

# Effects of Composted Biosolids and Treated Wastewater on Uptake and Translocation of Pharmaceuticals: Lettuce as a Case Study

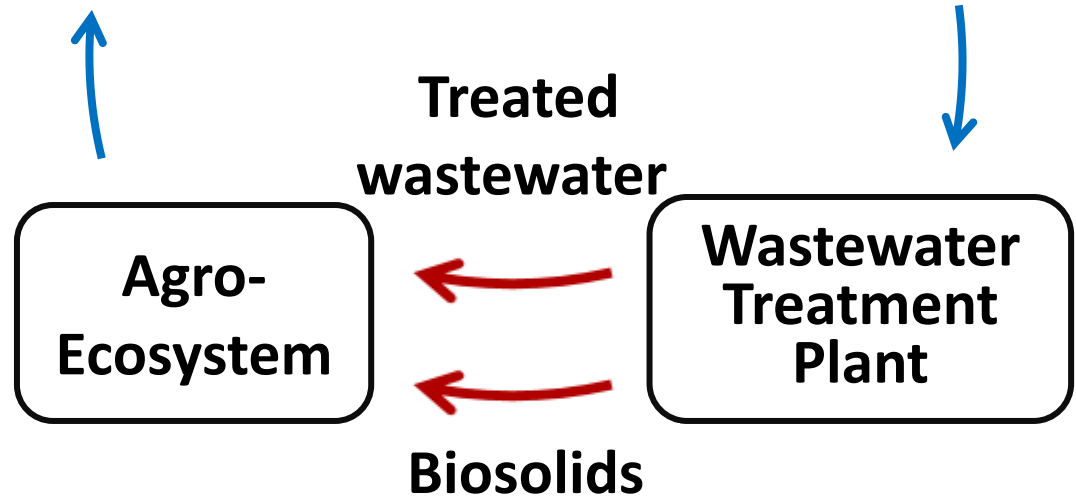
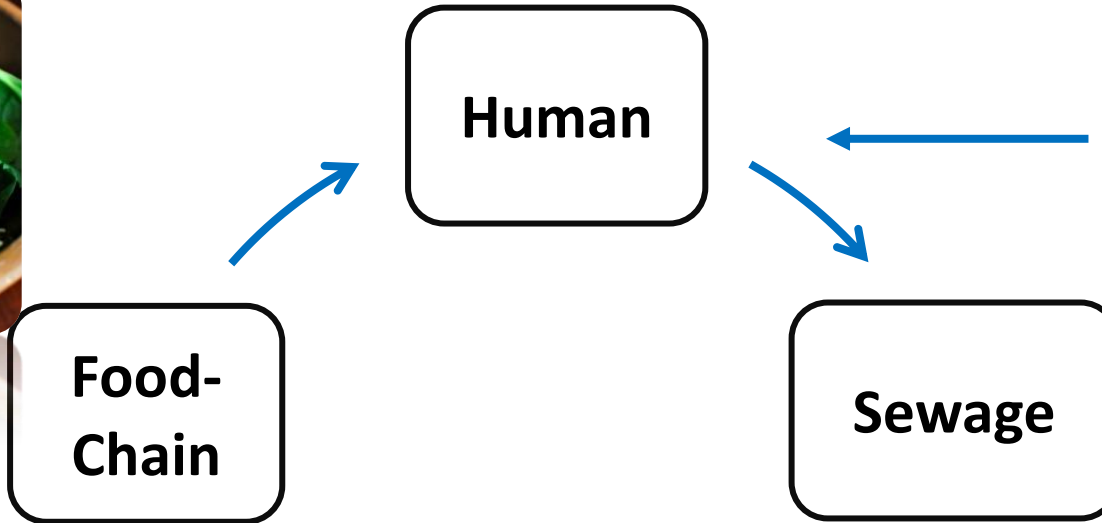


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# Research motivation

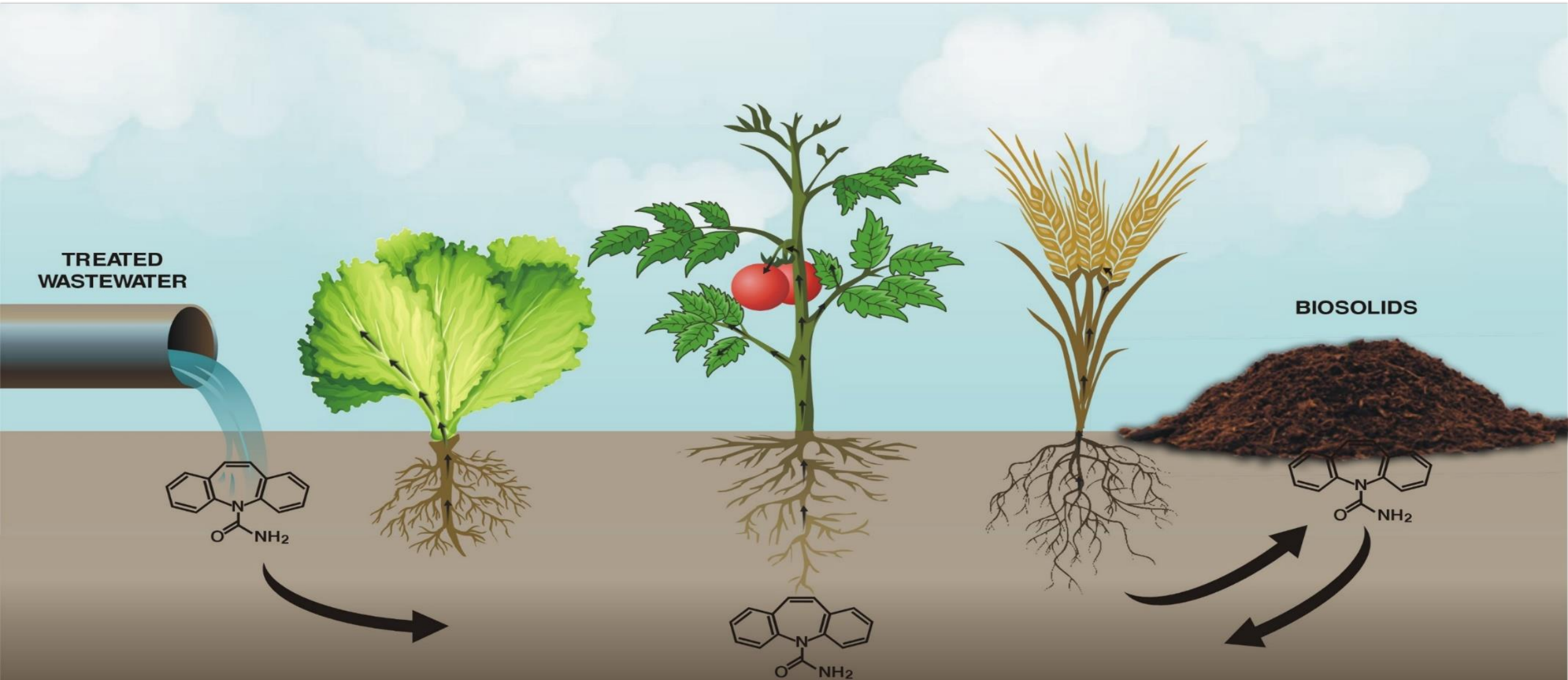


# Objectives

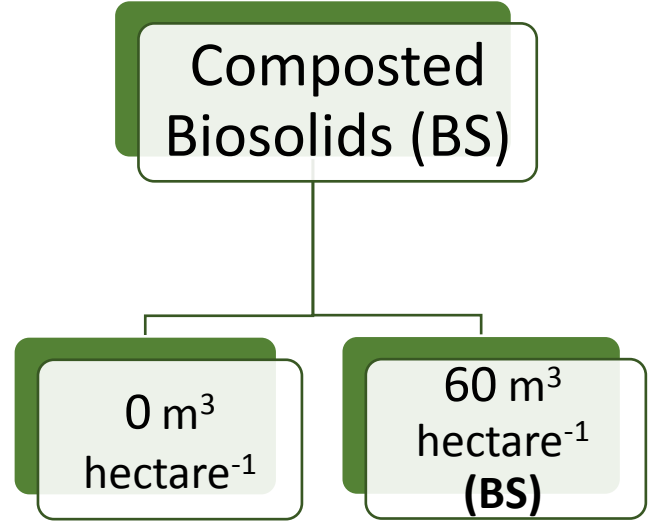
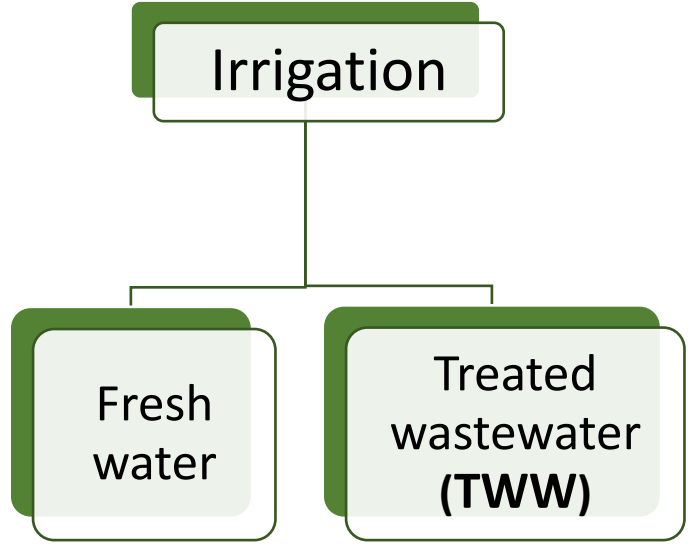
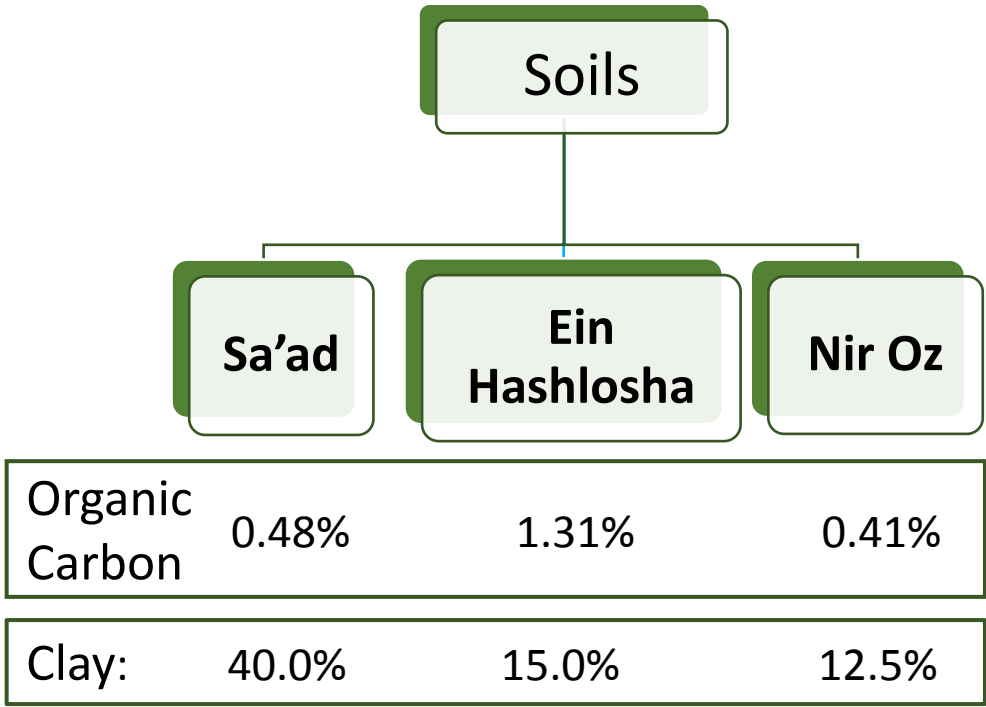
Study the effect of application medium: **biosolids** (BS) or **treated wastewater** (TWW) on *plant uptake, translocation* and *metabolism* of non-ionic pharmaceuticals.



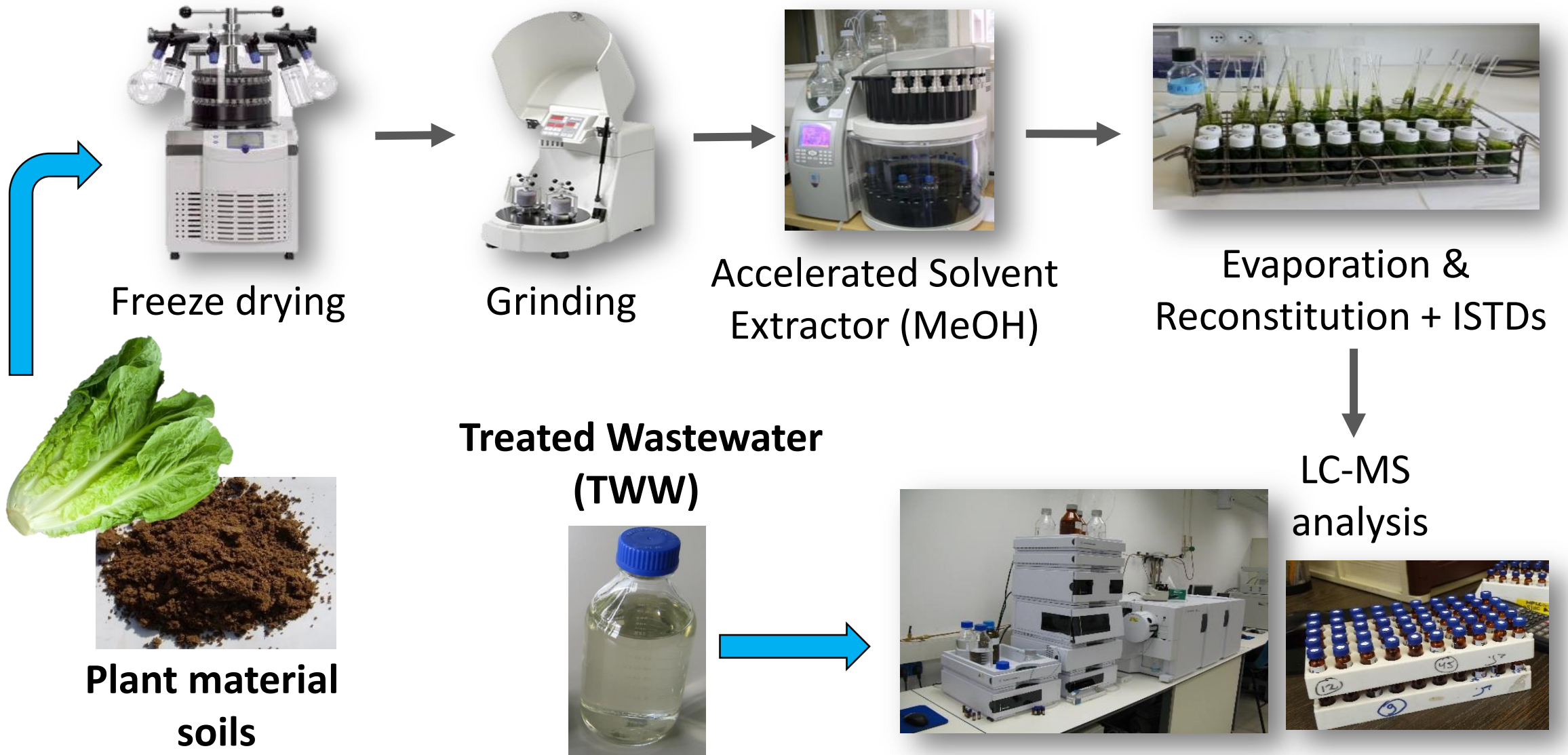
# Treated wastewater (TWW) & Biosolids (BS): source or sink



# Experimental scheme



# Analytical method



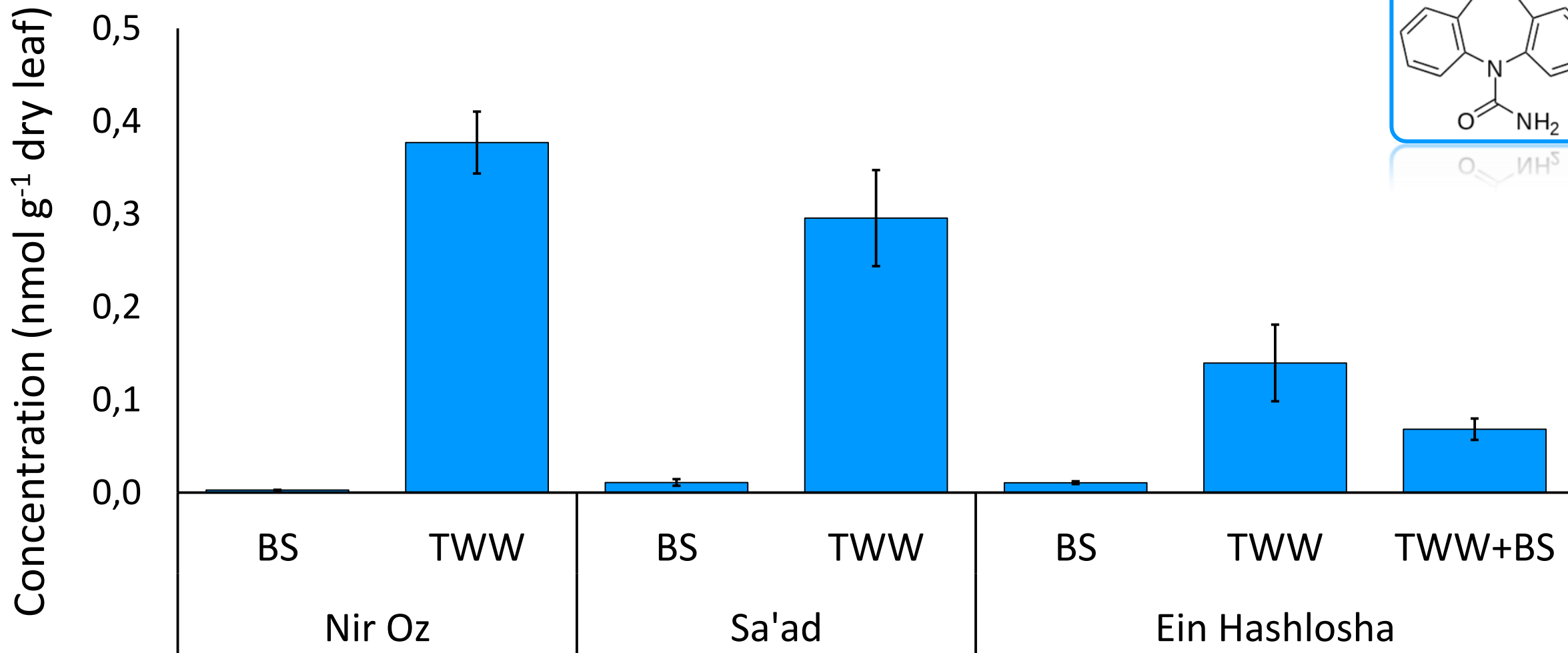
# Concentrations of selected pharmaceuticals in treated wastewater and composted biosolids



Pharmaceutical compound	Usage	Treated Wastewater range ( $\mu\text{g L}^{-1}$ )	Composted Biosolids average $\pm$ stdev ( $\mu\text{g kg}^{-1}$ )
Carbamazepine	Anticonvulsant	0.32-0.51	29.0 $\pm$ 2.1
Lamotrigine		2.50-10.26	nd
10,11-dihydroxy-CBZ	Carbamazepine metabolites	0.98-1.84	2.2 $\pm$ 0.7
10,11-epoxide-CBZ		0.03-0.06	nd
Bezafibrate	Lipid-lowering agent	0.02-0.12	2.4 $\pm$ 0.2
Gemfibrozil		nd	26.2 $\pm$ 3.3
Diclofenac	Anti-inflammatory	nd-0.07	nd
Ketoprofen		nd-0.02	nd
Naproxen		nd-0.06	nd
Sulfamethoxazole	Antimicrobial	0.03-0.09	nd
Sulfapyridine		nd	1.9 $\pm$ 0.4
Sildenafil	Vasoactive agent	nd	7.6 $\pm$ 0.3



# Carbamazepine (CBZ) concentration in lettuce leaves



Organic Carbon: 0.41 %

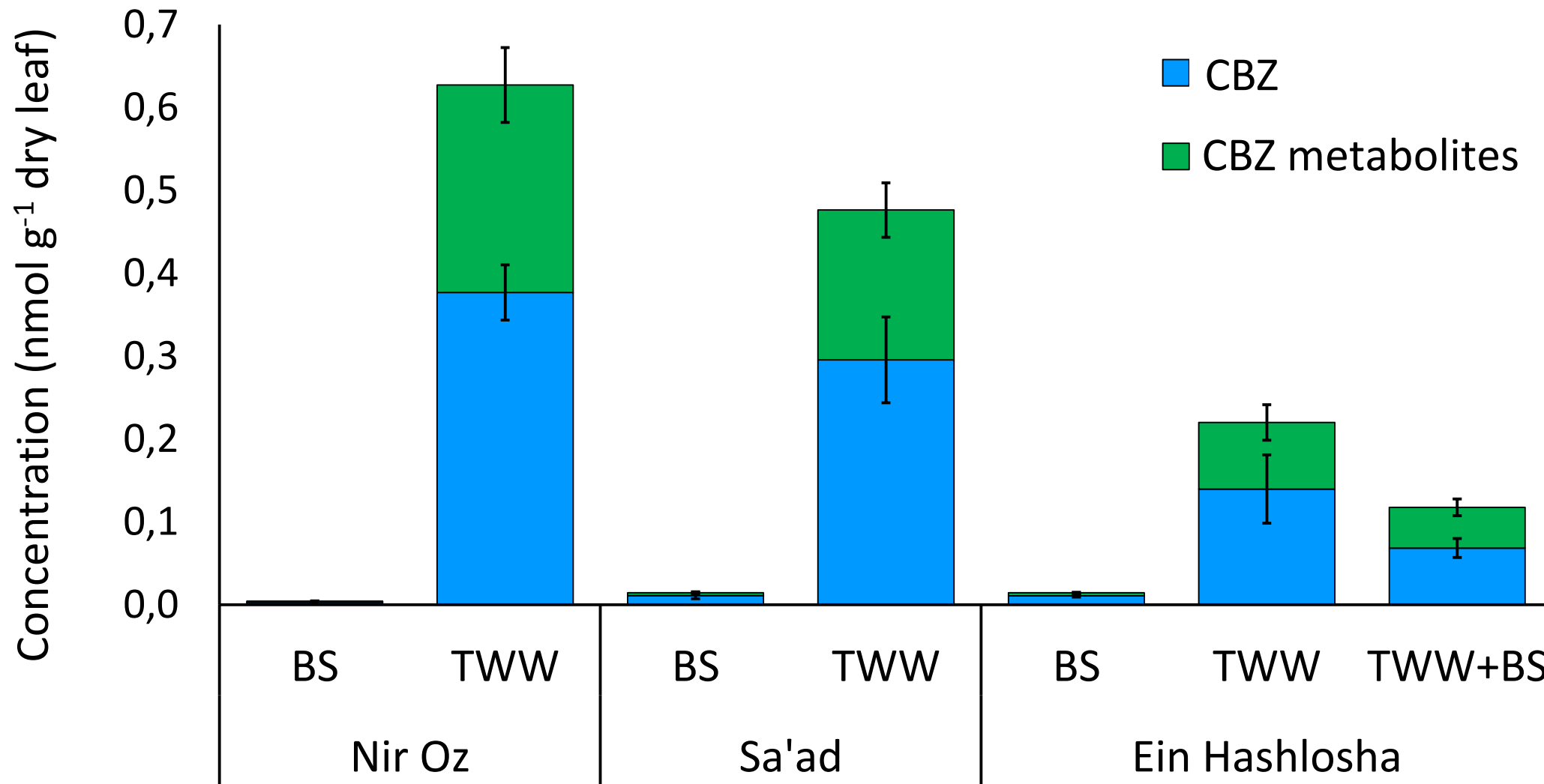
0.48 %

1.31 %

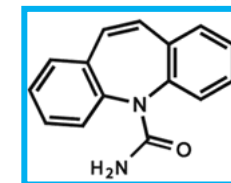




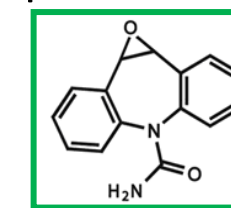
# Summed concentration of carbamazepine (CBZ) and its metabolites in lettuce leaves



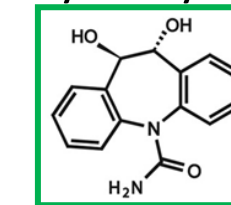
Carbamazepine



Epoxide-CBZ



Dihydroxy-CBZ



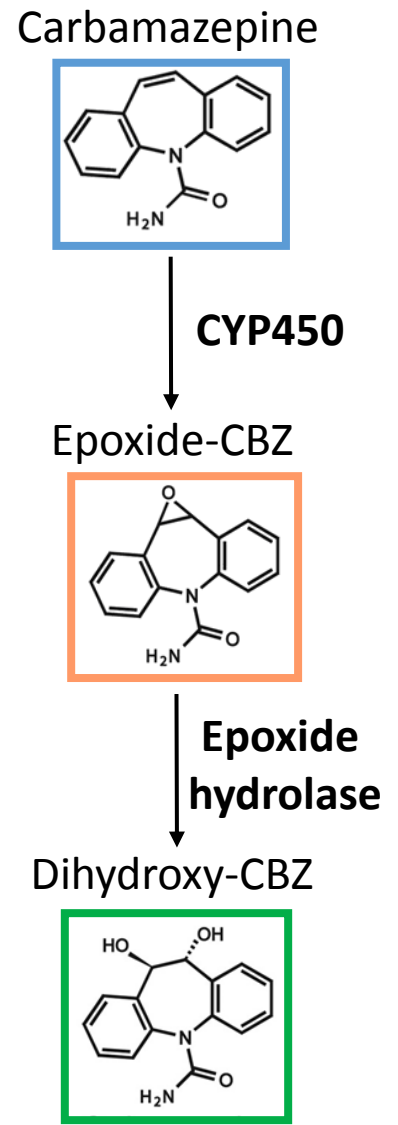
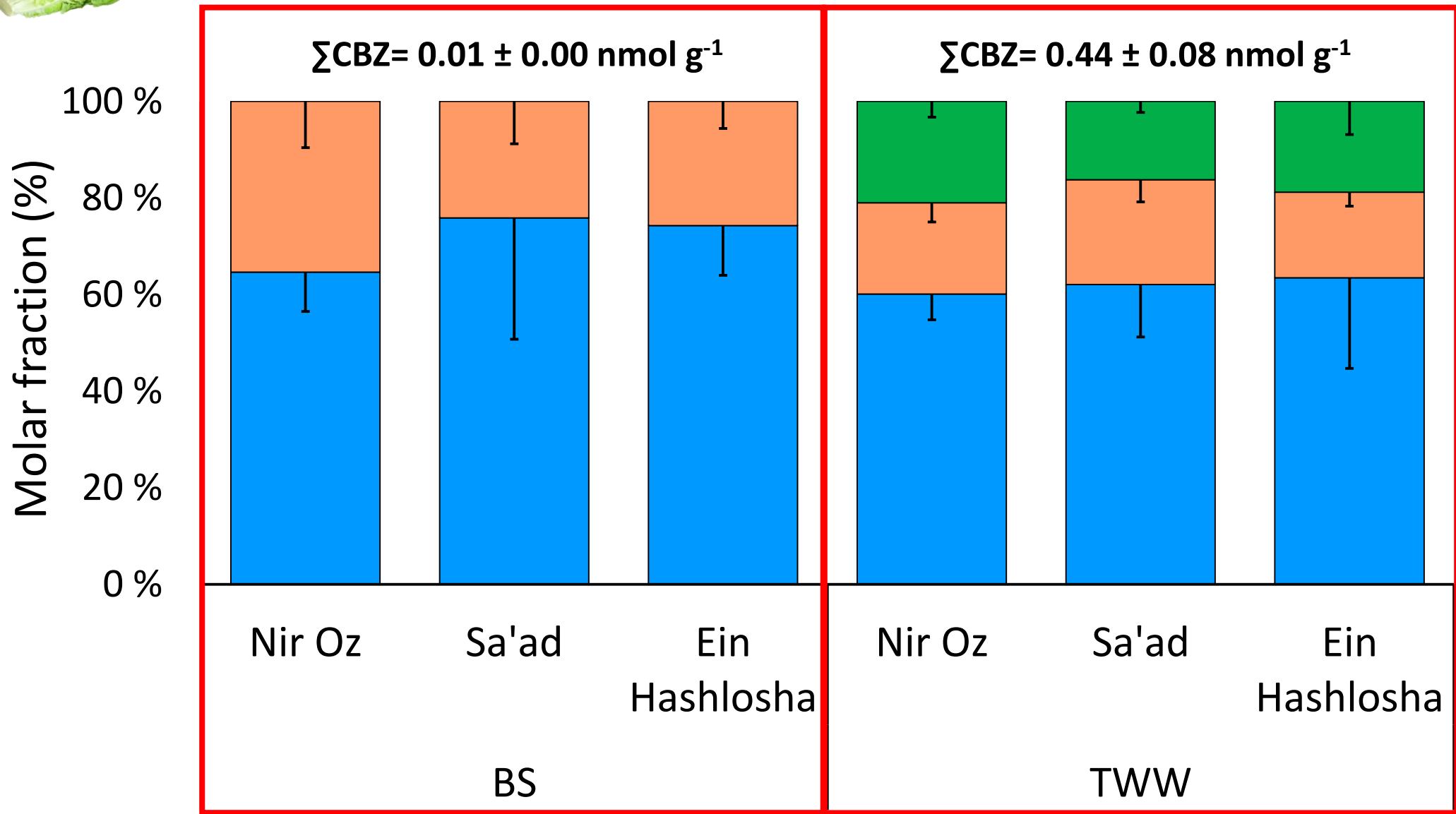
Organic Carbon: 0.41 %

0.48 %

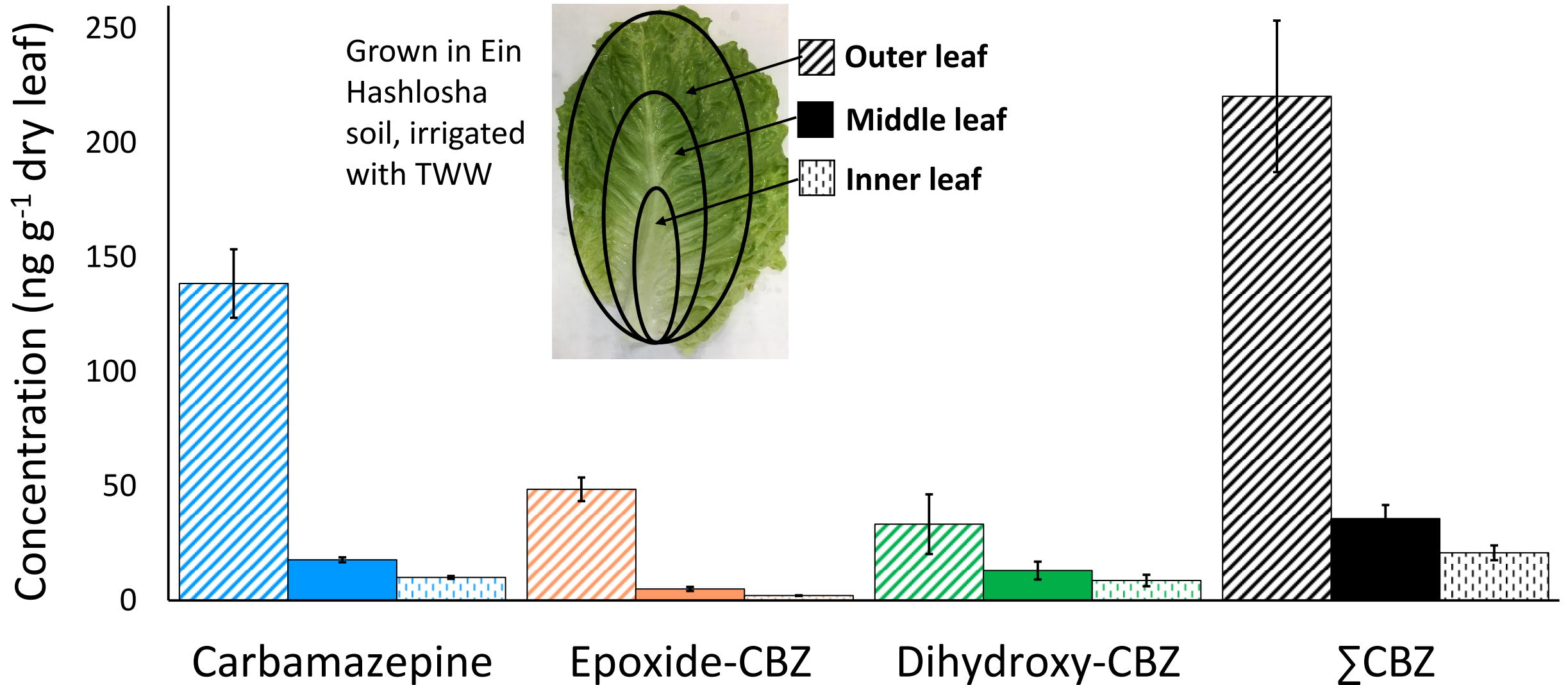
1.31 %



# Molar fraction of carbamazepine and its metabolites ( $\Sigma$ CBZ) in lettuce leaves

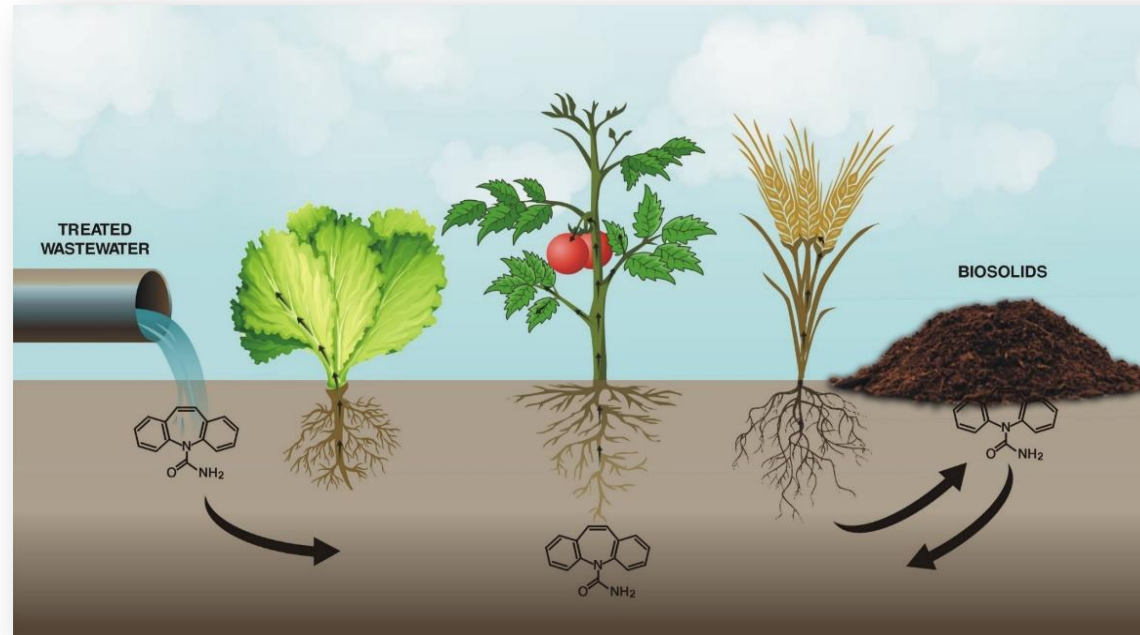


# Concentration of carbamazepine, the metabolites and their sum ( $\Sigma$ CBZ) in different segments of the lettuce leaf



# Conclusions

- ❖ Bioavailability of pharmaceuticals depends on the applied medium (TWW or BS) and the organic matter content in the soil.
- ❖ Biosolids amendment may hinder uptake of organic compounds originated from TWW irrigation due to sorption processes (sink).
- ❖ In-plant metabolism of carbamazepine is independent of soil type; but dependent on the amount taken-up by the plant.



# Acknowledgements



- Environment and Health Fund (EHF)  
Jerusalem



- Israel Ministry of Agriculture and  
Rural Development

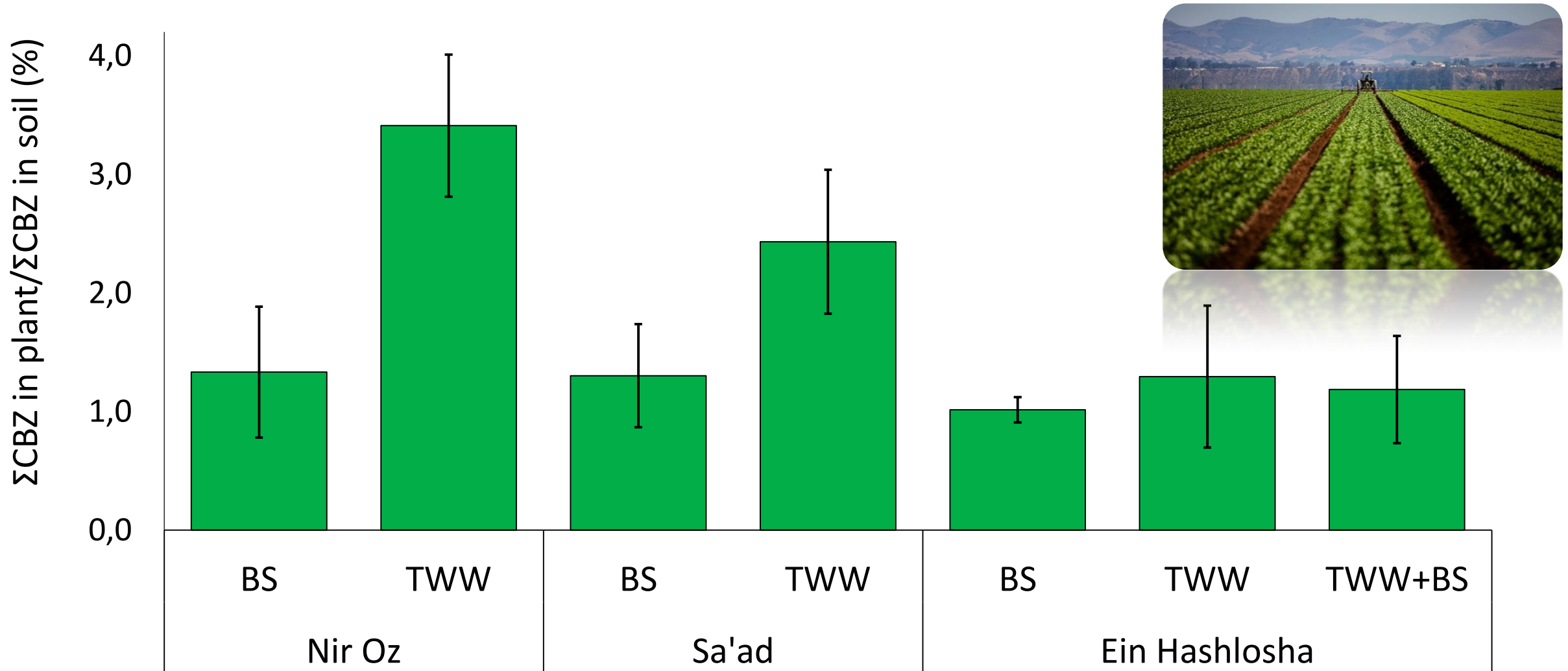


- The Hebrew University Center of Excellence  
in Agriculture and Environmental Health



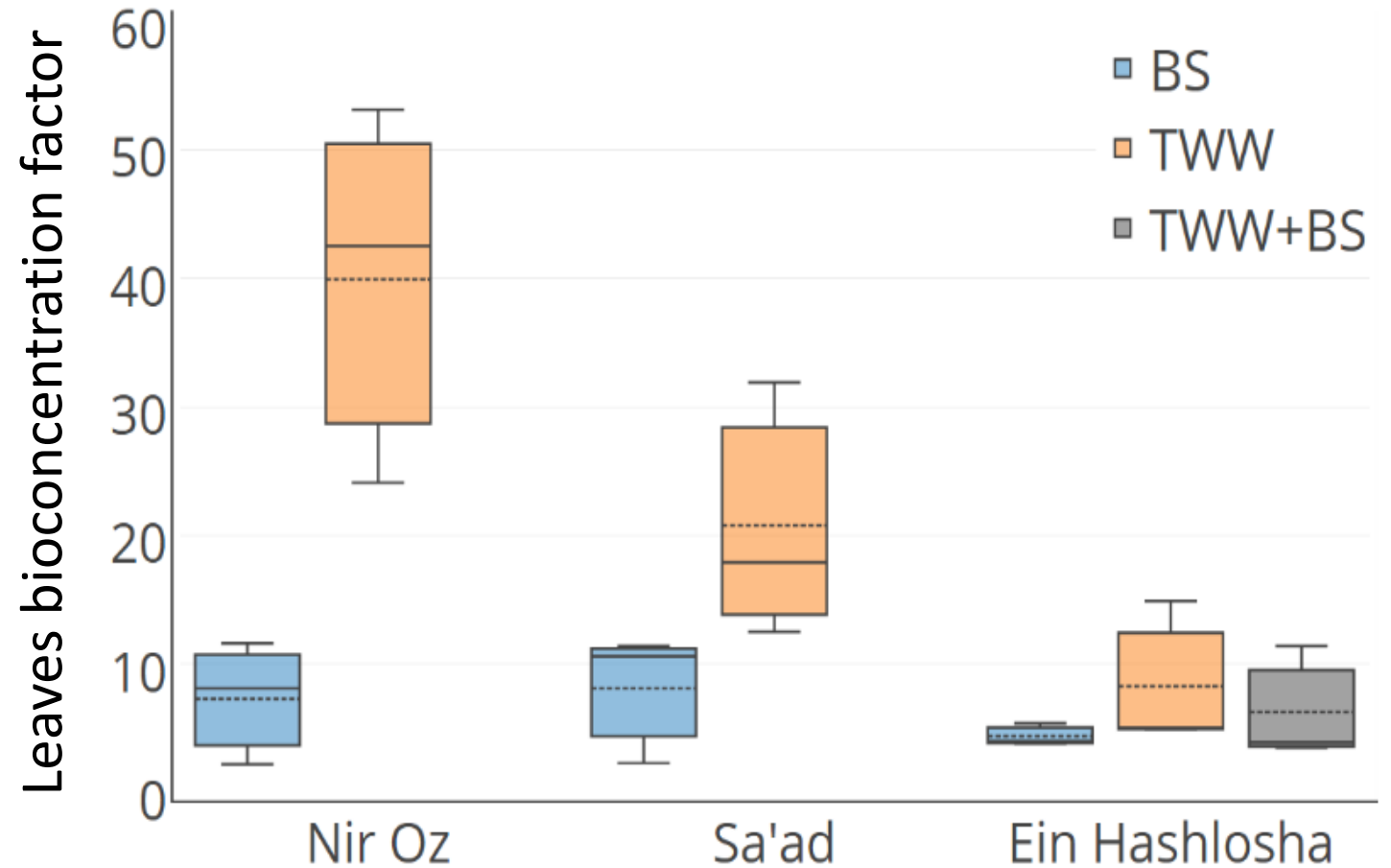
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# Plant-to-Soil Ratio of the Summed Amount of Carbamazepine and the Metabolites in the Lettuce Plant



# Leaves Bioconcentration Factor for $\Sigma$ CBZ

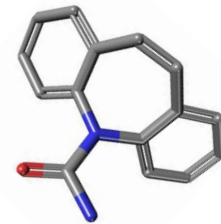
$$\text{Leaves bioconcentration factor} = \frac{\text{Leaves Conc.}}{\text{Soil Conc.}}$$



# Carbamazepine

## A common anticonvulsant drug used for treatment of epilepsy and neurological disorders

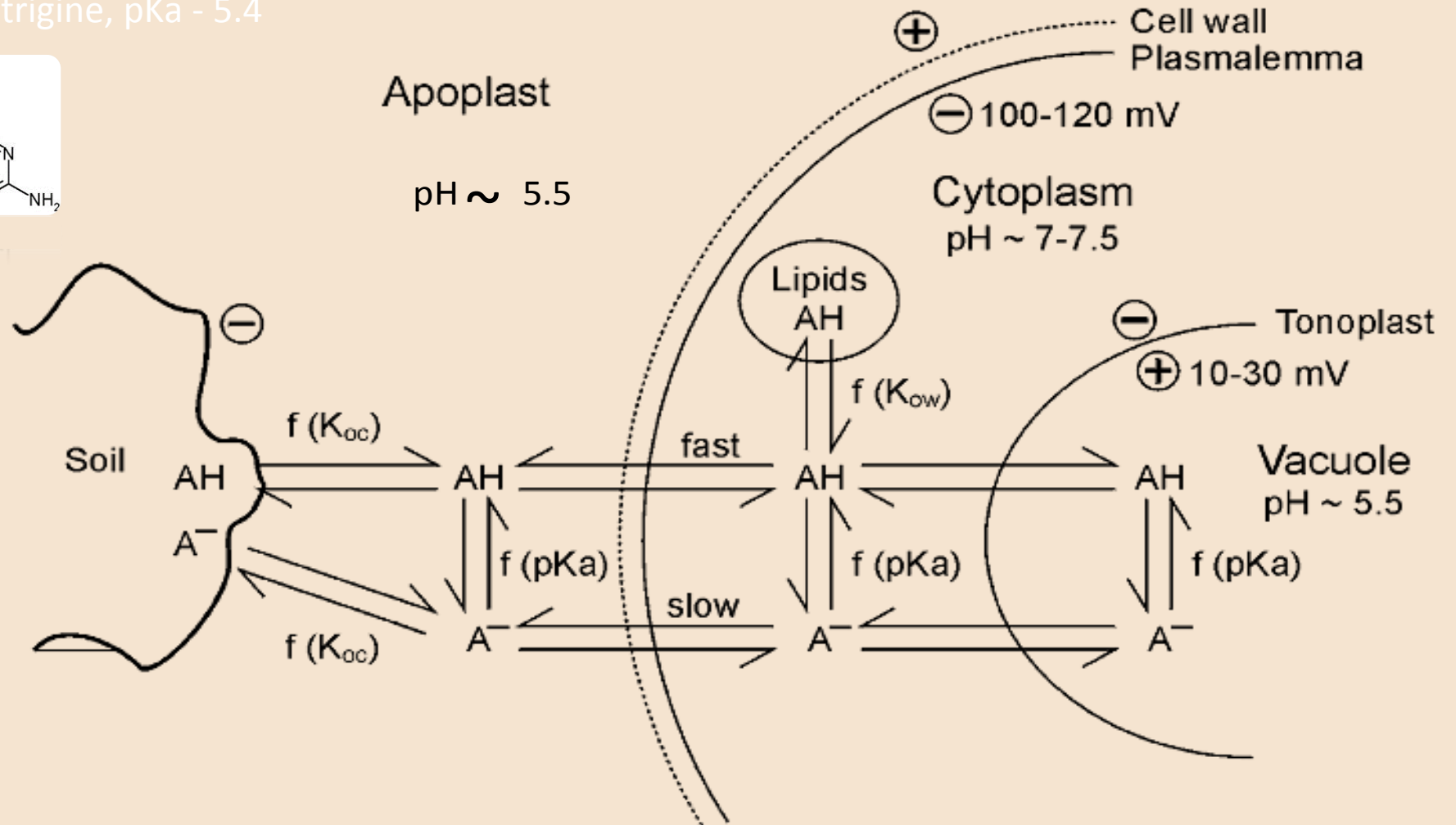
- ❖ Global consumption:  $>1000$  ton year<sup>-1</sup>;
- ❖ Low removal rates in WWTPs (-20% – 20%);
- ❖ Detected in irrigation water (0.5 – 2 ppb);
- ❖ Persistent in soils ( $t_{1/2} > 200$  days);
- ❖ Taken-up by crops;
- ❖ Considered as an anthropogenic marker;





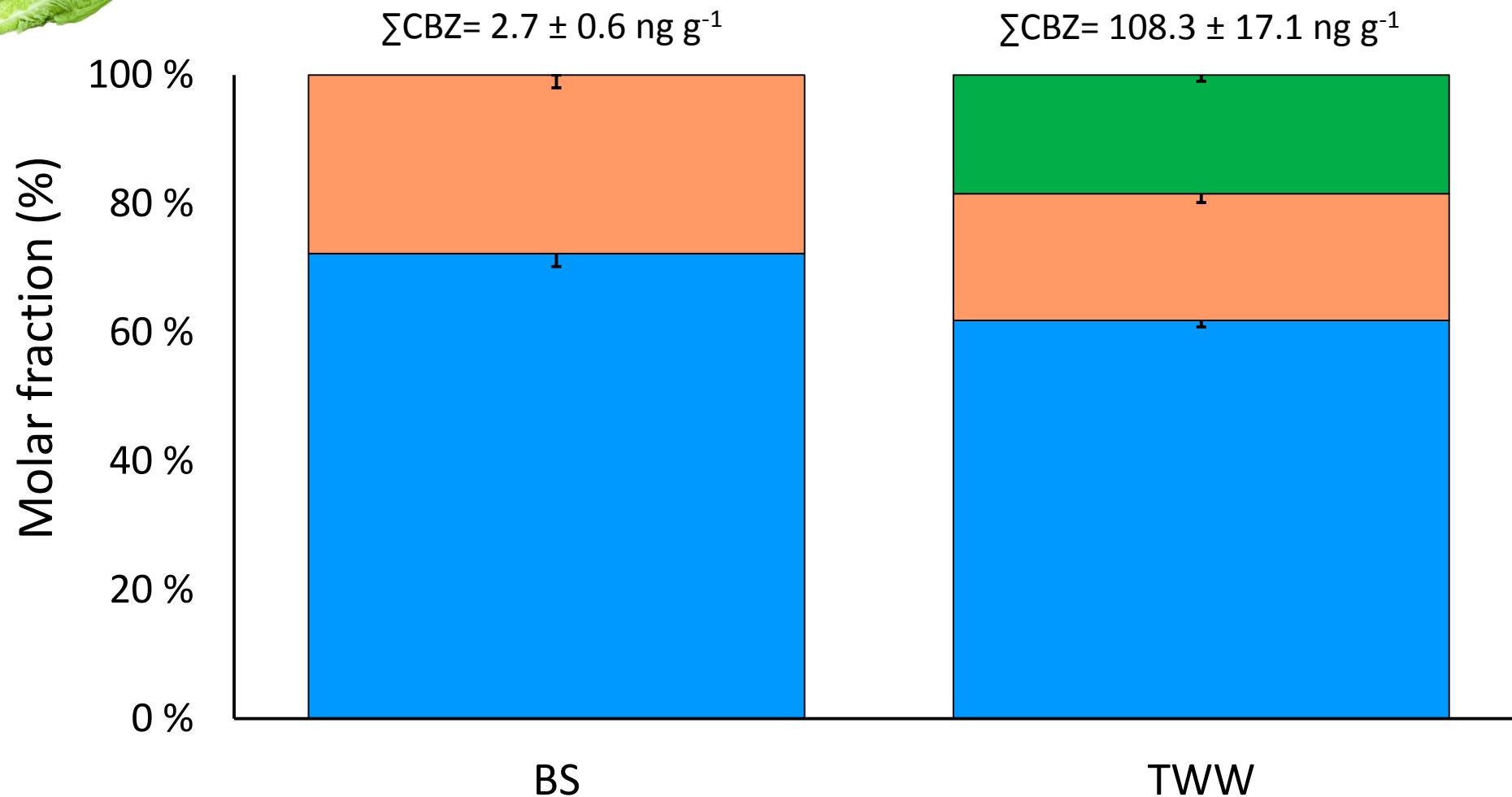
# Uptake of ionic organic compounds

Lamotrigine, pKa - 5.4

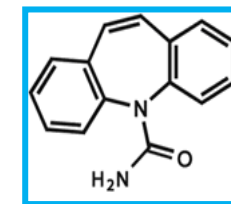


Whoa! That

# Molar Fraction of Carbamazepine and its Metabolites in Lettuce Leaves

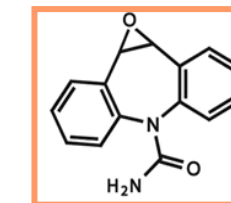


Carbamazepine



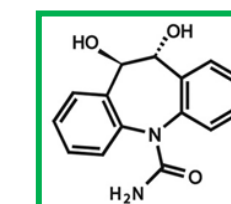
CYP450

Epoxide-CBZ

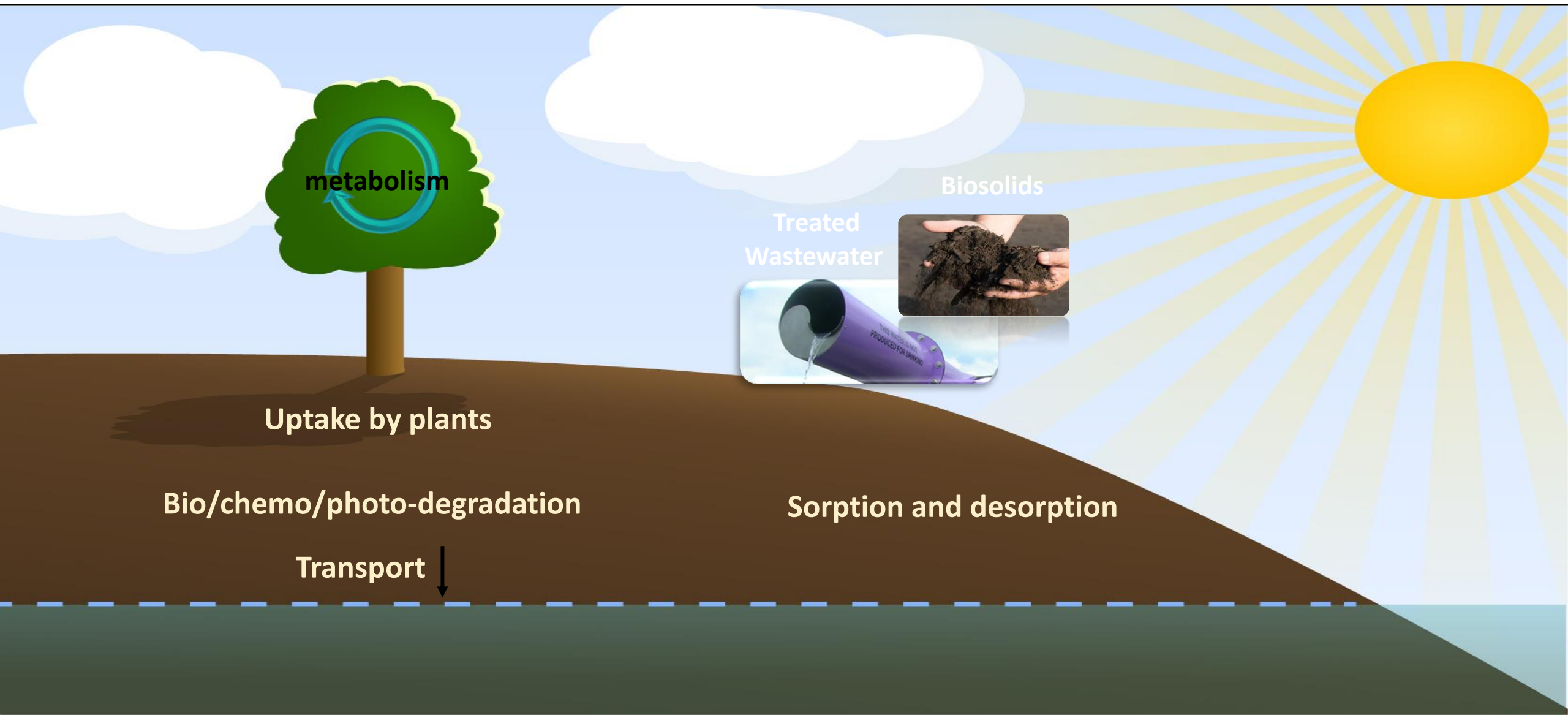


Epoxide-hydrolase

Dihydroxy-CBZ



# Fate of Pharmaceuticals in the Agro-environment



metabolism

Uptake by plants

Bio/chemo/photo-degradation

Transport ↓

Treated Wastewater

Biosolids



Sorption and desorption

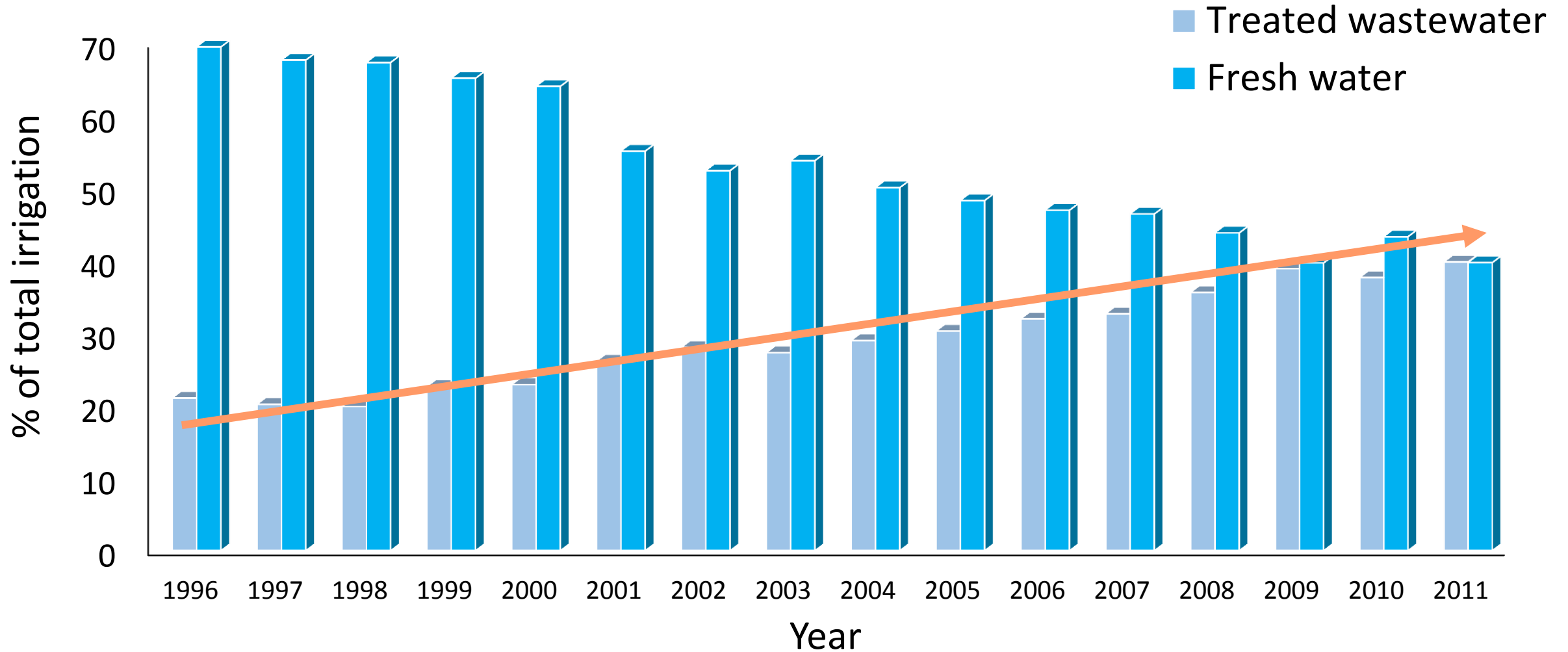
# Experiment Location



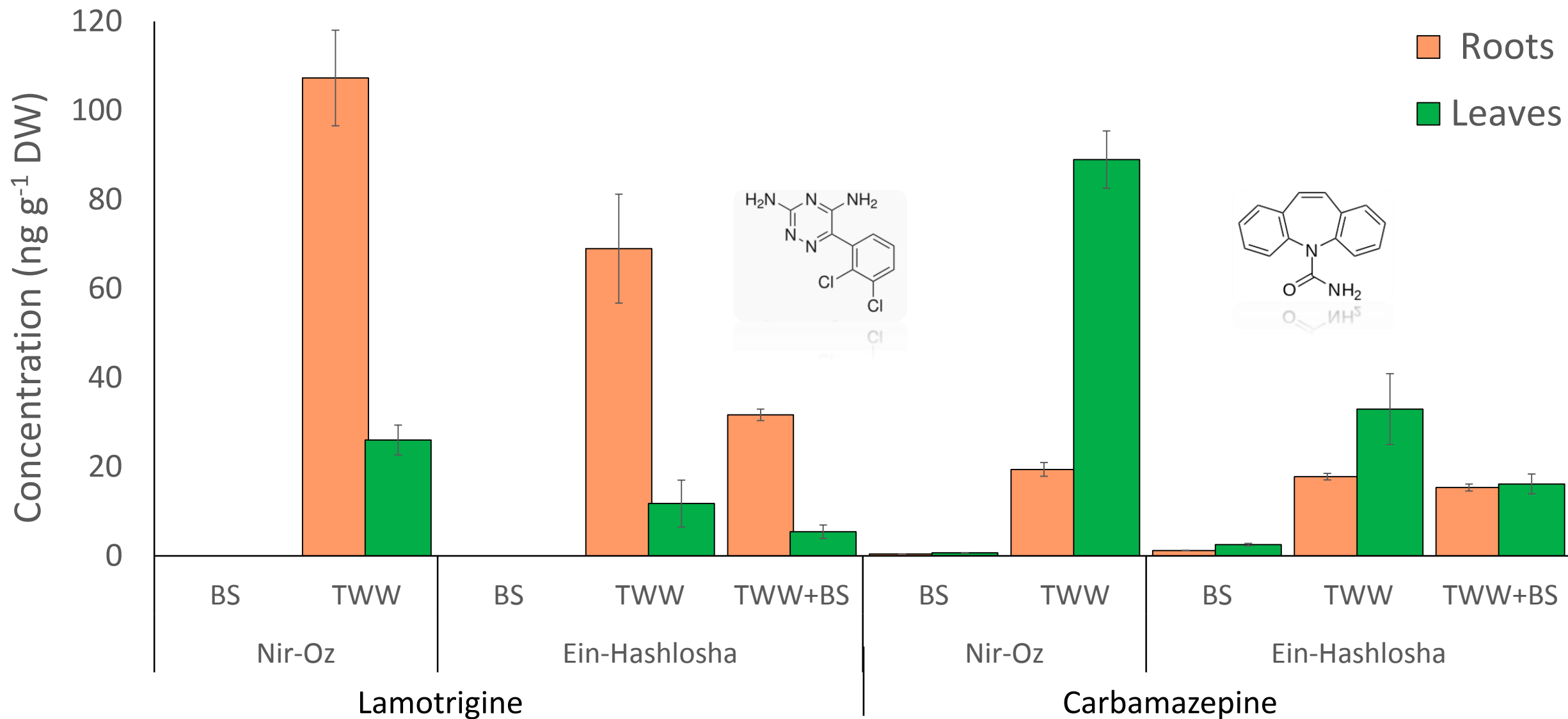
- Tomato: summer of 2014
- Wheat: winter of 2014-2015
- Lettuce: summer of 2015



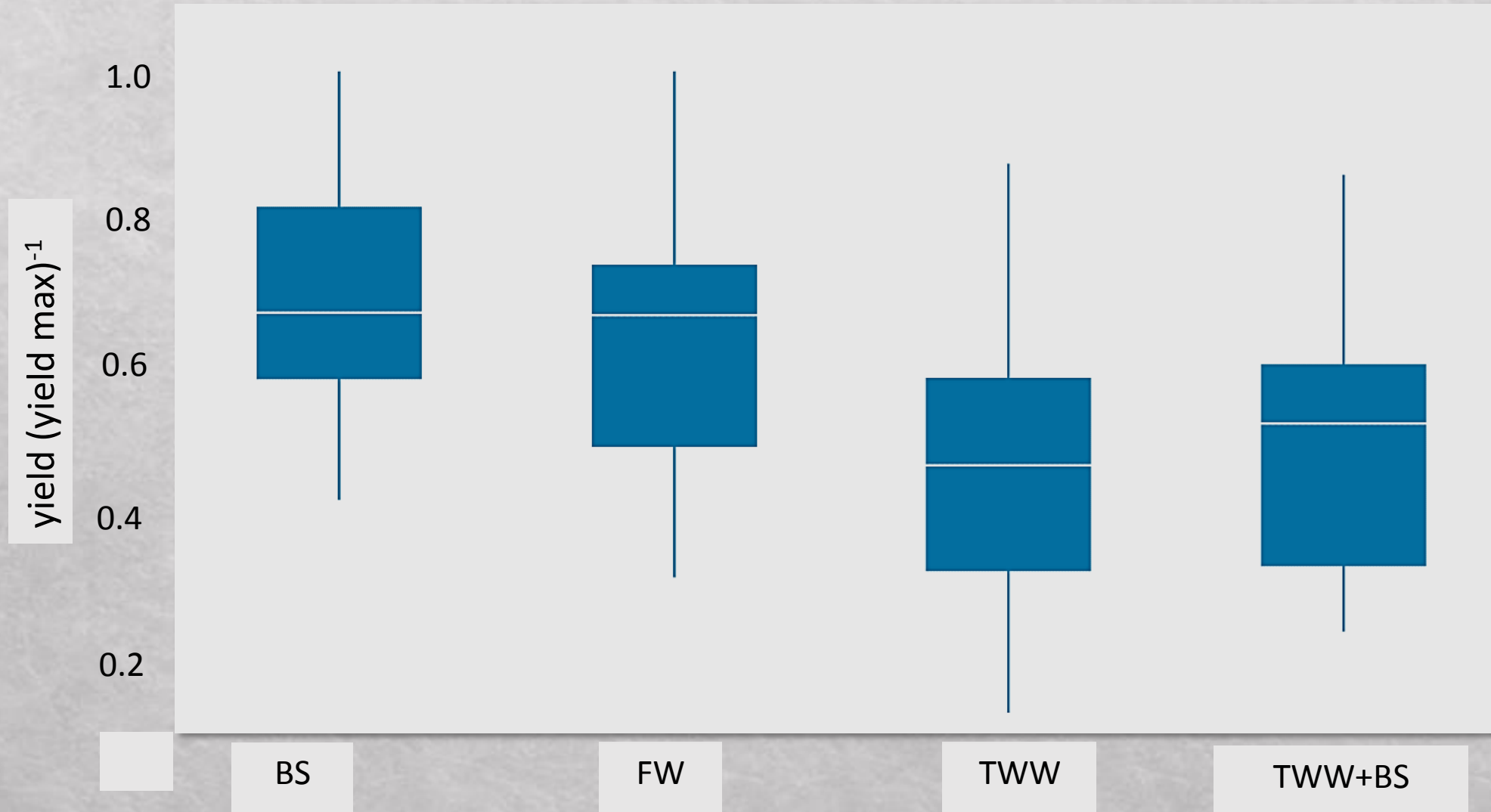
# Irrigation in Israel



# Concentration of Carbamazepine and Lamotrigine in Lettuce Roots and Leaves



# Combined Relative Yield; Analysis by Treatment



# Summed Concentration of Carbamazepine and its Metabolites in Lettuce Leaves

