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

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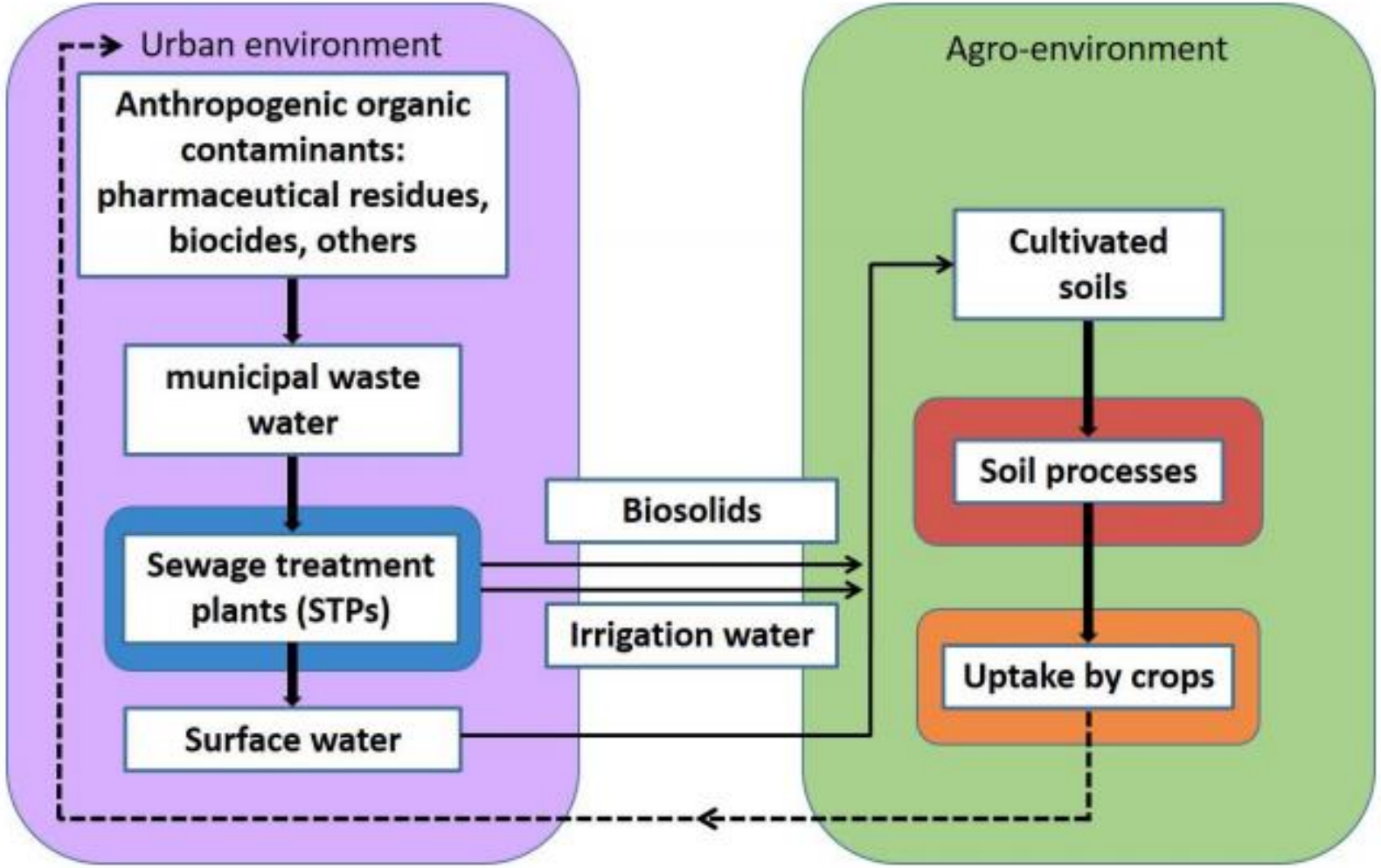
Problem definition



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

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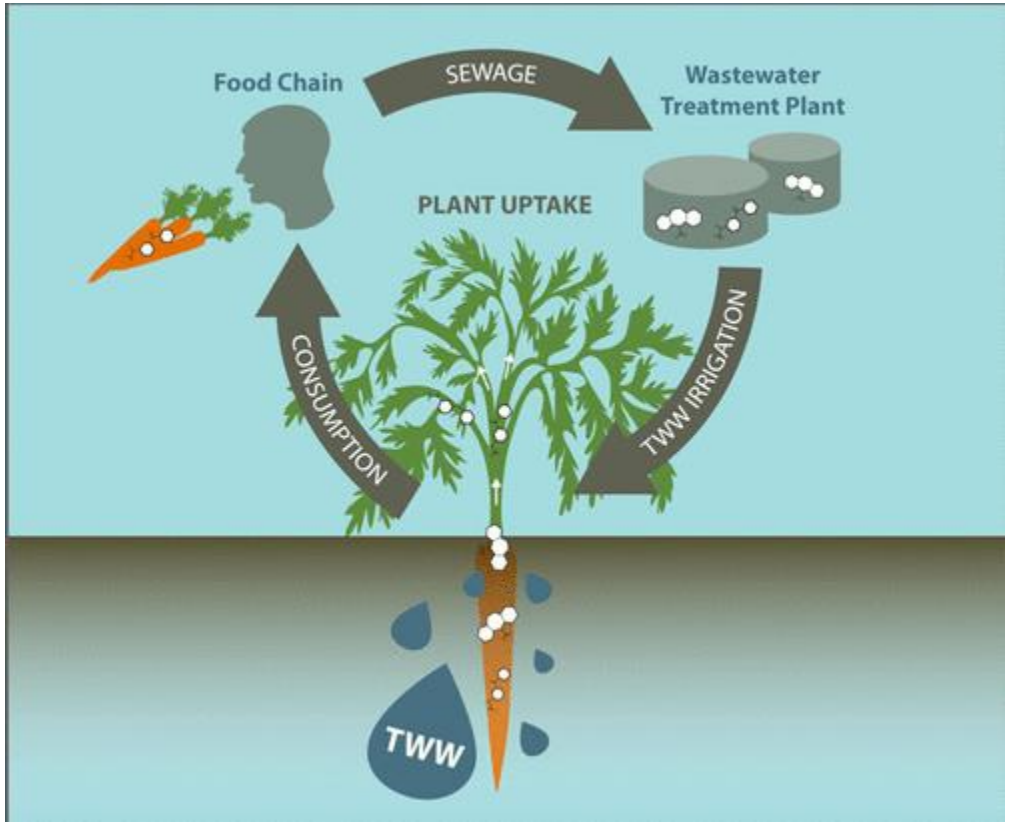
Background



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

Environmental Science & Technology

Article

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

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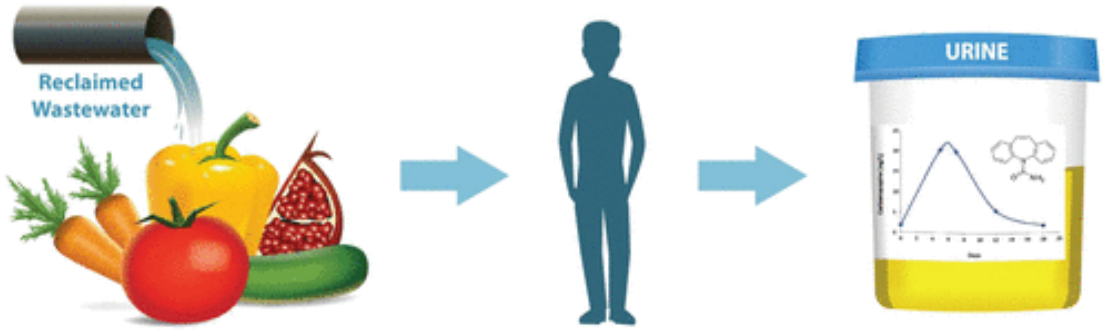
Background

Proof of Concept Study



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

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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.

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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.

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Project goal

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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

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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**

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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

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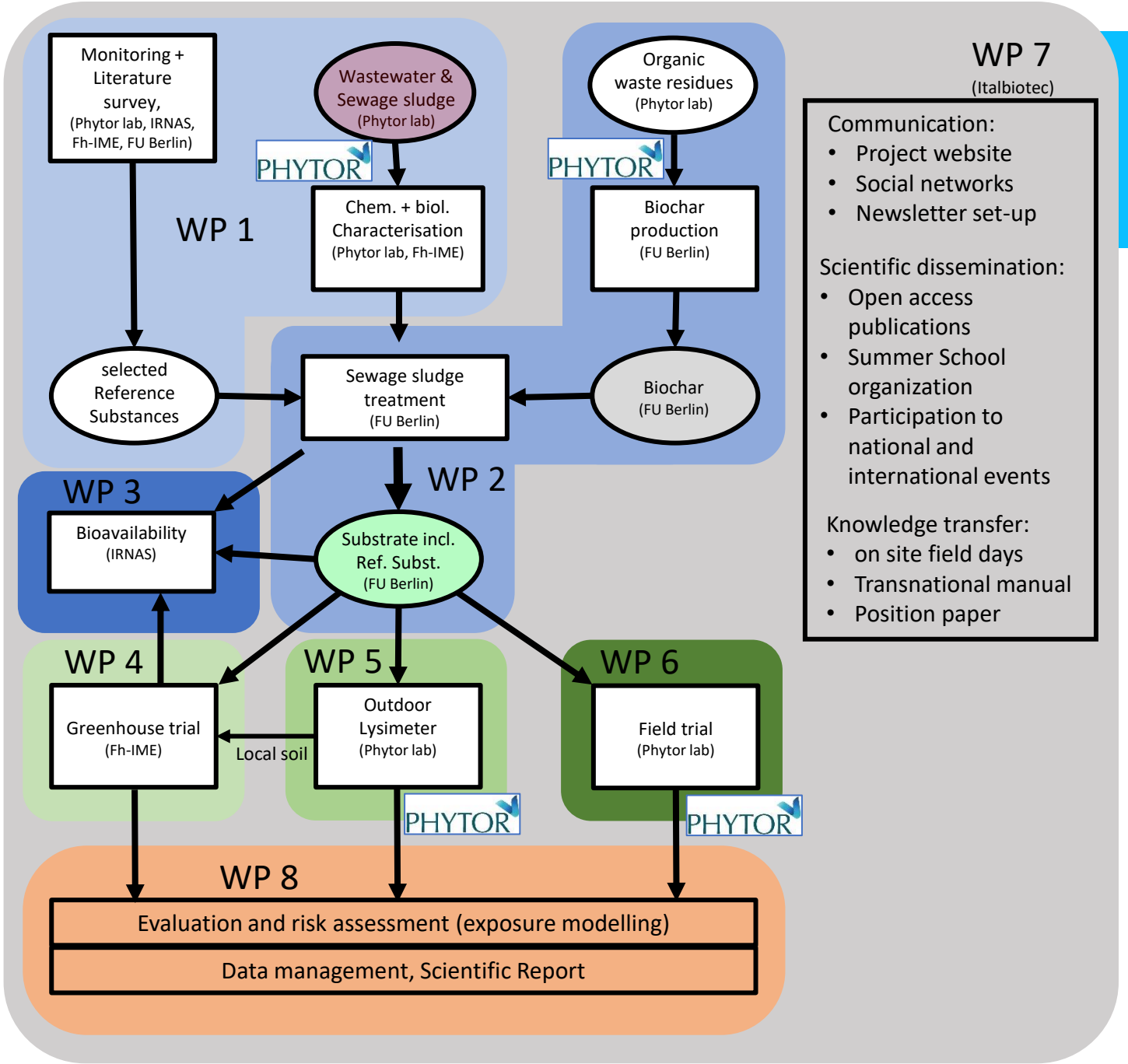
Project Structure



WP 7
(Italbiotec)

Communication:
- Project website
- Social networks
- Newsletter set-up

Scientific dissemination:
- Open access publications
- Summer School organization
- Participation to national and international events

Knowledge transfer:
- on site field days
- Transnational manual
- Position paper

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Project status- Phytor/ Hebrew University

Pharmaceuticals in soil solution: Effect of soil characteristics

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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.

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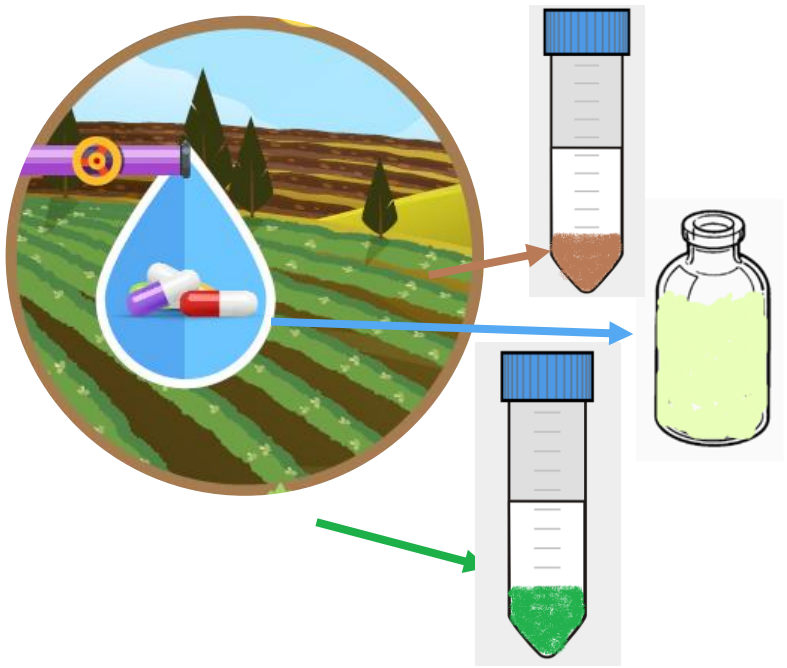
Sample preparation

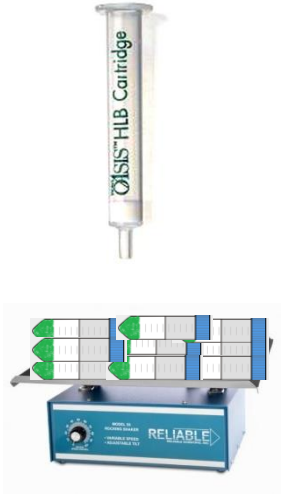


Sample of **Irrigation water, soil and plant**

Addition of **ISTDs**

Water samples

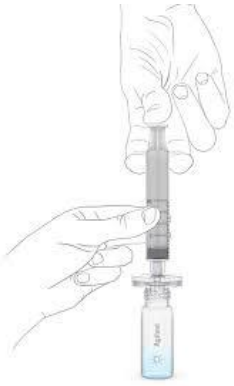
Soil/ plant samples



Extraction method

Drying and reconstitution

Clean up



MS or MS/MS Analysis

Extraction and analytical method per matrix:
mean analytes recoveries >90%,
mean R^2 for calibration curves >0.95

Methodology:
Conc. < LOD → **0**
LOD ≤ Conc. < LOQ → **LOQ/2**
Conc. ≥ LOQ → **Conc.**

Residue

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

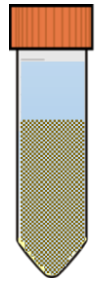
Concentration in soil solution: methodology and methods

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%

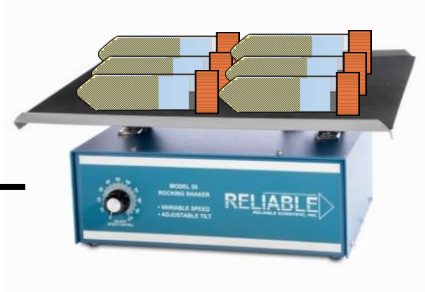
Soil collection (0-10 cm), 2.5 h after irrigation

Freeze drying



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

Concentration range: 0 – 4000 ng/L



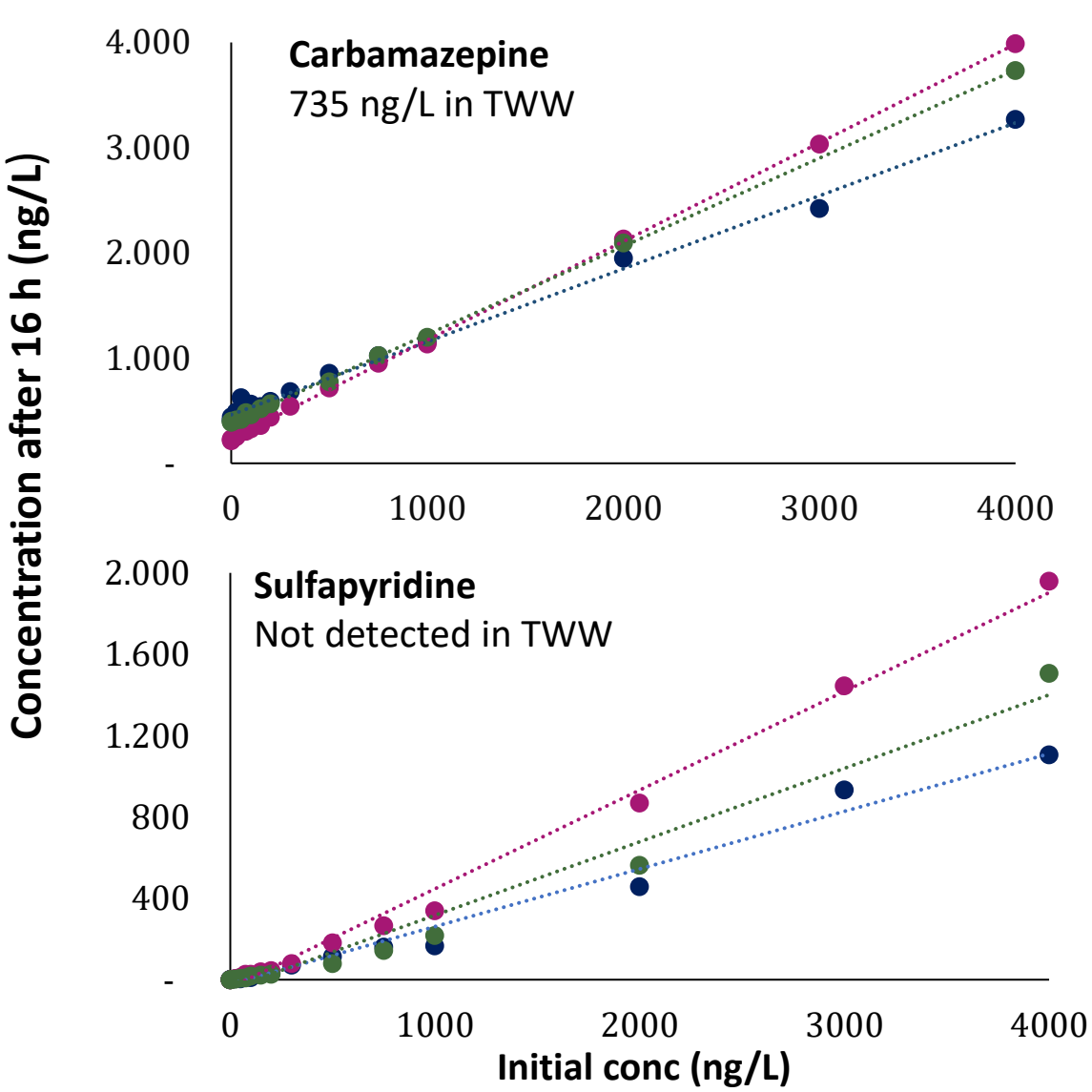
Shake: 16 hours

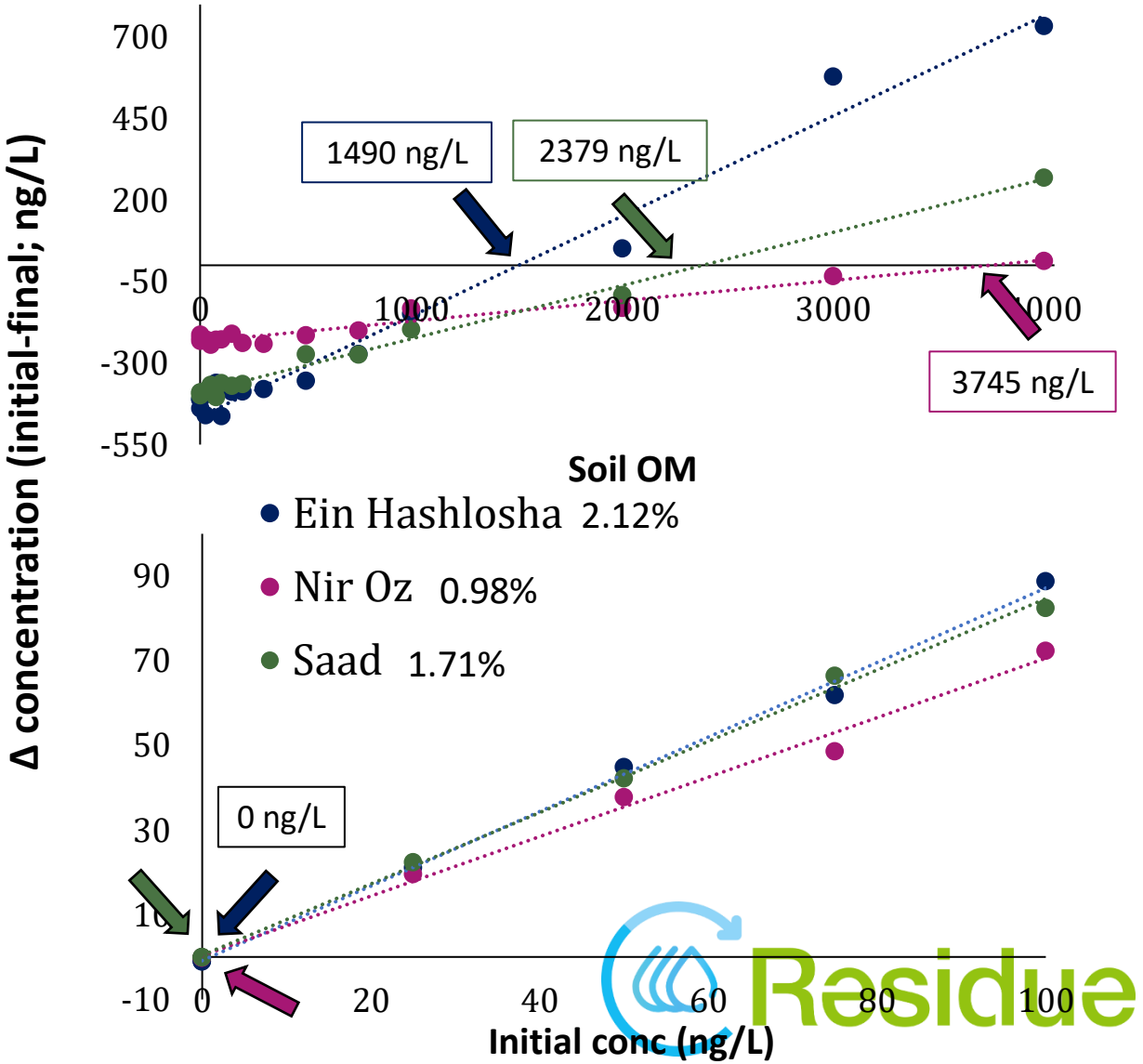
Clean-up and concentration

MS analysis

Residue

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





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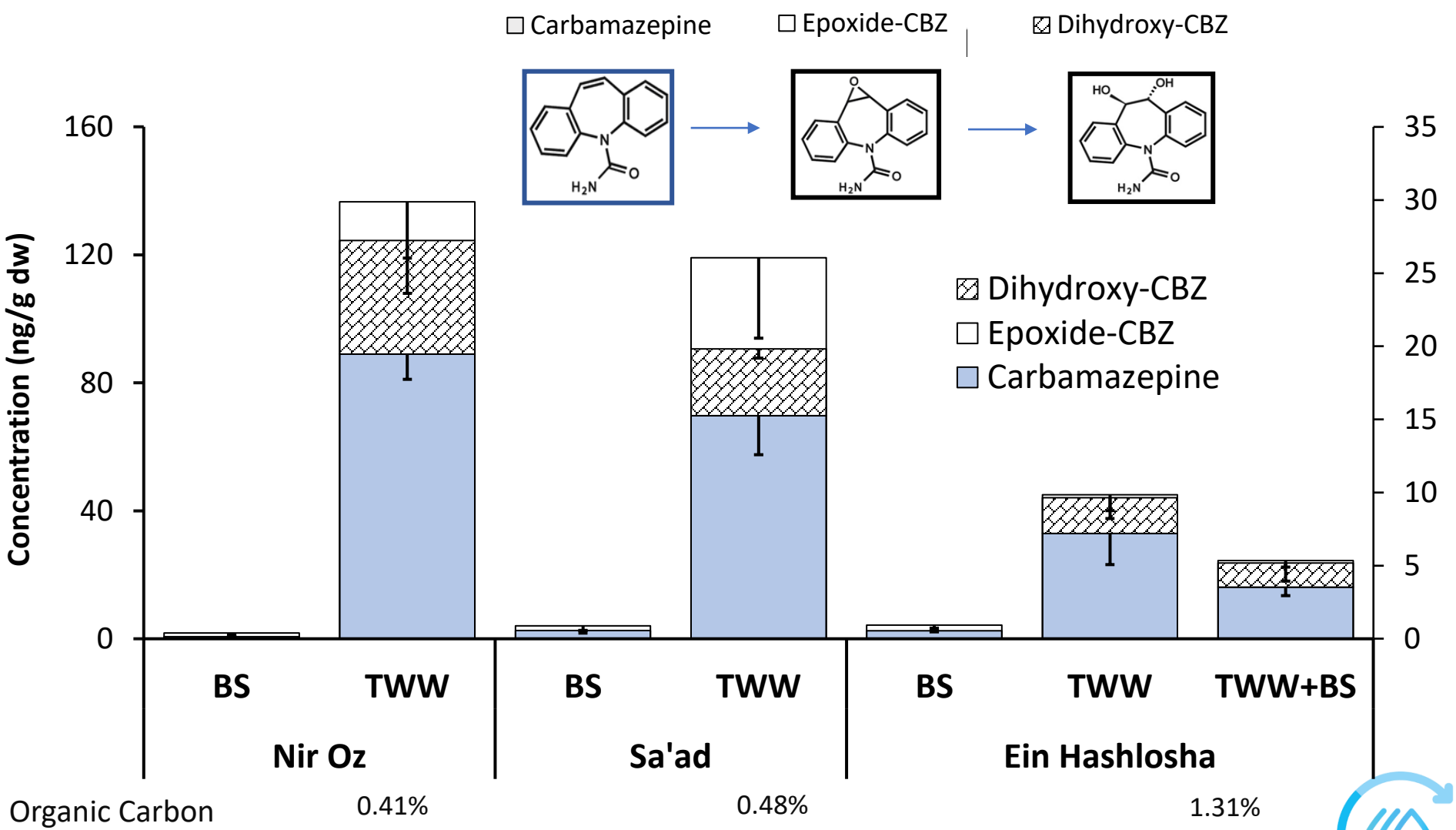
Treated wastewater vs. biosolids: Plant uptake (lettuce leaves)



Residue

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

Thank you for your attention

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