

Uptake of chemicals of emerging concerns in tomatoes irrigated with treated wastewater

E. Andreasidou, A. Kovačič, D. Heath, M. Pintar, N. Kacjan Maršič, U. Blaznik, E. Heath

Definition of the problem

Wastewater reuse as a non conventional water source

WWTPs can not effectively remove chemicals of emerging concern (CEC)

Uptake and translocation of CEC in plants

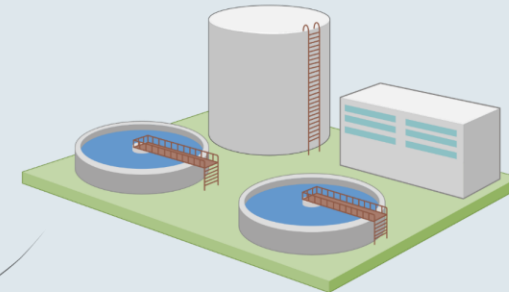
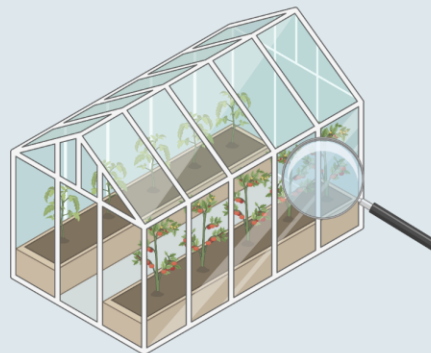
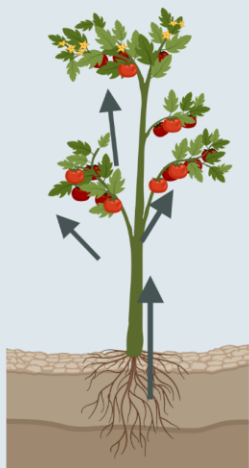
Population Growth

Demand in food

Water Scarcity

Climate Change

Existing Water Stress



Experimental Design

- Model plant: tomato (*Solanum lycopersicum L. Rally*)
- 2 different growing regimes (soil: lysimeters, soilless: hydroponics)
- Spiking of irrigation media with 14 organic contaminants to evaluate the uptake.

Chemicals of Emerging Concern

Industrial Chemicals:

BPA, BPS, 22-BPF, 24-BPF, 44-BPF

Pharmaceuticals:

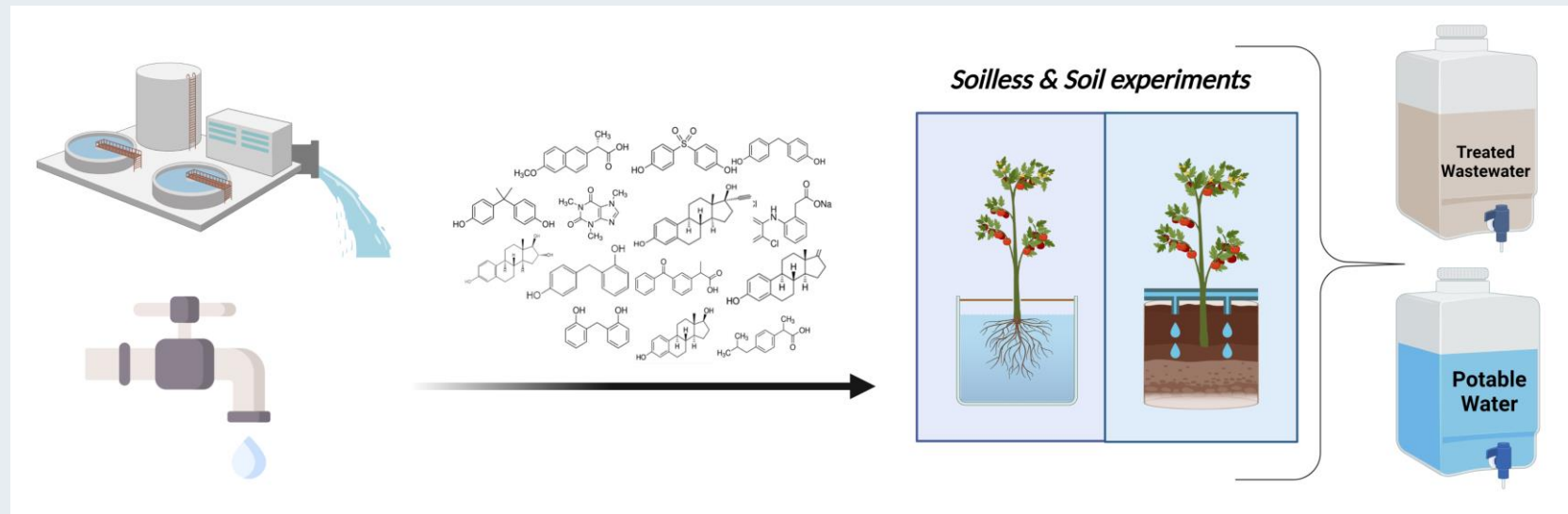
Ketoprofen, Ibuprofen, Naproxen, Diclofenac

Hormones

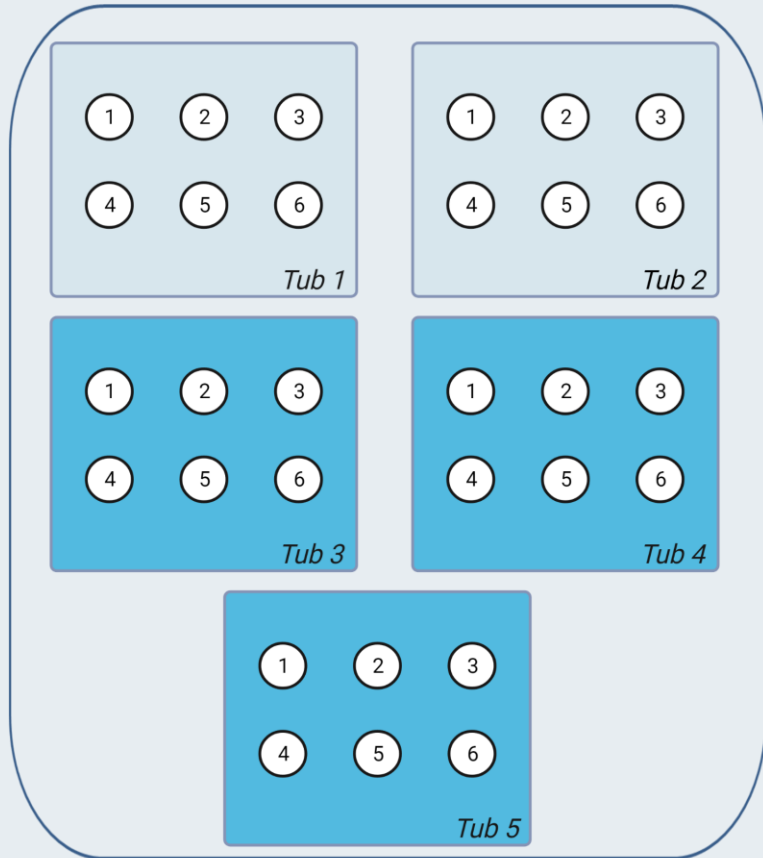
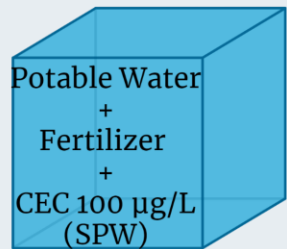
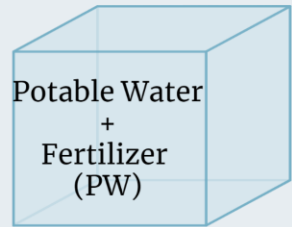
Estrone, 17 β -estradiol, 17 α -ethynyl estradiol,
Estriol

Psychoactive Substances:

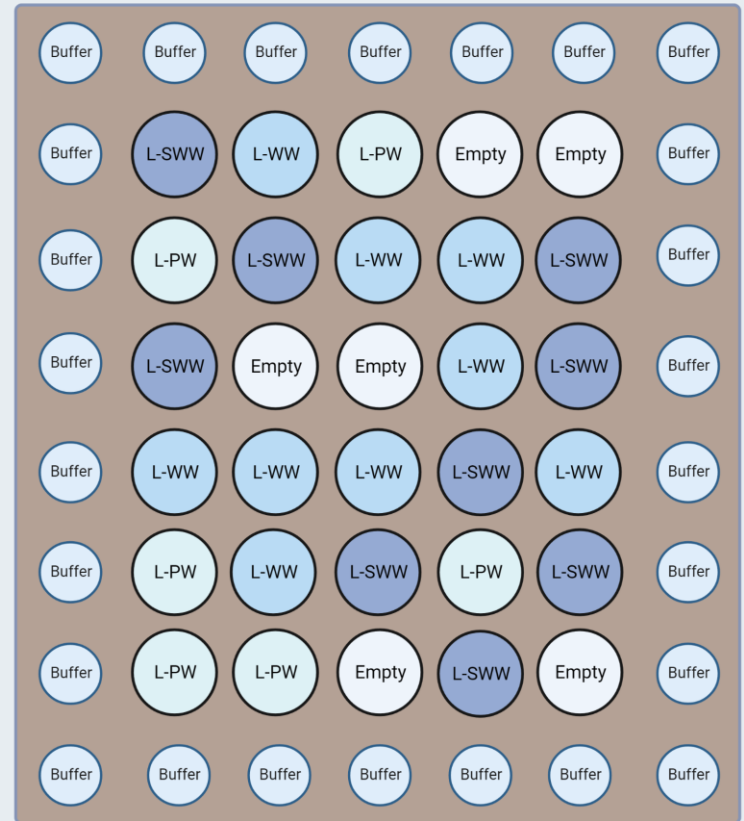
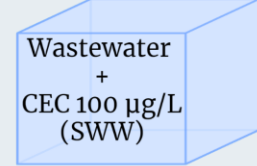
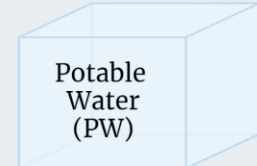
Caffeine



Experimental Design



Treatments:
HPW, HSPW



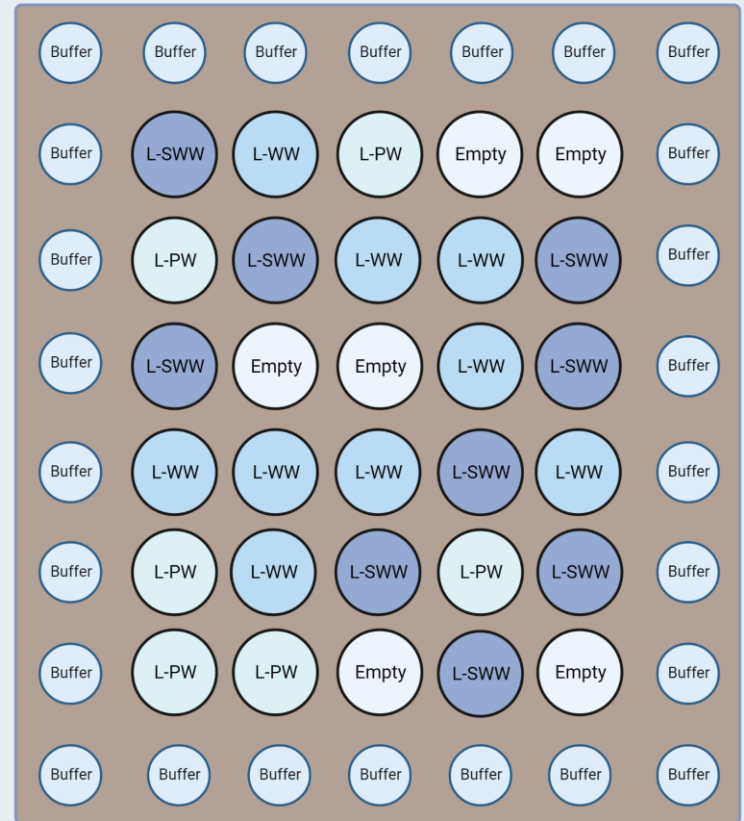
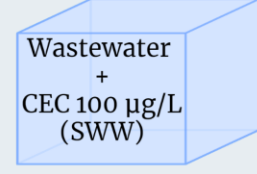
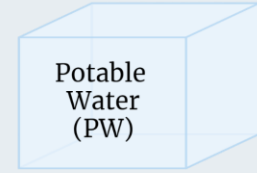
Treatments:
LPW, LWW, LSWW

	Start	1.5 month	2.5 months
Media Preparation	Freshly Prepared	Sampling	Freshly Prepared
Concentration	100 µg/L	100-50 µg/L	5 CEC > 50 µg/L

Experimental Design



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Sample Collection

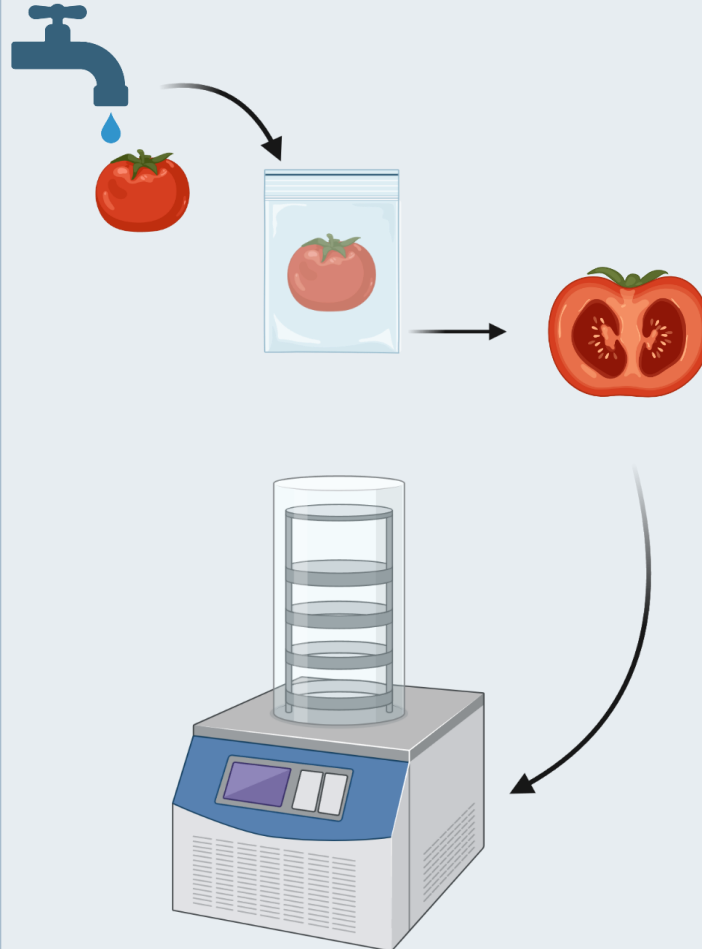
1

Collection of tomato samples in 3 different periods (S1-S3)



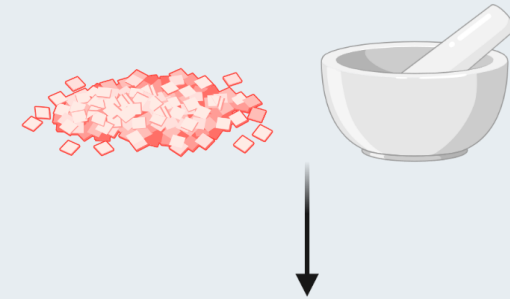
2

Wash, blotted dry, cut and freeze dried



3

Preparation of composites



1

All fruits per plant and per treatment

2

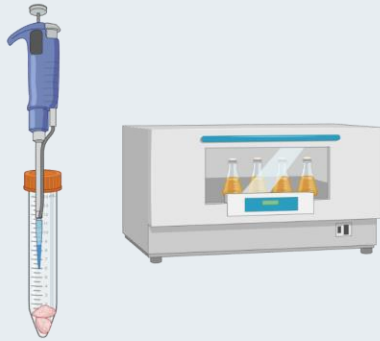
All fruits per harvest per treatment

3

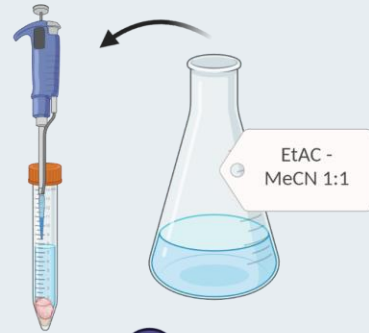
All fruits per treatment from 2-3 plants

Sample Preparation

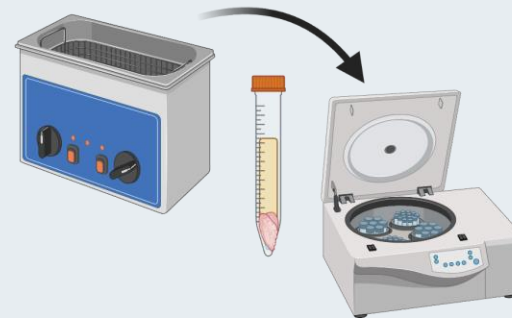
1
Equilibration of ISTDs



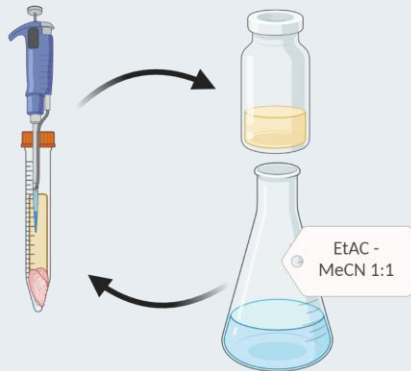
2
Addition of Extraction Solvent



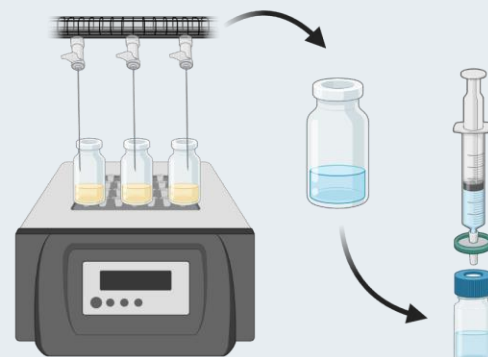
3
Ultrasound Extraction



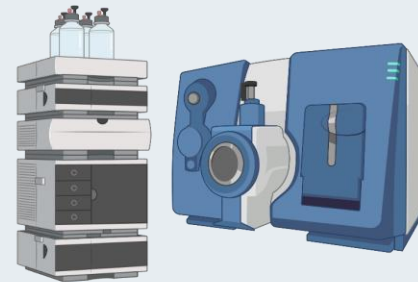
4
Transfer of supernatant & additional circle



5
Dry, reconstitute and filter

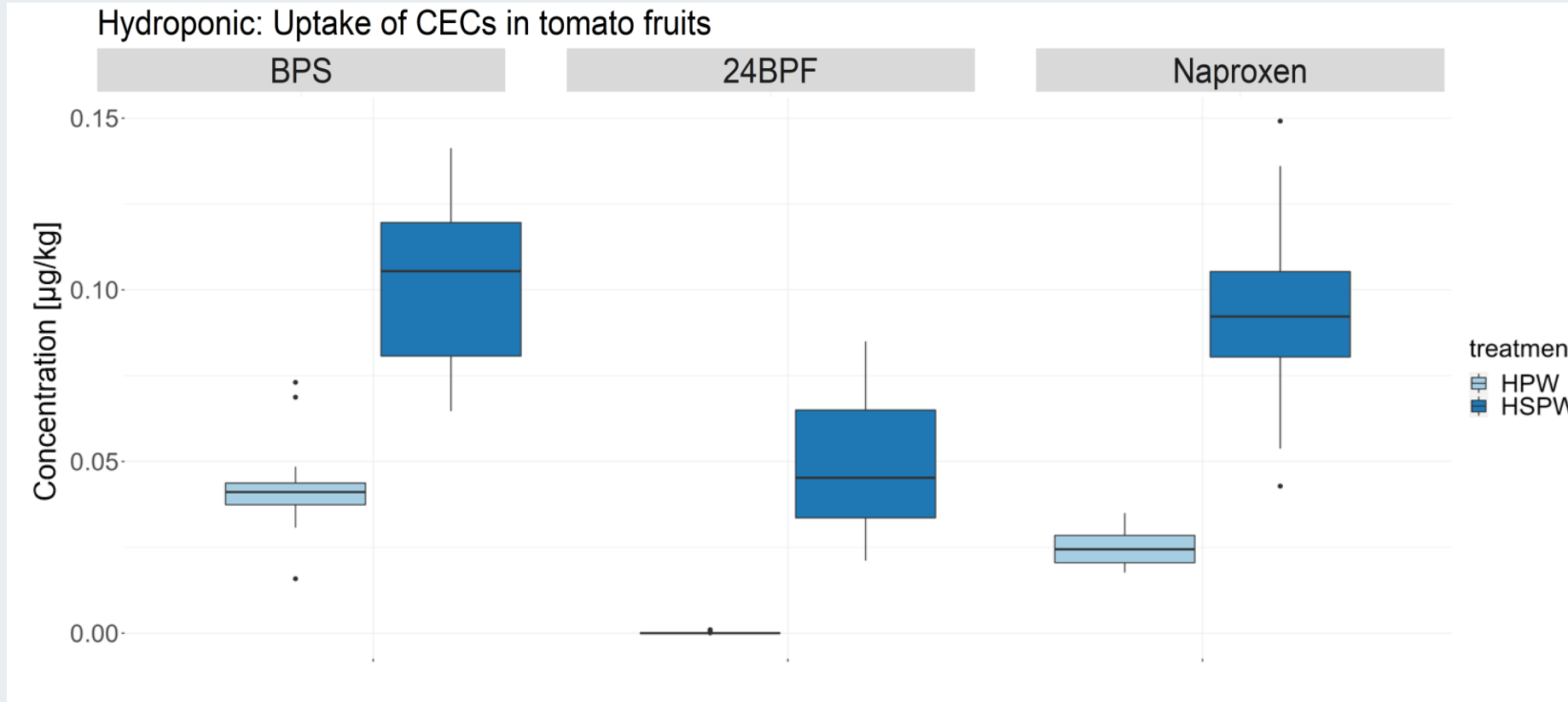


6
Analysis with UHPLC-MS/MS



UHPLC-MS/MS
Poroshell 120 EC-C18 (40°C)
Gradient elution with 0.3 mL/min flowrate
A: Methanol with 1 mM NH ₄ F
B: Ultrapure Water with 1 mM NH ₄ F
Electrospray ionisation (ESI) in negative mode
Multiple reaction monitoring (MRM) mode
LOQs: 0.5 or 1.0 ng/g (0.025 or 0.05 µg/kg f.w.) for 13 CECs and 40 ng/g (2.0 µg/kg f.w.) for BPA

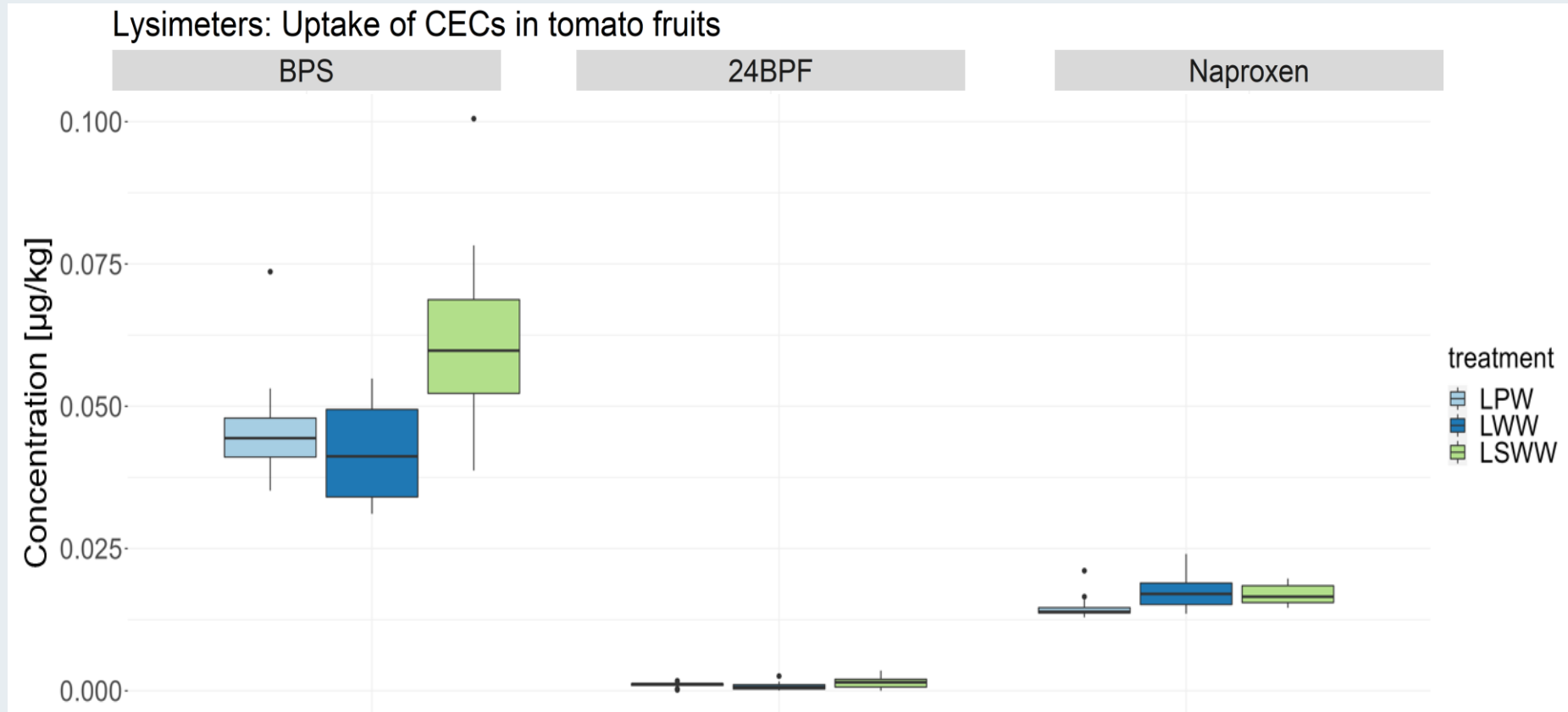
Results - Hydroponics



- Concentrations based on composition of a ripe tomato:
95% water and ~ 5% dry matter
- Detection only in tomatoes irrigated with spiked media

(0.071 – 0.134 µg/kg f.w.)

Results - Lysimeters



Average concentrations of CECs

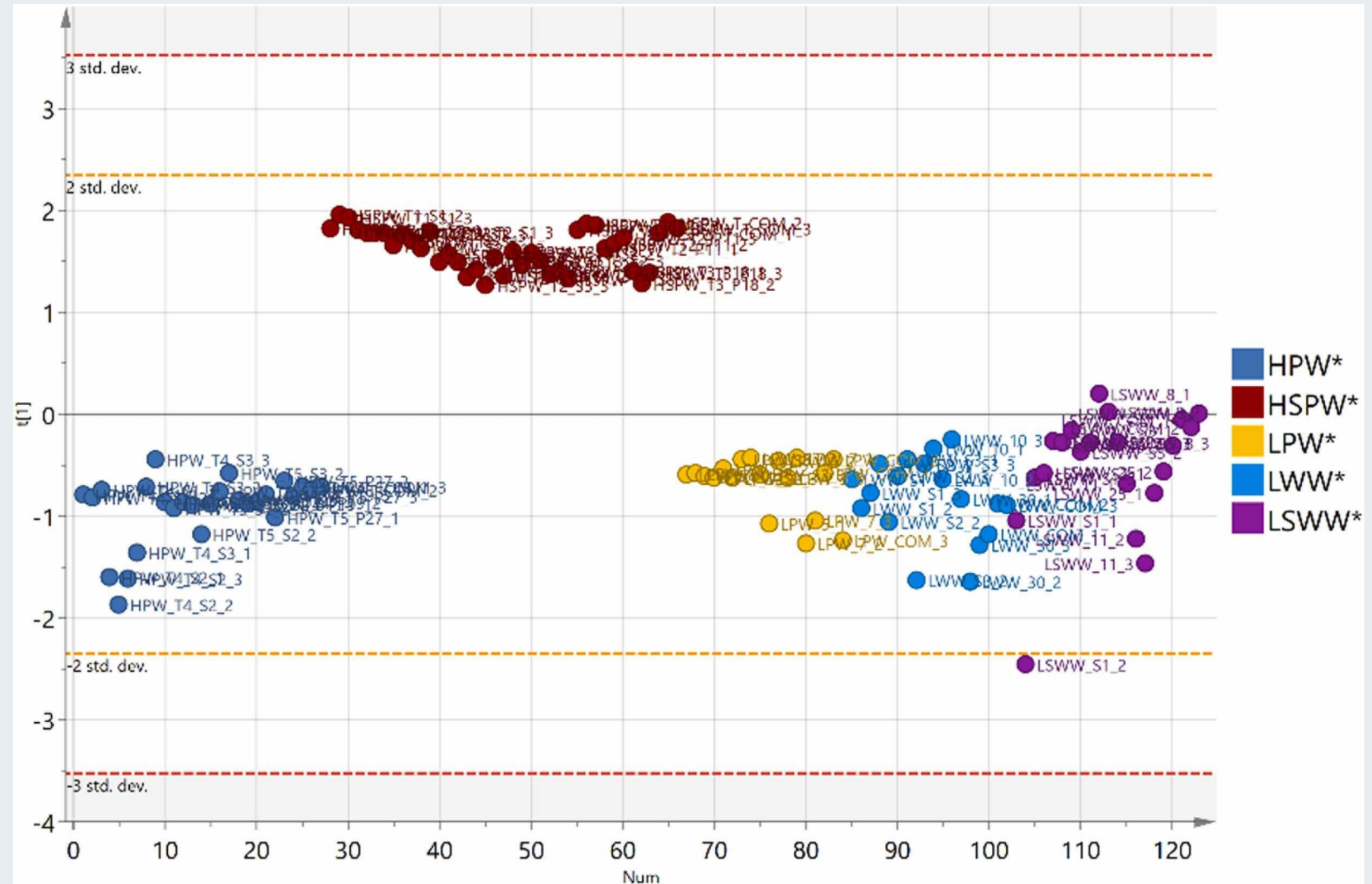
Hydroponically: 0.08 ± 0.03 $\mu\text{g}/\text{kg}$ f.w. and

Soil-grown tomatoes: 0.06 ± 0.01 $\mu\text{g}/\text{kg}$ f.w.

(0.034 – 0.070 $\mu\text{g}/\text{kg}$ f.w.)

Results

- PCA: Grouped samples into 3 groups
- No significant difference in the amount of CEC between harvests
- Significant difference in uptake of CEC between tomatoes grown with or without soil, with more significant uptake when grown without it.



Risk assessment and Dietary exposure

Dietary exposure

Estimated for children (toddlers) and adults

- Based on consumption levels from the EFSA.
- Derived No-Effect Level (DNEL) for BPS: 200 µg/(kg day)

ng/kg bw day	Hydroponics			Lysimeters
	BPS	24BPF	Naproxen	BPS
Average Chronic Exposure				
Children	0.02–0.27	0.01–0.13	0.02–0.26	0.02–0.16
Adults	0.01–0.15	0.01–0.08	0.01–0.15	0.01–0.09
High Exposure				
Children	0.15–0.97	0.07–0.48	0.14–0.93	0.59
Adults	0.09–0.51	0.05–0.26	0.09–0.50	-

Conclusions


- Uptake of BPS, 24BPF and Naproxen out of the 14 spiked CECs
- Higher uptake in the case of hydroponically grown tomatoes.
- No health risk from consuming tomatoes grown hydroponically or in soil.
- New list of 28 CEC spiked at higher concentration
- Uptake and translocation of CEC in tomato, leaves, stems and roots.
- Pot experiments with use of sludge.



Acknowledgements

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Research Article

Contaminant uptake in wastewater irrigated tomatoes

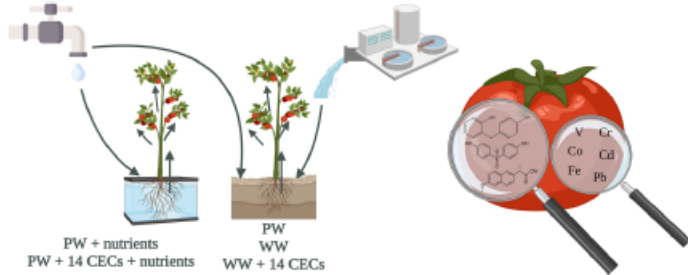
Ana Kovačič^{a,b}, Eirini Andreasidou^{a,b}, Anže Brus^a, Anja Vehar^{a,b}, Doris Potočnik^a, Marta Jagodic Hudobivnik^a, David Heath^a, Marina Pintar^c, Nina Kacjan Maršič^c, Nives Ogrinc^{a,b}, Urška Blaznik^d, Ester Heath^{a,b,*}

^a Department of Environmental science, Jožef Stefan Institute, Jamova cesta 39, Ljubljana 1000, Slovenia
^b International Postgraduate School Jožef Stefan, Jamova cesta 39, Ljubljana 1000, Slovenia
^c Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, Ljubljana 1000, Slovenia
^d Environmental Health Centre, National Institute of Public Health, Trubarjeva 2, Ljubljana 1000, Slovenia

HIGHLIGHTS

- Uptake study of 14 CECs and 27 elements in tomatoes grown in soil/soil-less media.
- Bisphenol S, 2,4 bisphenol F, and naproxen were detected in fruits.
- CECs presence and growing condition affect the elemental composition of tomatoes.
- Contaminants at determined levels showed low dietary chronic exposure.

GRAPHICAL ABSTRACT



FoodTraNet



Horizon 2020
European Union Funding
for Research & Innovation

