Residue

Risk reduction of chemical residues in soils and crops:
impact due to wastewater used for irrigation

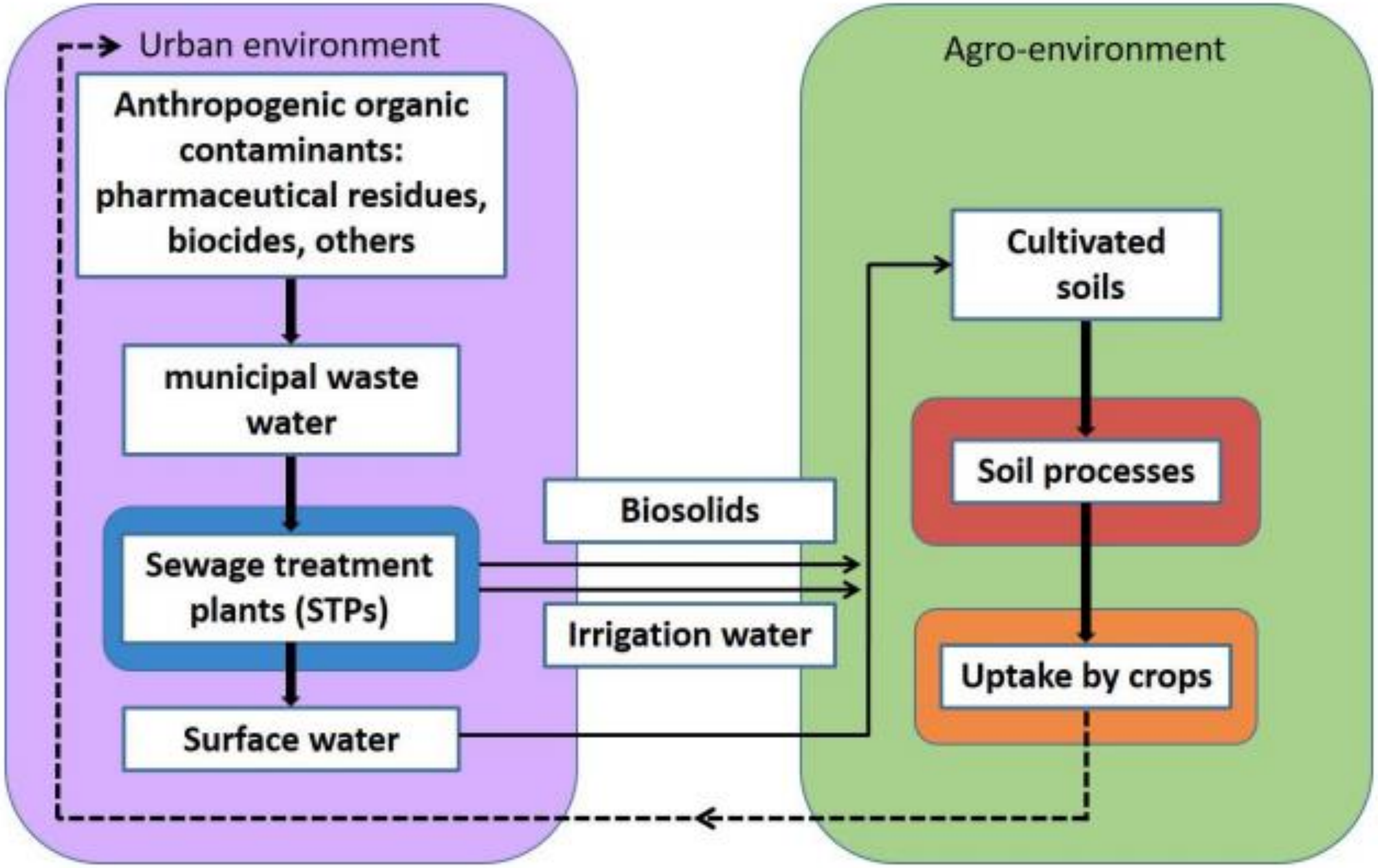
From wastewater treatment plants to our plate - The whole picture of exposure to wastewater-derived pharmaceuticals through food.

Dr. Yehoshua Maor, PhD.
Phytor Lab Jerusalem

PHYTOR

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA | Fraunhofer IME | Freie Universität Berlin | CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS | PHYTOR | Consorzio Italbiotec | האוניברסיטה העברית בירושלים THE HEBREW UNIVERSITY OF JERUSALEM

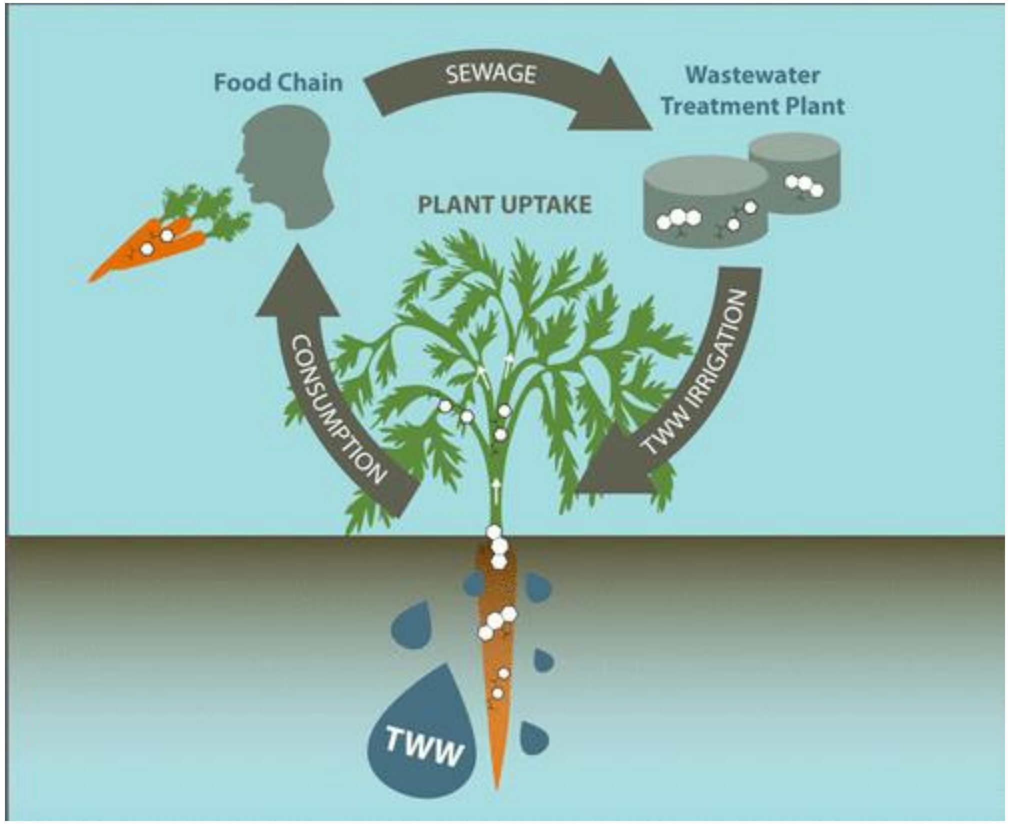
Problem definition



- Use of waste water in agriculture inevitable due to water scarcity
- Potential exposure of crops with anthropogenic organic chemicals
- Risk of food contamination

Residue

Background



Irrigation of Root Vegetables with Treated Wastewater: Evaluating Uptake of Pharmaceuticals and the Associated Human Health Risks

Environmental Science & Technology

Article

pubs.acs.org/est

Irrigation of Root Vegetables with Treated Wastewater: Evaluating Uptake of Pharmaceuticals and the Associated Human Health Risks

Tomer Malchi,[†,‡] Yehoshua Maor,[‡] Galit Tadmor,[†,‡] Moshe Shenker,[†] and Benny Chefetz*[,†,‡]

[†]Department of Soil and Water Sciences, Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot 76100, Israel

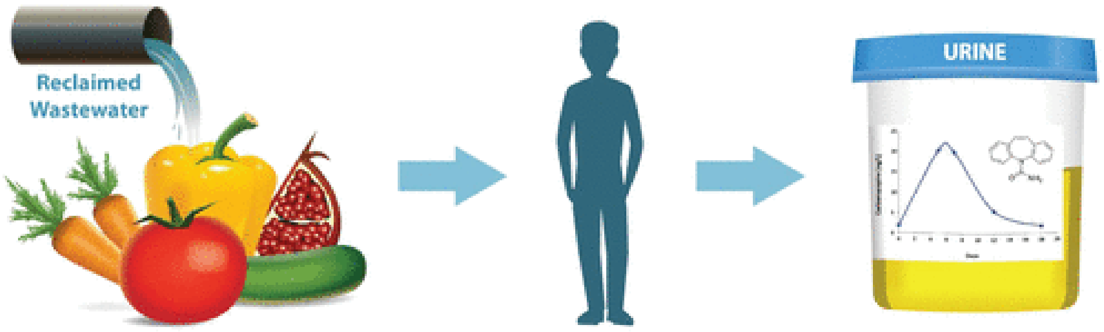
[‡]The Hebrew University Center of Excellence in Agriculture and Environmental Health, P.O. Box 12, Rehovot 76100, Israel

PHYTOR

Residue

Background

Proof of Concept Study



Human Exposure to Wastewater-Derived Pharmaceuticals in Fresh Produce: A Randomized Controlled Trial Focusing on Carbamazepine

Environmental Science & Technology
Article
pubs.acs.org/est

Human Exposure to Wastewater-Derived Pharmaceuticals in Fresh Produce: A Randomized Controlled Trial Focusing on Carbamazepine

Ora Paltiel,[*,†,‡,§] Ganna Fedorova,[§,∥] Galit Tadmor,[†,§,∥] Geffen Kleinstern,[†,§] Yehoshua Maor,[§] and Benny Chefetz[§,∥]

[†]Braun School of Public Health and Community Medicine, Hadassah-Hebrew University of Jerusalem, Jerusalem 9112001, Israel
[‡]Department of Hematology, Hadassah-Hebrew University Medical Center, Jerusalem 9112001, Israel
[§]The Hebrew University Center of Excellence in Agriculture and Environmental Health
[∥]Department of Soil and Water Sciences, Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot 7610001, Israel

PHYTOR

Residue

Importance of the Study – Hebrew University

- Important data regarding the level of human exposure to carbamazepine by consumption of commercially available produce in Israel.

- Variance in exposure levels between subjects of different groups and estimation of potential risk to vulnerable populations.

- The data generated could guide policy decision.

Project goal

MISSION

The RESIDUE project is aimed at improving the safety of agricultural products grown under the influence of waste materials used for irrigation and fertilization by **developing an innovative technology that significantly reduces risks of transferring organic contaminants into the agricultural products**, improving their safety. RESIDUE uses locally available resources and ensures the easy applicability of the new technique in common agricultural practices.

PHYTOR

Residue

Project goal

Improvement of soil functions leading to an **in-situ removal and detoxification from organic pollu-tants** introduced by waste materials

New production procedures for **safe soil amendments** based on sewage sludge, through biochar addition and composting

Clear discrimination of non-bioavailable organic pollutants introduced into soil that do not consti-tute a risk for agri-culture

PHYTOR

Residue

Project goal

- improve the safety of agricultural products grown in countries, which are obliged to use waste materials for irrigation and fertilization in agriculture
- no setting of new limits but develop a technology with significantly reduced risks of transfer of organic contaminants into the agricultural products
- to enhance the in situ removal and detoxification of introduced organic pollutants by the improvement of soil functions
- new production procedures for safe soil amendments using local waste streams

PHYTOR

Residue

THE BENEFIT

A more pragmatic approach to **water management under water scarcity**

Cost reductions in water treatment through **residue revalorization** and reconsideration of wastewater depuration targets

A more **effective and sustainable agriculture**

PHYTOR

Residue

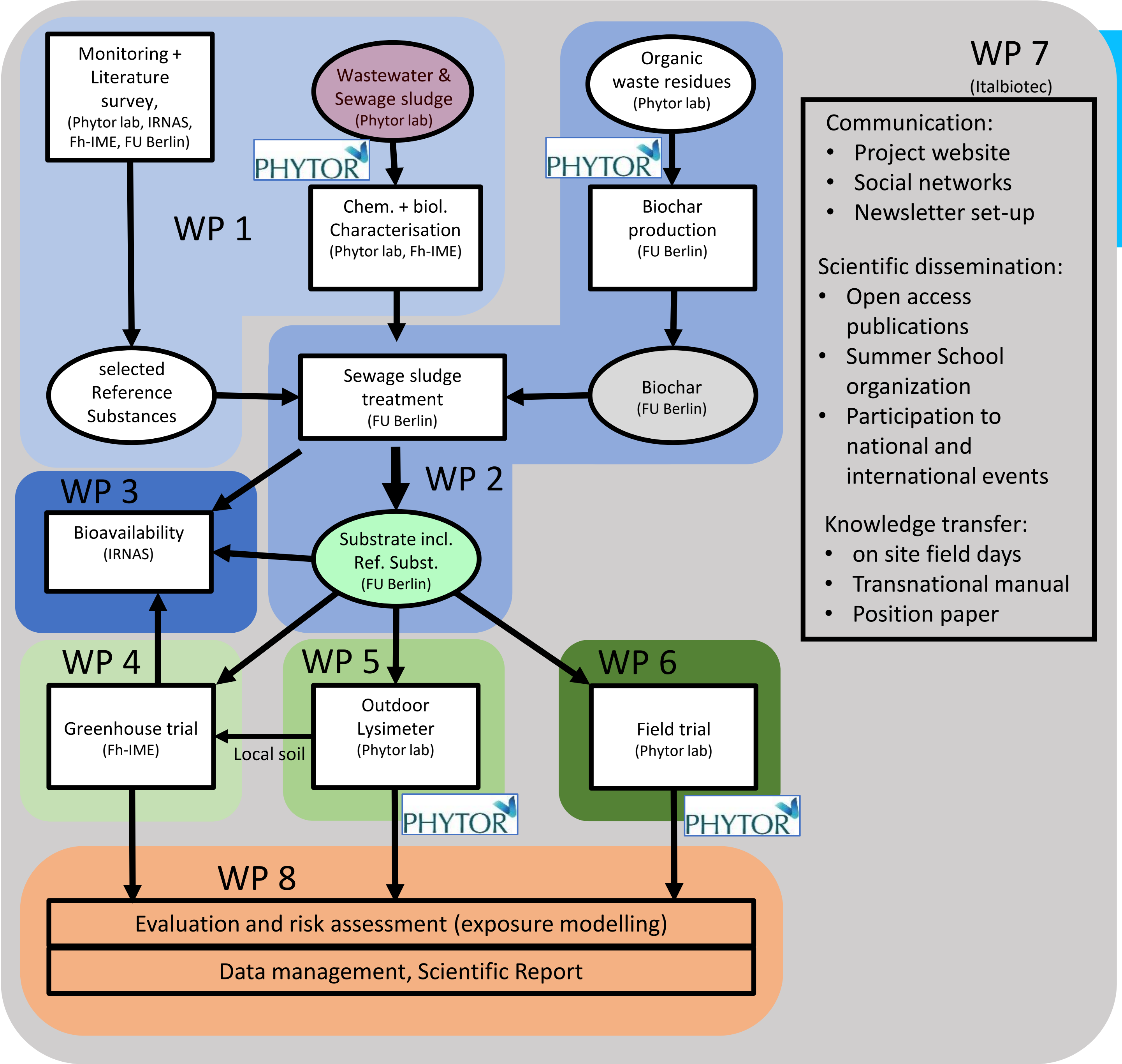
Project Partners

- Fraunhofer IME, Schmallenberg, Germany (Project coordination)
- PHYTOR Ltd. LAB Jerusalem, Israel,
- Institute of Natural Resources and Agrobiology of Sevilla (IRNAS)-CSIC, Seville, Spain
- Working Group Geoecology Free University, Berlin, Germany
- Consorzio Italbiotec, Milan, Italy
- Faculty of Agriculture, Hebrew University, Jerusalem, Israel

PHYTOR

Residue

Project Structure



Residue

Project status- Phytor/ Hebrew University

Pharmaceuticals in soil solution: Effect of soil characteristics

PHYTOR

Residue

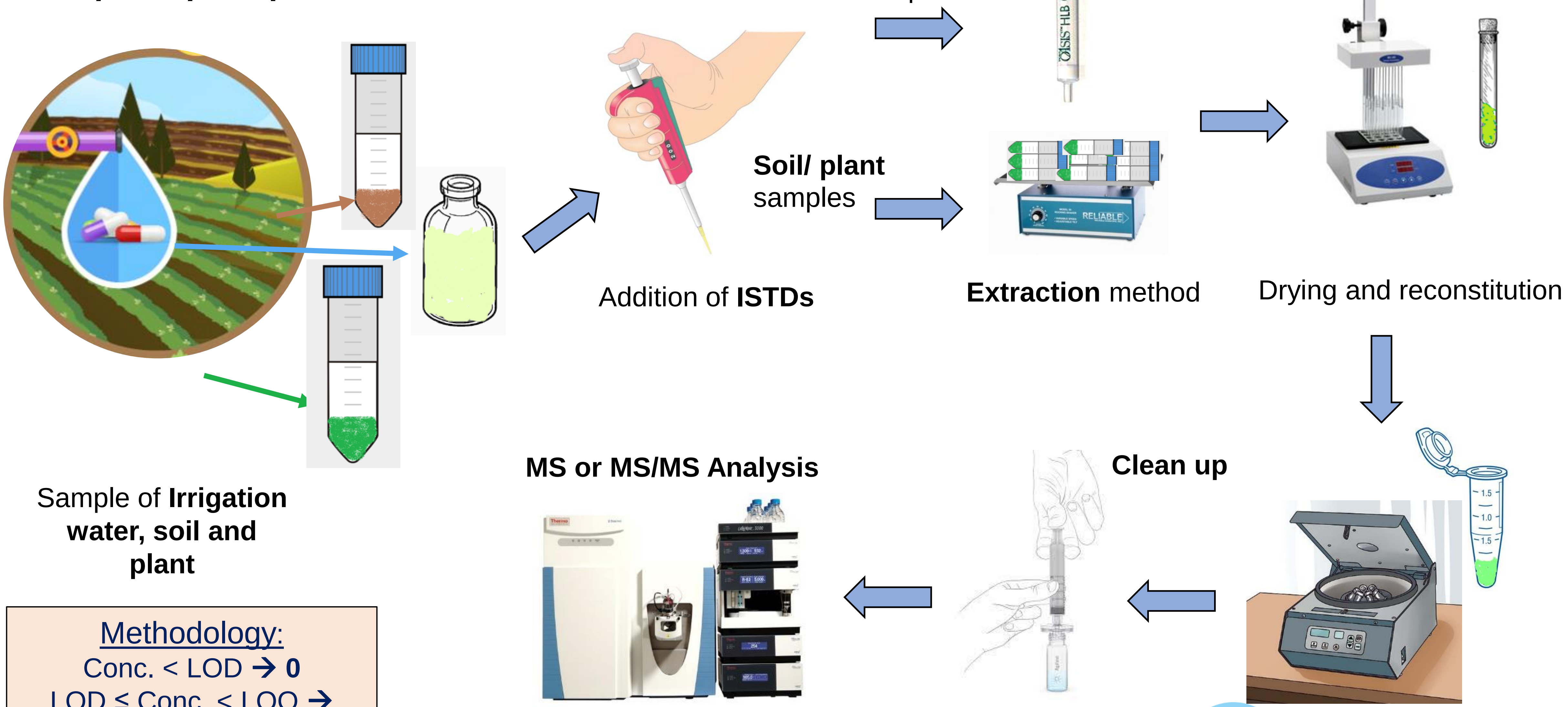
Analytes by group

Group	# of analytes in group	Usage
Antimicrobial agents	31	Antibiotics and antifungals
Antiarrhythmic agents	8	Suppress abnormal rhythms
Anticonvulsive agents	5	Epileptic seizures treatment
Analgesic agents	4	Pain relievers
Antidepressant agents	4	Depressive disorder treatment
Hypolipidemic agents	3	Lipid-lowering drugs
Stimulants	3	Stimulant, antidepressant, antipsychotic etc.
Antiparasitic agents	2	Parasitic diseases treatment
Sweeteners	2	Sugar substitute
Antihistamines	1	Allergies treatment
Opiates	1	Severe pain relievers (amongst others)
Phosphodiesterase inhibitors	1	Erectile dysfunction treatment
Corrosion inhibitor	1	Corrosion inhibitor, de-icing, etc.

PHYTOR

Residue

Sample preparation



Methodology:

Conc. < LOD → **0**

LOD ≤ Conc. < LOQ → **LOQ/2**

Conc. ≥ LOQ → **Conc.**

Extraction and analytical method per matrix:

mean analytes recoveries >90%,

mean R^2 for calibration curves >0.95

Analytes, groups, LOD and LOQ

Compound	Group	LOD / LOQ (ng/L)
Bezafibrate	Hypolipidemics ; n=3	0.25 / 0.75
Clofibric acid		3 / 9
Warfarin		0.65 / 1.95
Codeine	Opiate ; n=1	0.1 / 0.3
Sildenafil	phosphodiesterase inhibitor ; n=1	3 / 9
Cotinine	Psychoactives ; n=3	0.65 / 1.95
Caffeine		1 / 3
Nicotine		200 / 600
Acesulfame K	*Sweeteners ; n=2	40 / 80
Aspartame		60 / 180
Thiabendazole	Antiparasitics ; n=2	0.24 / 0.72
Crotamiton		2 / 6
Carbamazepine Epoxide	Anticonvulsants ; n=5	0.2 / 0.6
Lamotrigine		0.25 / 0.75
DIOH-CBZ		1 / 3
Carbamazepine		0.1 / 0.3
Gabapentin		50 / 120
Diazepam	Antidepressants ; n=4	0.03 / 0.09
Alprazolam		0.04 / 0.12
Venlafaxine		0.7 / 2.1
Fluoxetine		3 / 9
Atenolol	Antiarrhythmic agents ; n=8	0.4 / 1.2
Metoprolol		1 / 3
Bisprolol		0.6 / 1.2
Sotalol		0.4 / 1.2
Doxazosin		1 / 3
Diltiazem		0.3 / 0.9
Digoxin		8 / 24
Digoxigenin		8 / 24
4-Aminoantipyrine	Analgesic agents ; n=4	4 / 12
Diclofenac		4 / 12
Acetaminophen		4 / 12
Ketoprofen		1.5 / 4.5

Compound	Group	LOD / LOQ (ng/L)
Trimethoprim	Antimicrobial agents ; n=31	0.8 / 2.4
Sulfamethoxazole		1.5 / 4.5
Sulfapyridine		0.5 / 1.5
Methylparaben		2 / 6
Ciprofloxacin		0.45 / 3
Ofloxacin		3 / 9
Sulfamerazine		1.5 / 4.5
Sulfadiazine		2 / 6
Azithromycin		0.5 / 4
Clinafloxacin		2.5 / 7.5
Clindamycin		0.8 / 2.4
Roxithromycin		4.2 / 12.6
Clarithromycin		0.8 / 2.4
Lincomycin		0.25 / 0.75
Enrofloxacin		1 / 2
Sulfanilamide		40 / 120
Sulfadimethoxine		0.2 / 0.6
Ormetoprim		2 / 6
Oxolinic Acid		1.8 / 5.4
Sulfamethazine		0.25 / 0.75
Flumequine		0.8 / 2.4
Virginiamycin M1		0.8 / 2.4
Erythromycine		5 / 15
Norfloxacin		20 / 60
Lomefloxacin		10 / 30
Miconazole		2.8 / 8.4
Sarafloxacin		70 / 210
Sulfamethizole		12 / 36
Triclocarban		200 / 600
Tylosin		9 / 27
Virginiamycin S1		10 / 20
Norgestimate	Hormone ; n=1	1 / 3
Diphenhydramine	Antihistamine ; n=1	4 / 8

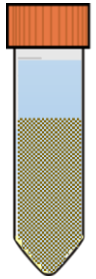
Concentration in soil solution: methodology and methods

Irrigated for 20 years (Gat WWTP)

	Organic matter:	Clay:
Nir Oz	**0.98%**	12.5%
Sa'ad	**1.71%**	49.5%
Ein Hashlosha	**2.12%**	15%

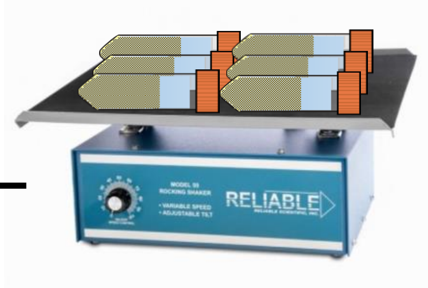
Soil collection (0-10 cm), 2.5 h after irrigation

Freeze drying



9:40 ratio – soil:ddw (w/w) (falcon 50 mL)

Concentration range: 0 – 4000 ng/L



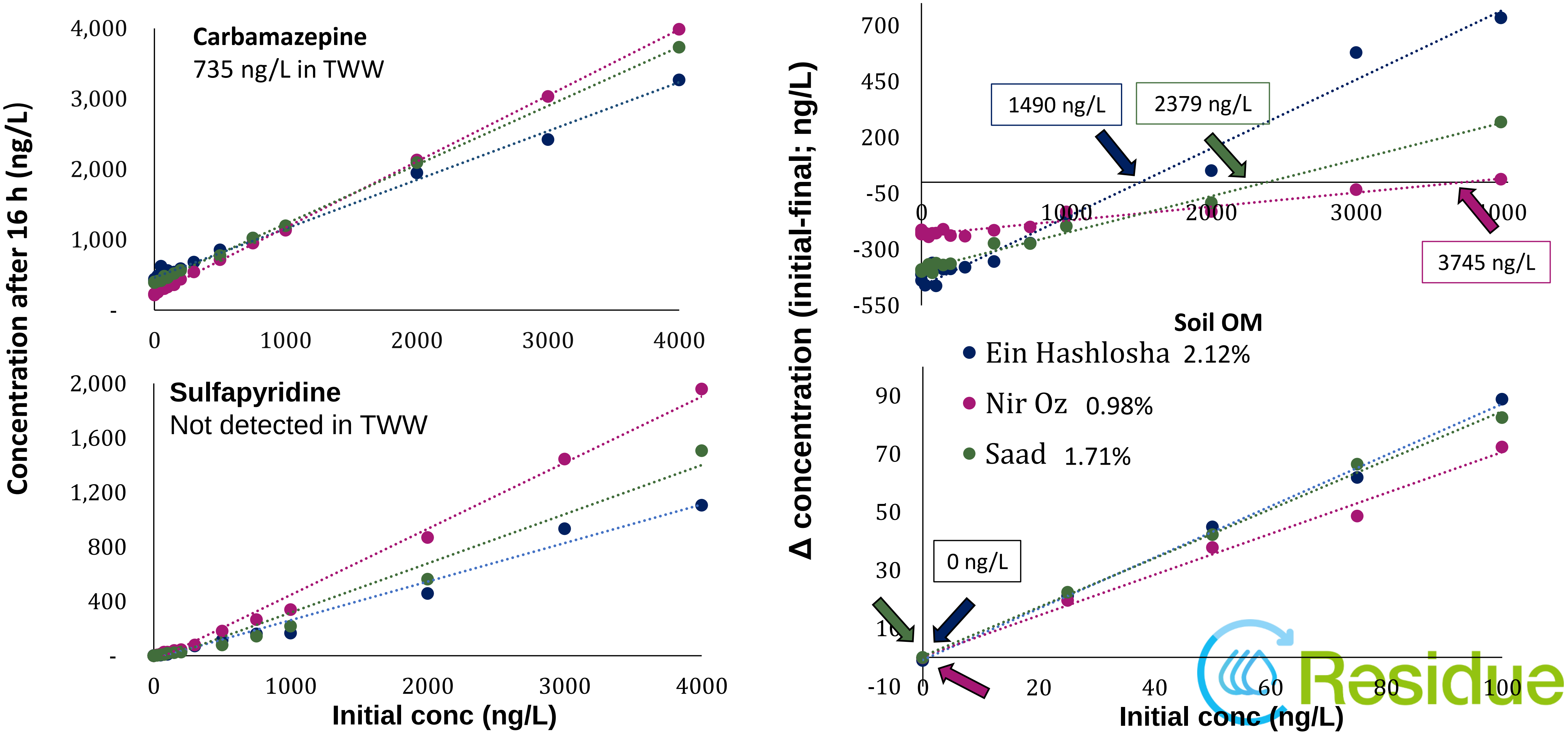
Shake: 16 hours

Clean-up and concentration

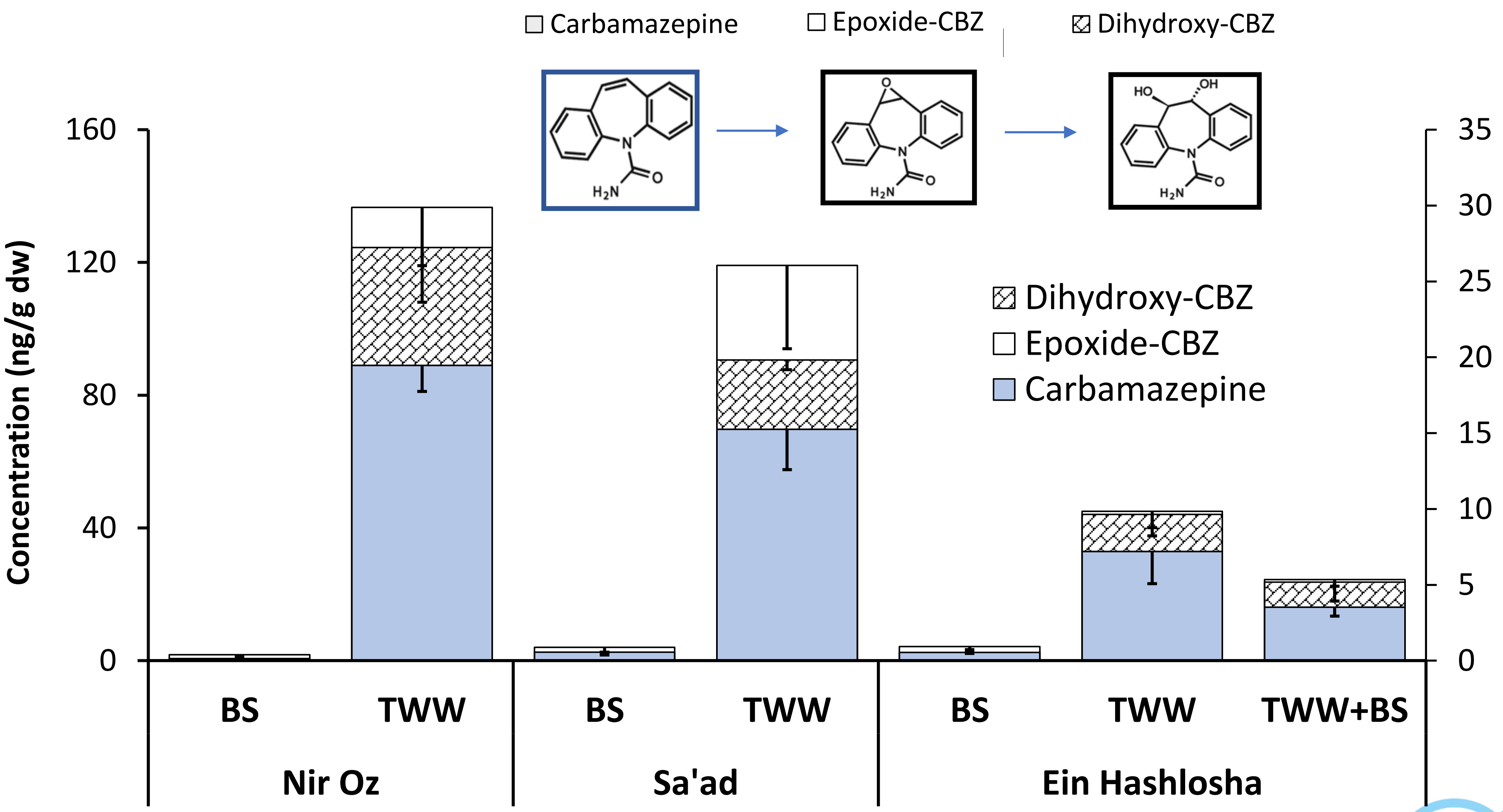
MS analysis

Residue

Pharmaceutical concentration in soil solution: effect of soil characteristics and concentration in irrigation water



Treated wastewater vs. biosolids: Plant uptake (lettuce leaves)



Organic Carbon 0.41% 0.48% 1.31%

Residue

Risk reduction of chemical residues in soils and crops: impact due to wastewater used for irrigation

Thank you for your attention

PHYTOR

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA | Fraunhofer IME | Freie Universität Berlin | CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS | PHYTOR | Consorzio Italbiotec | האוניברסיטה העברית בירושלים THE HEBREW UNIVERSITY OF JERUSALEM