Pharmaceutical active compounds in groundwater: contamination and related risks under reclaimed water reuse in agriculture

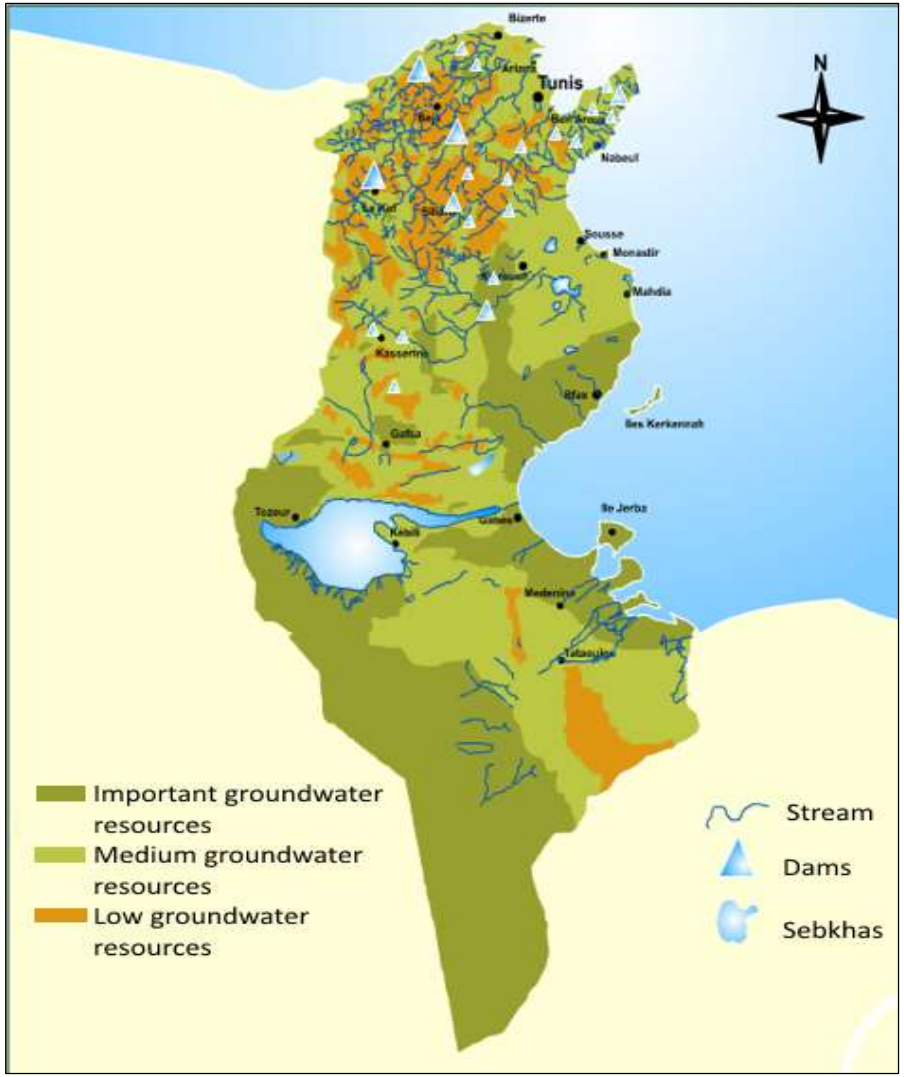
Walid Chmingui[1], Olfa Mahjoub[1], Monica Brienza[2], Amel Jemai[1], Marwa Rmili[1], Serge Chiron[2]

[1] National Research Institute for Rural Engineering, Water, and Forestry, Carthage University, Tunisia.
[2] UMR Hydro Sciences 5569, Montpellier University, France.

IWRA - 2020 Online Conference: Addressing Groundwater Resilience under Climate Change
29-30 October 2020

General Context

Map of water resources in Tunisia



Balance of Tunisian water resources

Conventional water resources	Non-conventional water resources
Rainfall: 36 Mm^3/year.	Desalinization: 36200 m^3/day (4 desalination plants in the south.
Surface water: 2700 Mm^3/year, mobilized by 27 big dams, 193 dams and 812 hill lakes.	Reuse of TWW: 11 wastewater treatment plants: 270 Mm^3/year. Reuse of only 8% of the treated effluents and 72% reach the environment.
Groundwater: 2175 Mm^3/year (746 Mm^3/year from phreatic aquifers and 1429 Mm^3/year from depth aquifers).	Water recharge: 23 aquifers.

(DGRE, 2017)

- ✓ Renewable water resources 450 m^3/capita/year.
- ✓ 226 phreatic aquifers and 340 deep aquifers, out of which 141 are overexploited.
- ✓ Coastal aquifers are facing several pressures linked to the anthropogenic activities and agricultural activities.

➔ Degradation of quality and marine intrusion.

The study area

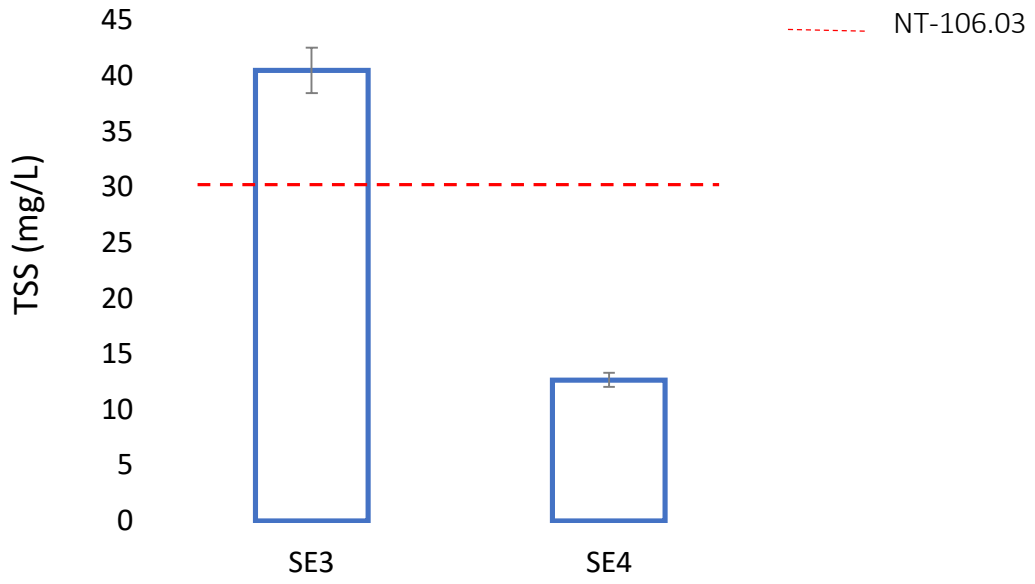
- ✓ Oued Souhil area, near Nabeul city (North East of Tunisia).
- ✓ Semi-arid climate.
- ✓ Water deficit (2017): about 52 mm.

- ✓ The irrigated area of Oued Souhil (276 ha) was created in 1984 as the first pilot site to study the impact of the reuse of TWW.
- ✓ TWW is supplied by two treatment plants: SE3 (oxidation channel) and SE4 (activated sludge).

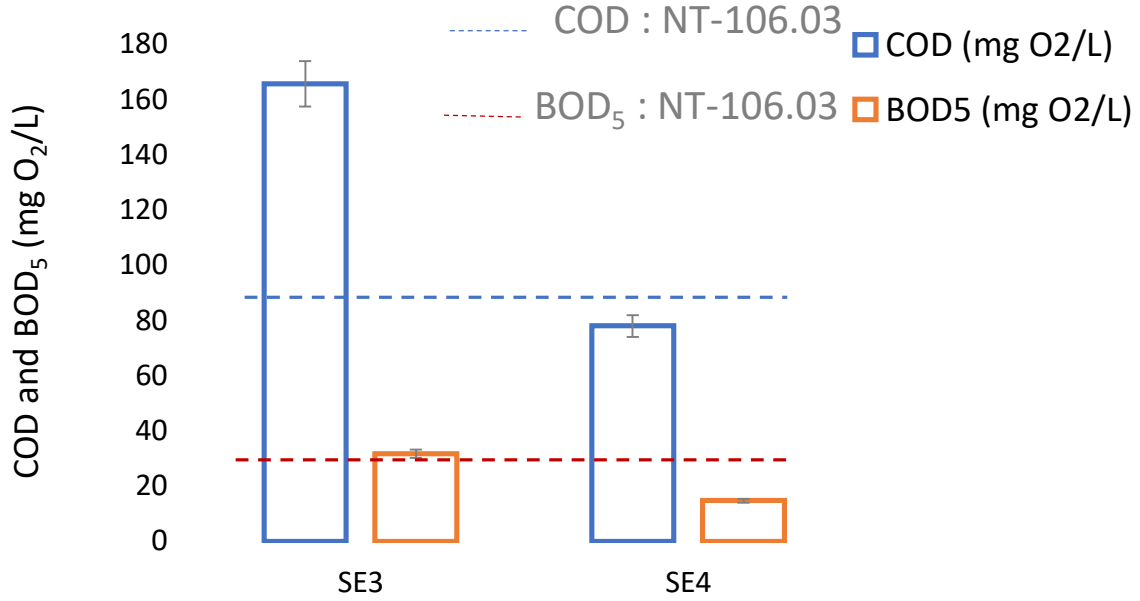
Quality of treated wastewater

Physico - chemical parameters

Total Suspended Solids in TWW from SE3 and SE4



COD and BOD_5 in TWW from SE3 and SE4



NT-106.03 (1989) Tunisian Standard of reuse in agriculture:

- ✓ TSS: 30 mg/L
- ✓ COD: 90 mg O_2/L
- ✓ BOD_5: 30 mg O_2/L

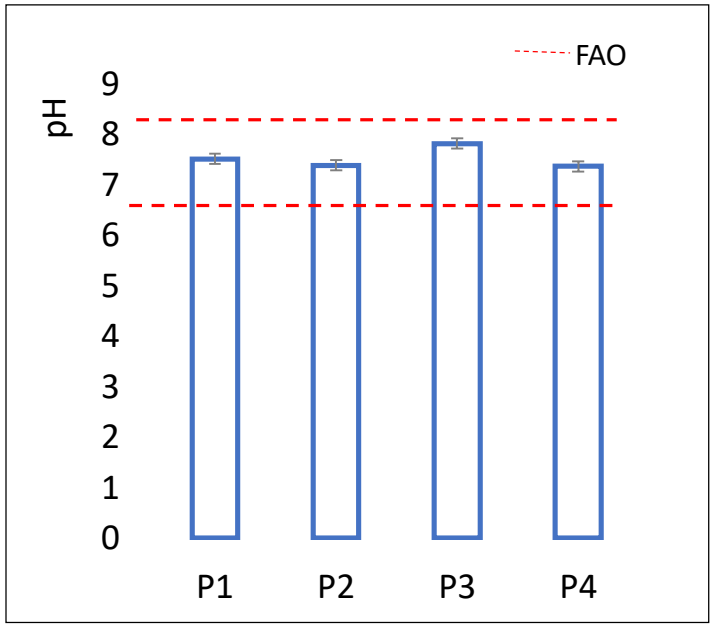
The poor quality of SE3 effluent is due to:

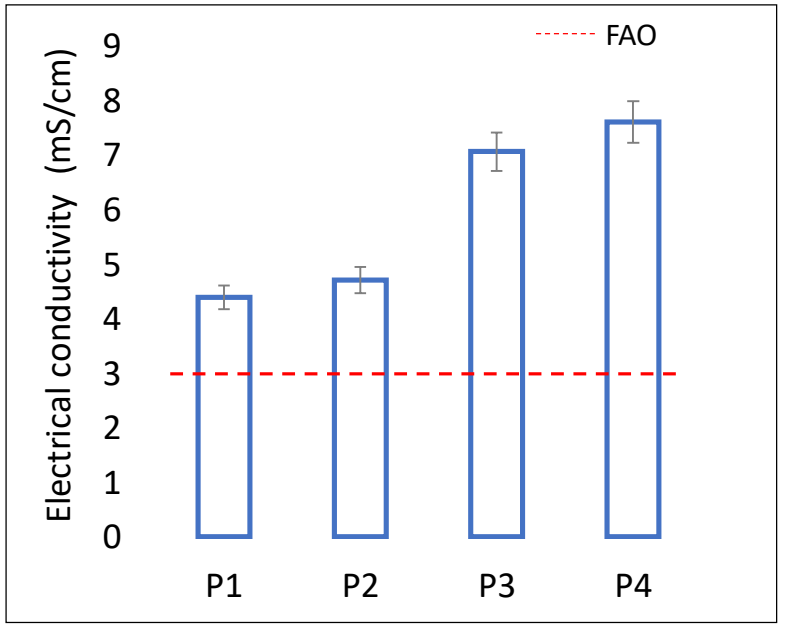
- ✓ The hydraulic and biological overload.
- ✓ Effluents origin: industrial, touristic, hospitals
- ✓ Point and non point sources pollution.

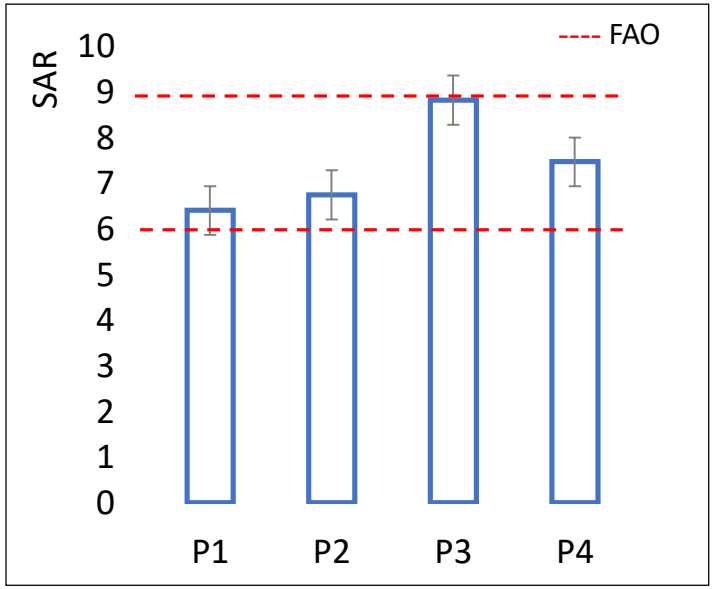
Quality of groundwater

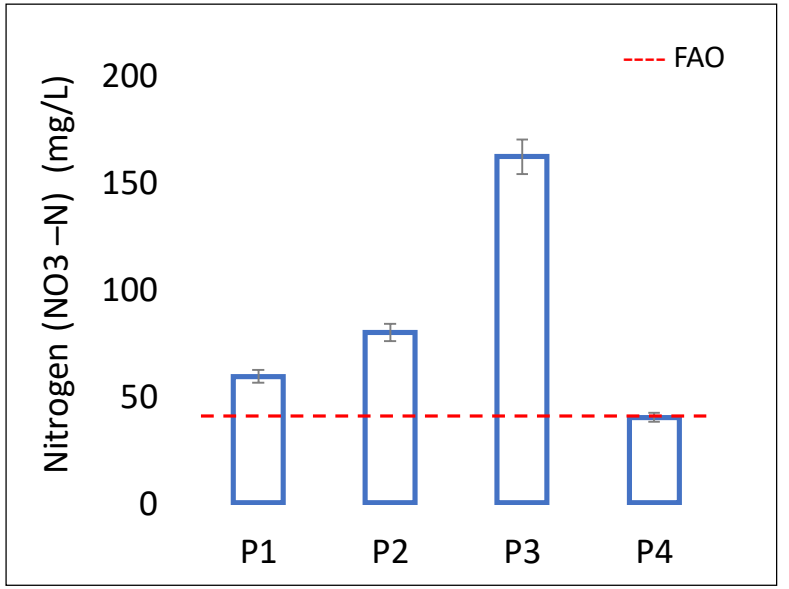
FAO recommendations for the quality of water used in agriculture:

		Degree of Restriction on Use		
	Unit	None	Slight to Moderate	Severe
pH	-	<6.5	6.5 – 8.4	> 8.4
Salinity				
EC	mS/cm	< 0.75	0.75 - 3	>3
DW	mg/L	<450	45 - 2000	>2000
SAR	-	<6	6 - 9	>9
Specific Ion Toxicity (affects sensitive crops)				
Na	meq/L	<3	3 - 9	>9
Cl	meq/L	4	4 - 10	>10
Bo	meq/L	<0.7	0.7 - 3	>3
Miscellaneous Effects (affects susceptible crops)				
N	mg/L	<5	5 - 30	>30
HCO3	meq/L	<1.5	1.5 – 8.5	>8.5









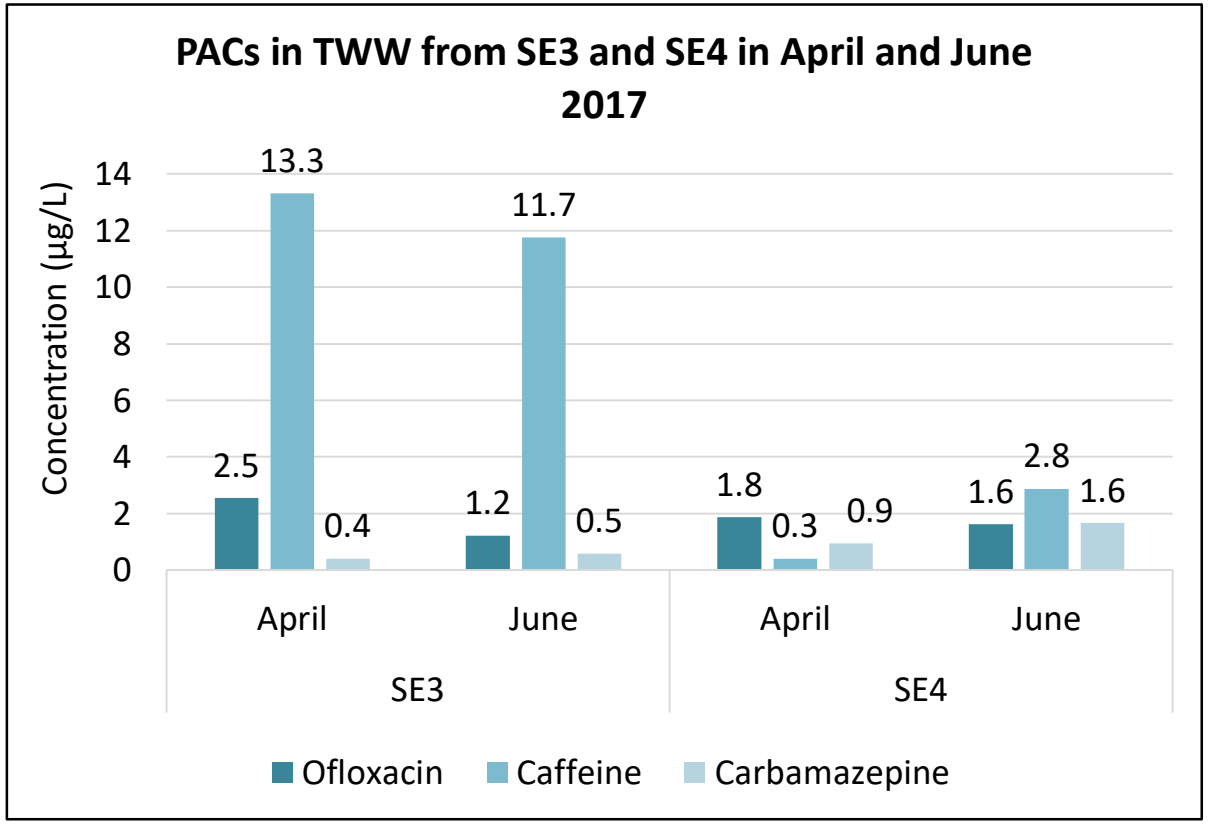
Screening of PACs in GW and TWW samples

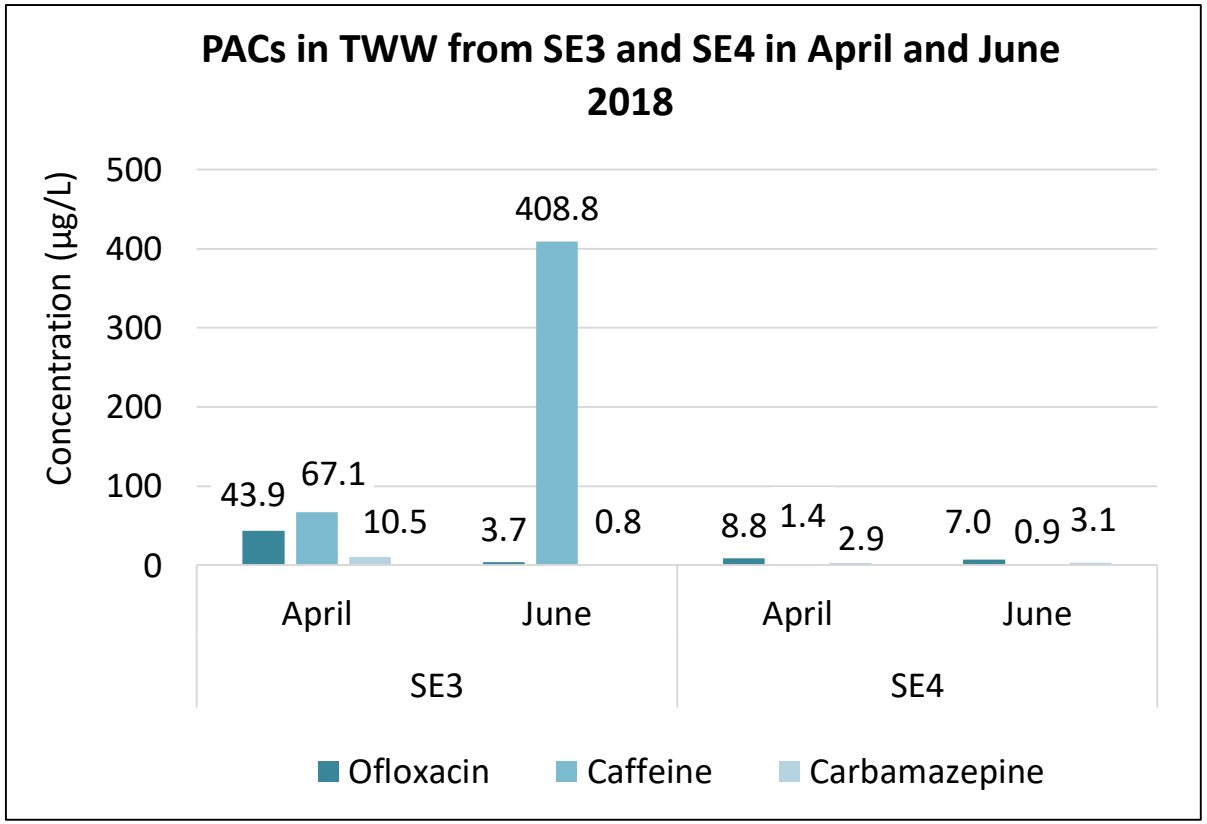
30 molecules in samples collected, in April and June 2017, from GW and TWW ➔ 4 compounds

	Molecules	GW								TWW			
		April				June				April		June	
		P1	P2	P3	P4	P1	P2	P3	P4	SE3	SE4	SE3	SE4
Antibiotics	Ofloxacin												
	Amoxicillin												
	Ciprofloxacin												
	Sulfamethazine												
	Sulfamethoxazole												
	Trimethoprim												
	Sulphapyridine												
	Enrofloxacin												
Analgesics	Antipyrine												
	Acetaminophen												
	Codeine												
	Lysine acetylsalicylate												
Anti – inflammatory	Ketoprofen												
	Ibuprofen												
	Diclofenac												

	Molecules	GW								TWW			
		April				June				April		June	
		P1	P2	P3	P4	P1	P2	P3	P4	SE3	SE4	SE3	SE4
Antiepileptics	Carbamazepine												
	Primidone												
	Oxazepam												
Alkaloids	Cotinine												
Anticancer	Tamoxifen												
Anti-hyperlipidemic	Fenofibric Acid												
	Clofibric Acid												
Beta blockers	Atenolol												
	Propranolol												
	Sotalol												
Broncho-dilatation	Terbutaline												
	Theobromine												
Elicit drogues	Benzoylecgonine												
Stimulants	Caffeine												
	Paraxanthine												

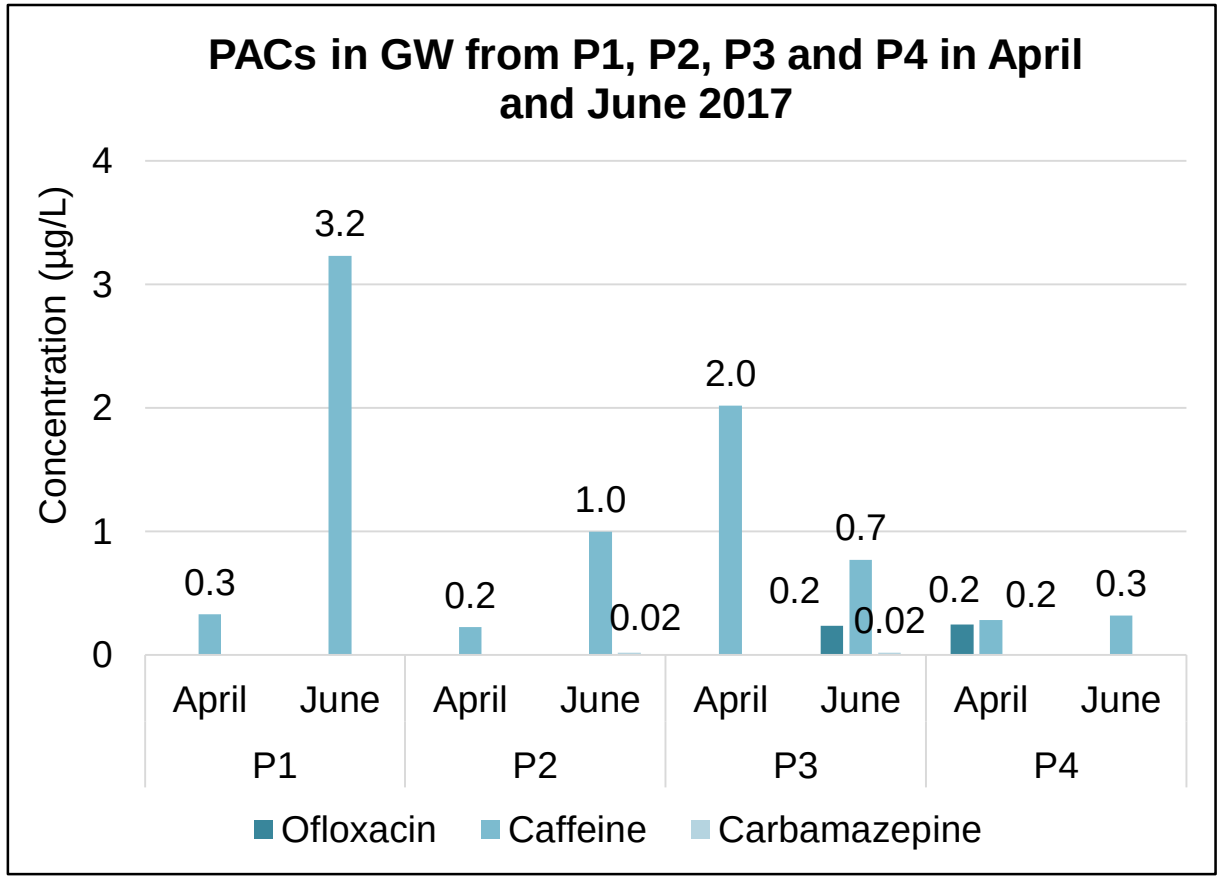
PACs in treated wastewater

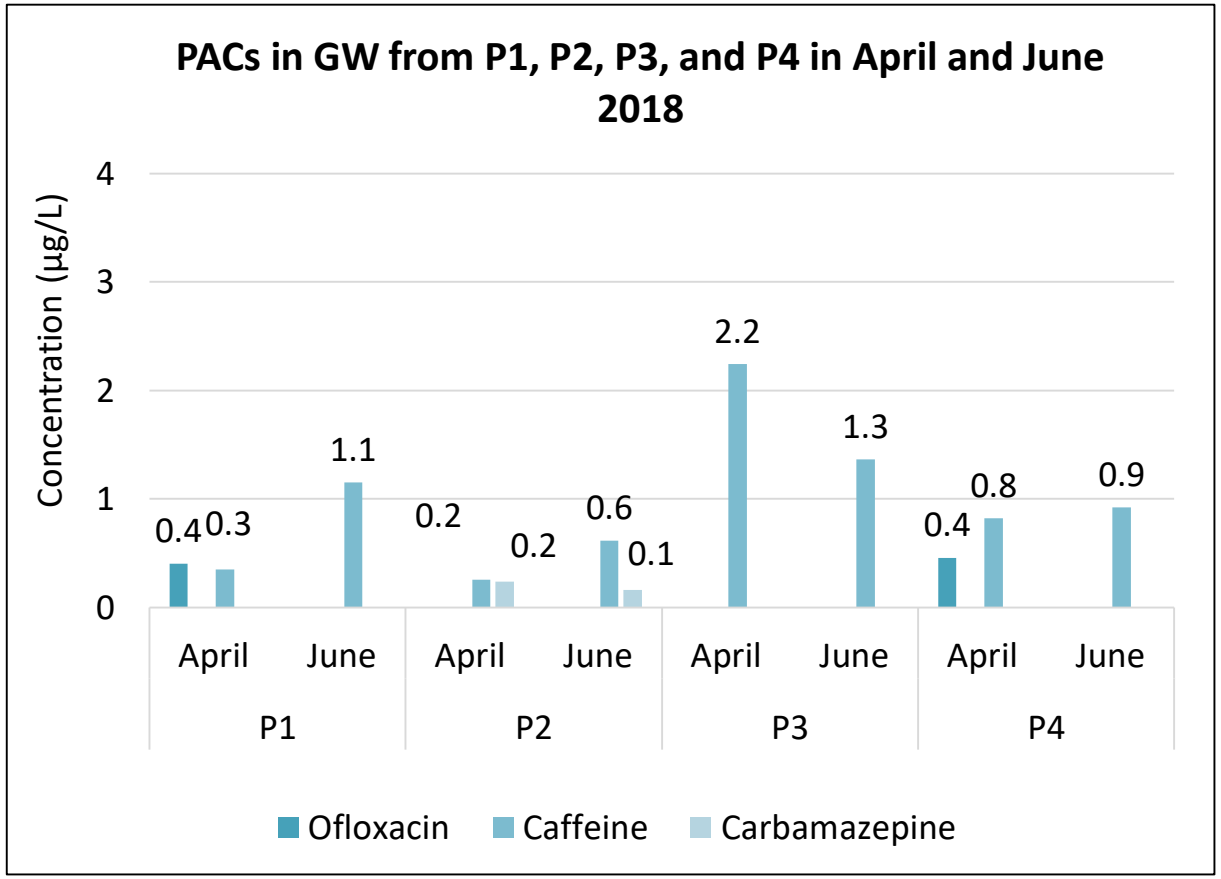




- ✓PACs $_{SE3}$ > PACs $_{SE4}$: Sewage effluents from hospitals and hotels.
- ✓High concentration of ofloxacin during winter season: high consumption of antibiotics?
- ✓High concentration of caffeine during summer season: touristic activity and the massive consumption on daily basis.
- ✓HQ = (MEC)/(PNEC) ➔ Ofloxacin (552), Carbamazepine (50), Caffeine (5) ➔ High ecological risk.

PACs in groundwater





- ✓ PACs concentrations detected in GW are higher than those reported in literature (0,01 – 0,7 µg/L).
- ✓ Ofloxacin is used in both human and veterinary medicine.
- ✓ Detection of caffeine in GW is an indicator of anthropogenic contamination.
- ✓ Carbamazepine is a persistent compound often detected in groundwater.

Key messages

- ✓ In addition of the poor quality of TWW, anthropogenic activities amplify the contamination of the aquifer.
  - Surface irrigation with TWW ➔ infiltration of water to reach the aquifer.
  - Manure fertilization ➔ possible release of veterinary PACs in groundwater.
- ✓ The persistence of antibiotics at low levels can promote the proliferation of antibiotic resistant bacteria.
- ✓ A Hazard Quotient > 1 ➔ ecological risk of TWW to the environment.
- ✓ Based on the detection of PACs in GW, there is a concern about potential hazard for humans and animals resulting from any usage of GW for the irrigation of other crops (garden crops and condiments), which is frequently observed despite the ban.

Thank you for your attention