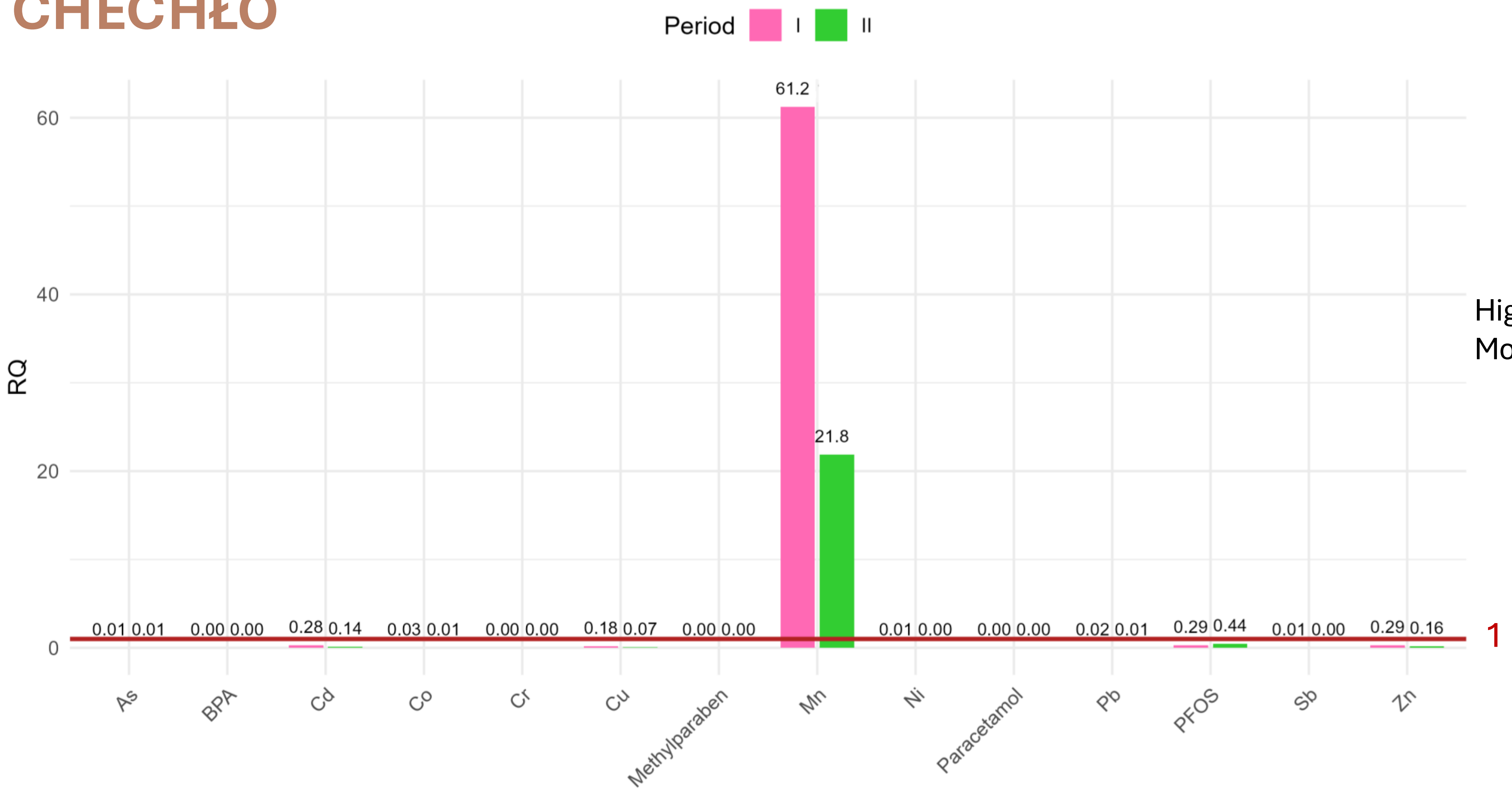
BALATON



High: Mn
Moderate: PFOS

RISK ASSESSMENT

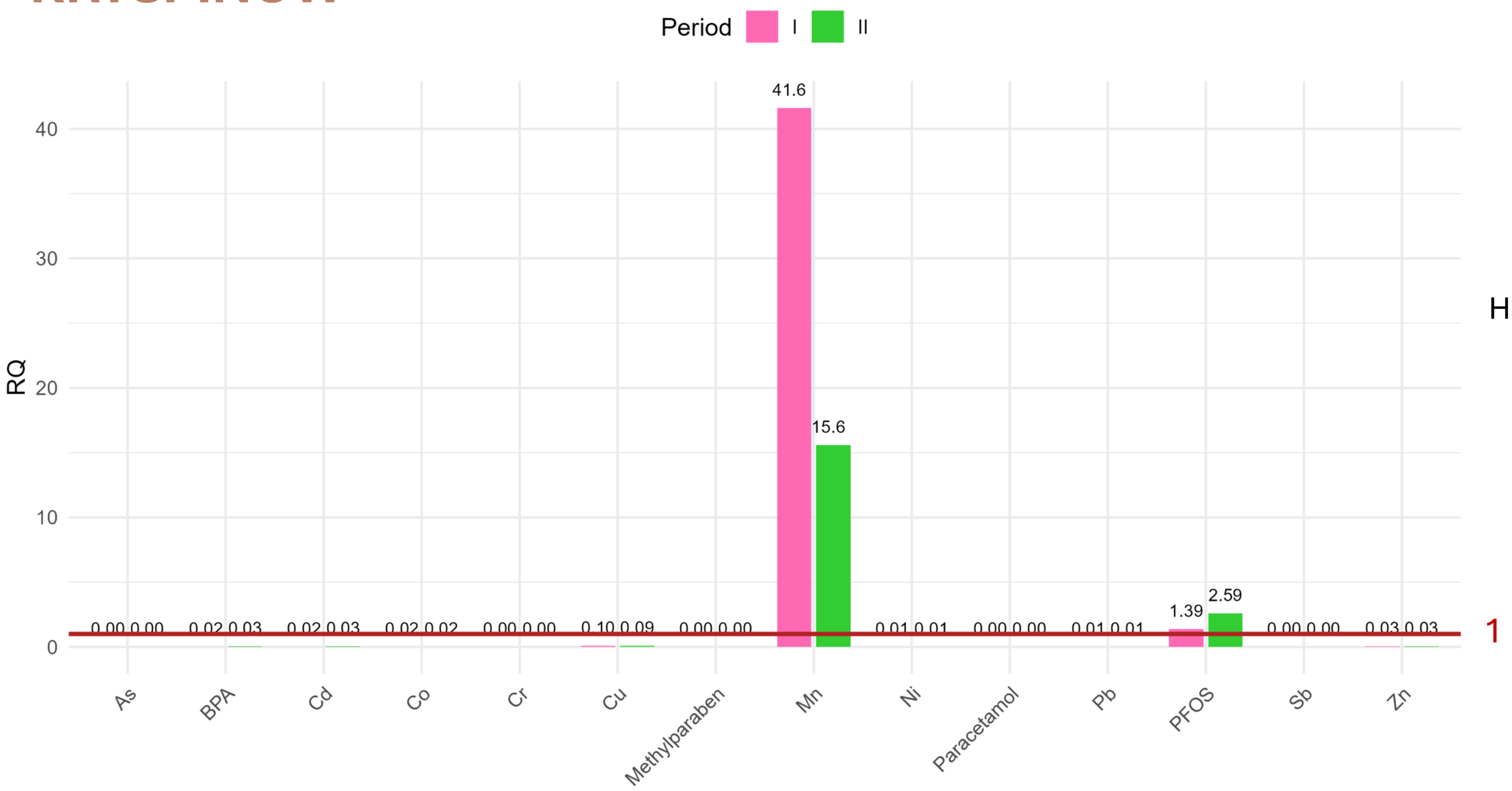
CHECHŁO



High: Mn
Moderate: Zn, Cd, PFOS

RISK ASSESSMENT

KRYSPINOW



High: Mn, PFOS

CUMULATIVE ECOLOGICAL RISK

DI: High
DII: High

BI: Moderate
BII: Moderate

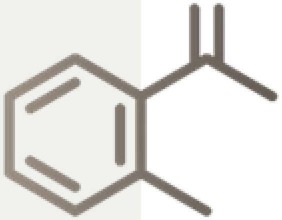
CI: High
CII: Moderate

KI: Moderate
KII: Moderate

CONCLUSIONS

- Heavy metals emerged as the most represented group of contaminants across all four reservoirs, with manganese exhibiting high RQ values, indicating a significant risk in every reservoir analyzed.

- The reservoir which serves as the principal drinking water source for Kraków's population (reservoir D), exhibited the highest cumulative risk quotient among all studied sites, highlighting the need for remediation strategies and continuous monitoring to ensure water quality and protect public health in Krakow.



- Clay composition of reservoir D sediments favors greater adsorption and retention of organic and inorganic contaminants compared to the sandy sediments of other reservoirs (B, C, K), which have lower specific surface area and retention capacity.

- While individual contaminants predominantly presented negligible to low risk quotients when assessed separately, the cumulative risk assessment revealed moderate to high overall risk levels, demonstrating significant additive effects and emphasizing the importance of multi-contaminant approaches in ecological risk evaluation

AGH - UGR

THANK YOU FOR YOUR ATTENTION!