



# Pharmaceuticals Residues in Agricultural Irrigation Water in Tunisia: A Step Forward in Enhancing Knowledge

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# UNESCO Project

## Emerging Pollutants in Wastewater Reuse in Developing Countries



*Implemented under*

**UNESCO-IHP International Initiative on Water Quality (IIWQ)**

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2014-2018

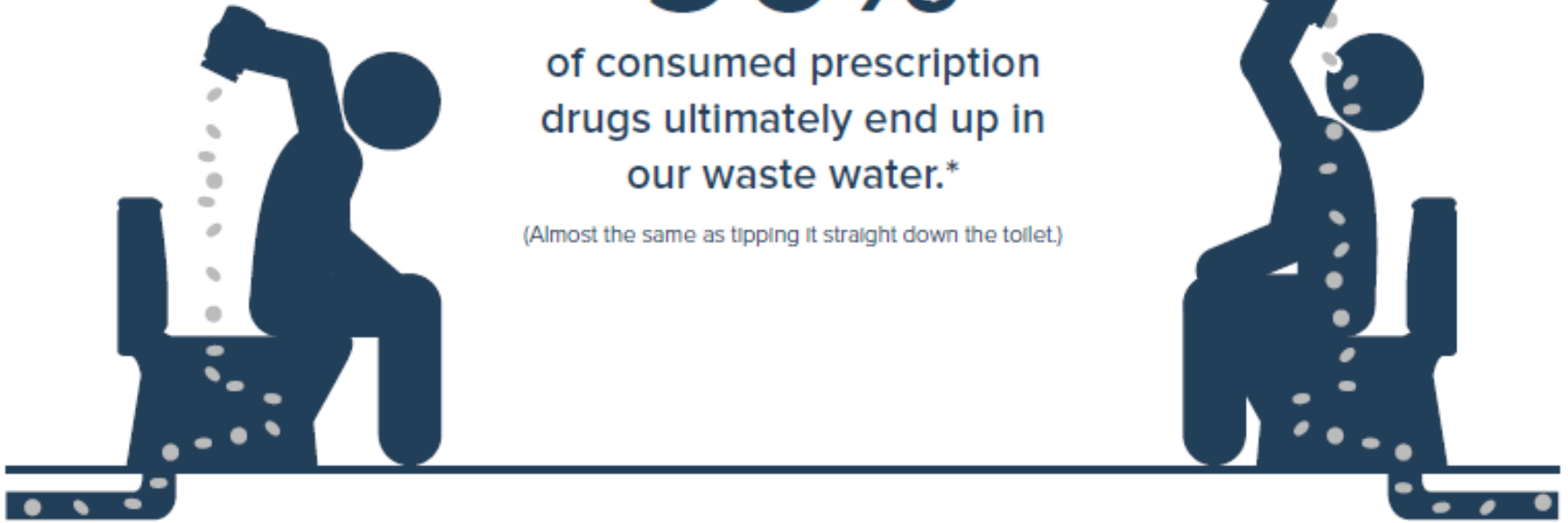
- Consumption of pharmaceuticals is needed to improve the quality of life.



# 90%

of consumed prescription  
drugs ultimately end up in  
our waste water.\*

(Almost the same as tipping it straight down the toilet.)



(Micropollutants.com, 2017)

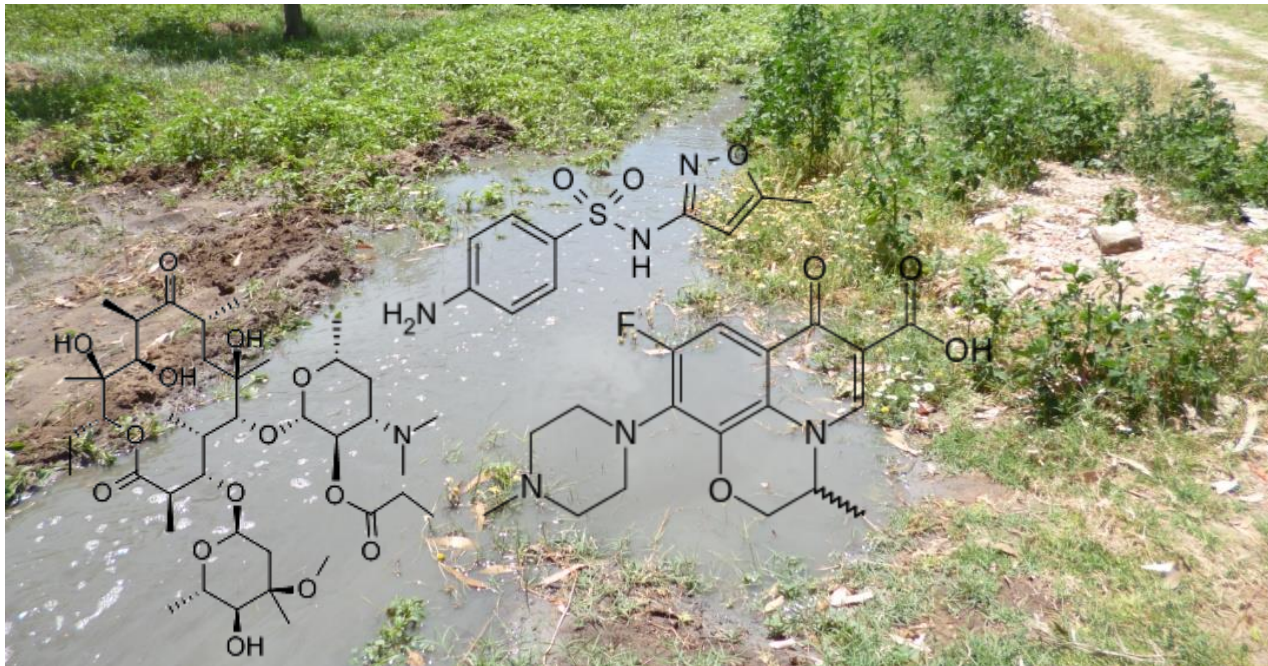
- 70% of PR in the wastewater comes from household use (20% from livestock farming).
- Pharmaceutical residues (PR) are recongnized as emerging pollutants (EP) for the water resources.



- Wastewater reuse is promoted through water policies as an alternative source of water and nutrients to produce food crops.

# Questions to be answered

- What do people in the institutions of the water and water-related sectors know about EP and PR? What are the knowledge gaps that should be filled?
- What PR can occur in water resources used for irrigation and what are their concentrations, in the specific case of the area of Oued Souhil (Tunisia) irrigated with TWW?



# Survey (October 2015)

## ■ Questionnaire

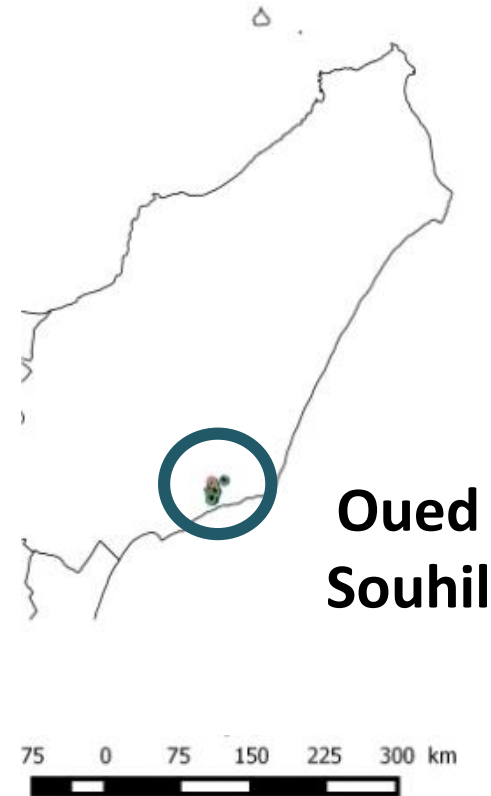
- A. General information and definition
- B. Presence, fate, behaviour in the environment
- C. National policy
- D. Regulation in the environment
- E. Analytical and human capacities
- F. Treatment and elimination in wastewater
- G. Risks perception related to the presence in irrigation water
- H. Remarks and suggestions

- 12 institutions: 9 Governmental (4 ministries) + 3 NGOs
- 41 interviewees (37 validated responses)

Institution	Acronym	Affiliation/ type of institution	Field of expertise	# participants
National Agency for Sanitary Control and Environmental Protection	ANCSEP	Ministry of Public Health	Environment, health, food	3
Department of Hygiene of Milieu and Environmental Protection	DHMPE		Public health	2
National Institute for Research and Physicochemical Analysis	INRAP	Ministry of Higher Education and Scientific Research	Research, analysis	5
Department of Environment and Quality of Life	DG/EQV	Ministry of Environment and Sustainable Development	Environment	3
International Center for Environnemental Technologies	CITET		Water, environment	5
National Agency for Environmental Protection	ANPE		Environment	4
National Utility for Sanitation	ONAS		Wastewater treatment	4
Department of Rural Engineering and Water Use	DG/GREE		Water, rural engineering	2
National Institute for Marine Science and Technologies	INSTM	Ministry of Agriculture, Water Resources and Fishery	Research, marine environment	4
Association Eau et Développement	AED	NGOs	Water, reuse, agriculture	1
Association SOS BIAA	SOS BIAA		Water, waste, environment	2
World Wilde Foundation, North Africa Office	WWF		Ecology and environment	2
<b>Total</b>				<b>37</b>

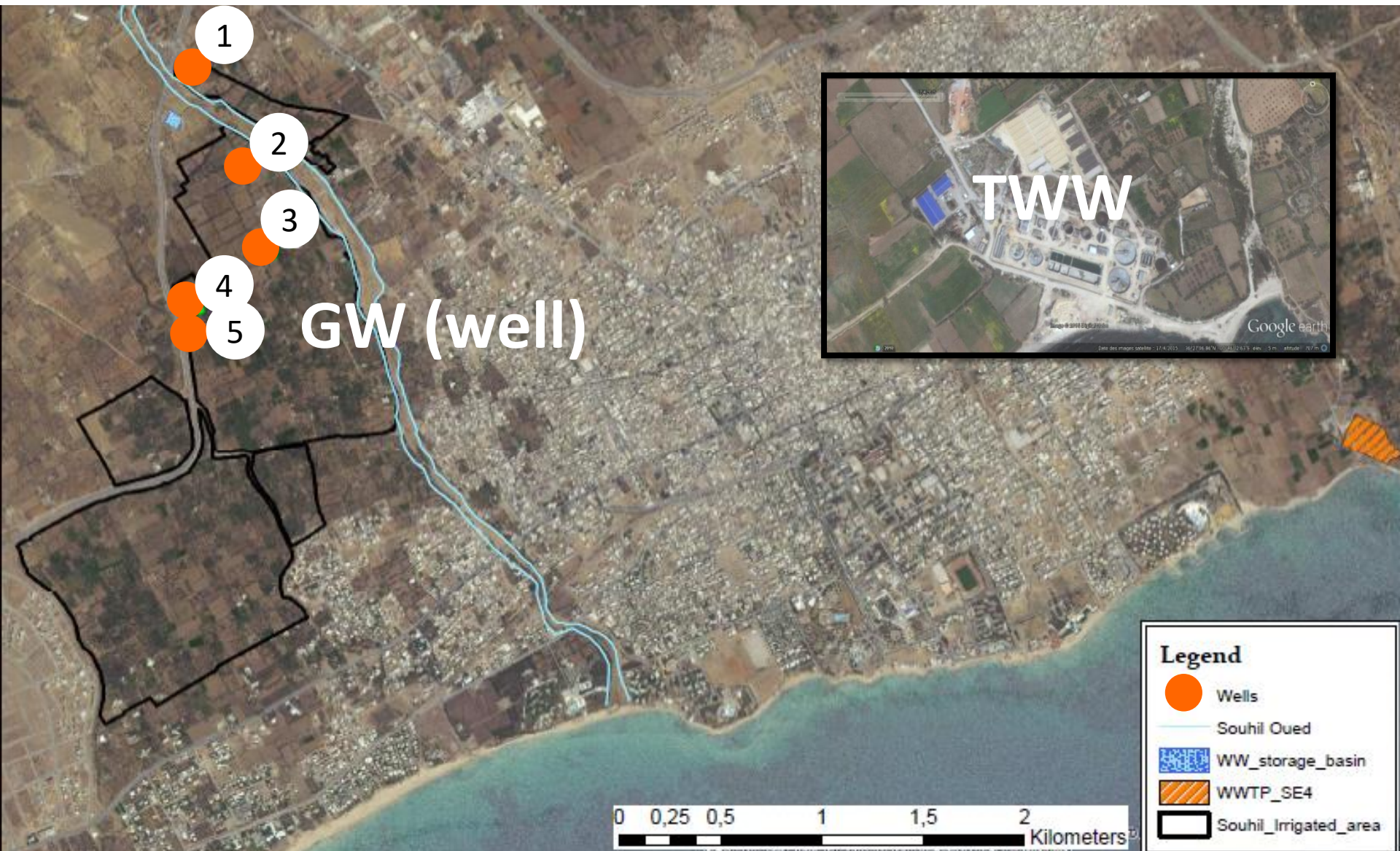


# Irrigated Area of Oued Souhil



- Reuse of secondary TWW for more than 30 years.
- 280 ha, cultivation of citrus and fodders.
- TWW and GW may be conjunctively used for irrigation.

# Sampling (October-December 2015)



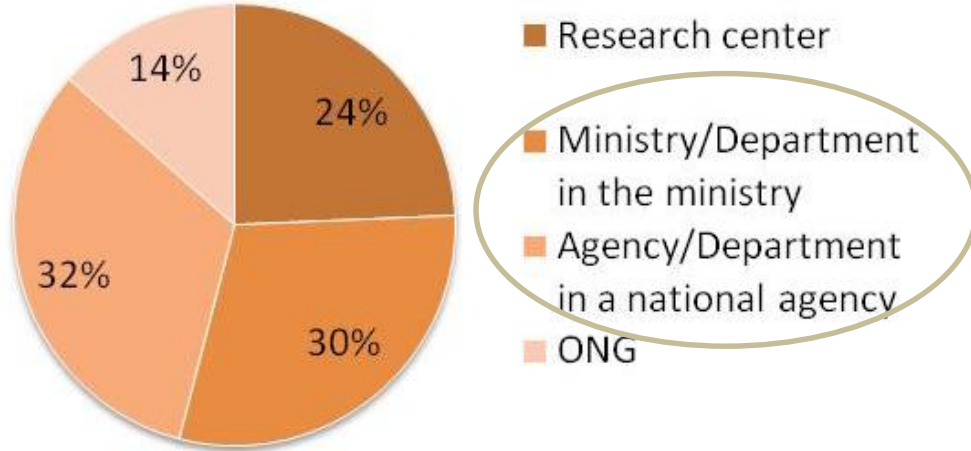
# Analysis

- **Target Analysis** (26 compounds) → 1 TWW  
5 GW (1-5)
  - Antibiotics (9)
  - NSAIDs (4)
  - $\beta$ -Blockers (4)
  - Hormone (3)
  - Lipid regulators and cholesterol lowering drugs (2)
  - Psychiatric drugs (2)
  - Central nervous system stimulant (1)
  - Anti-ulcer agent (1)

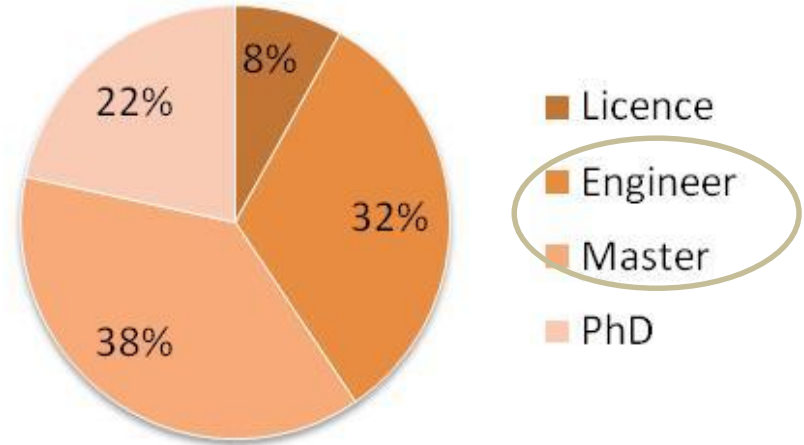
**Non-target Analysis** → 1 TWW  
1 TWW (storage basin)  
2 GW (1 and 5)

# Survey outcomes

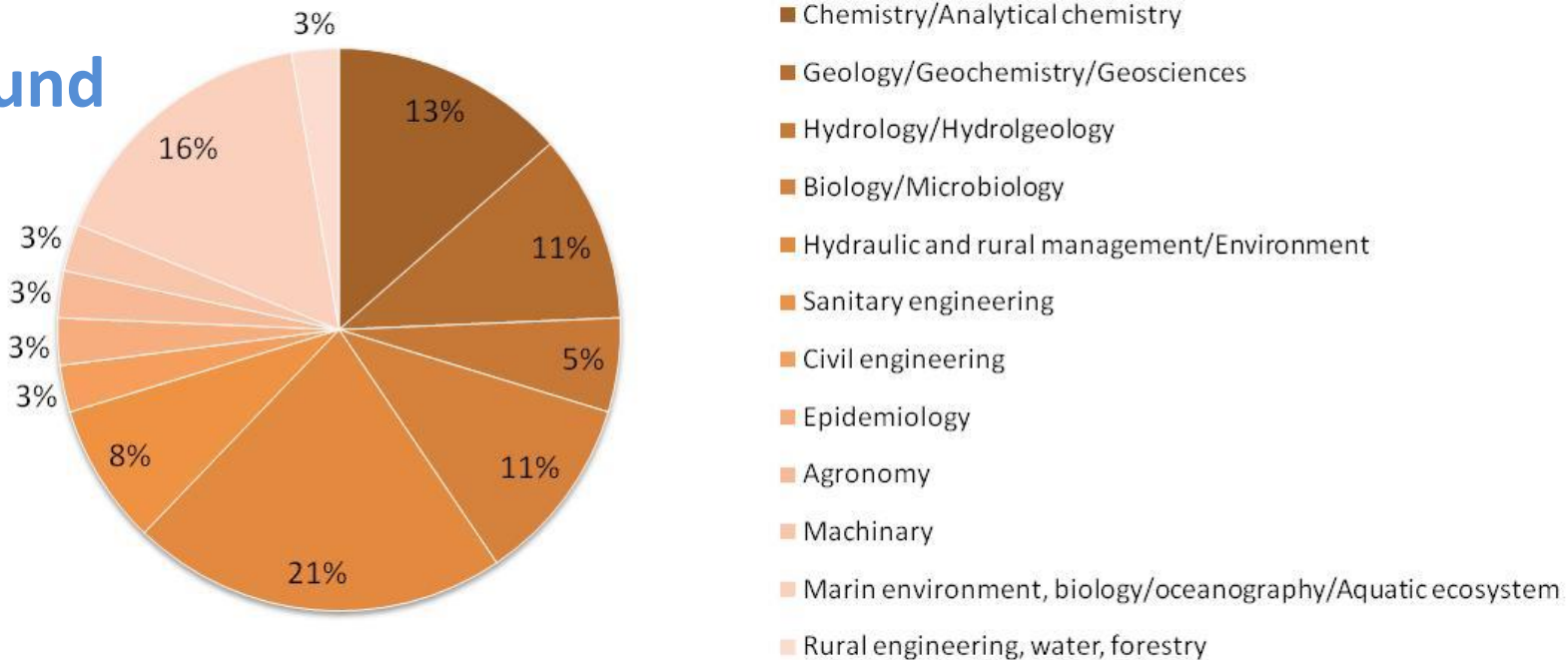
## Affiliation



## Education

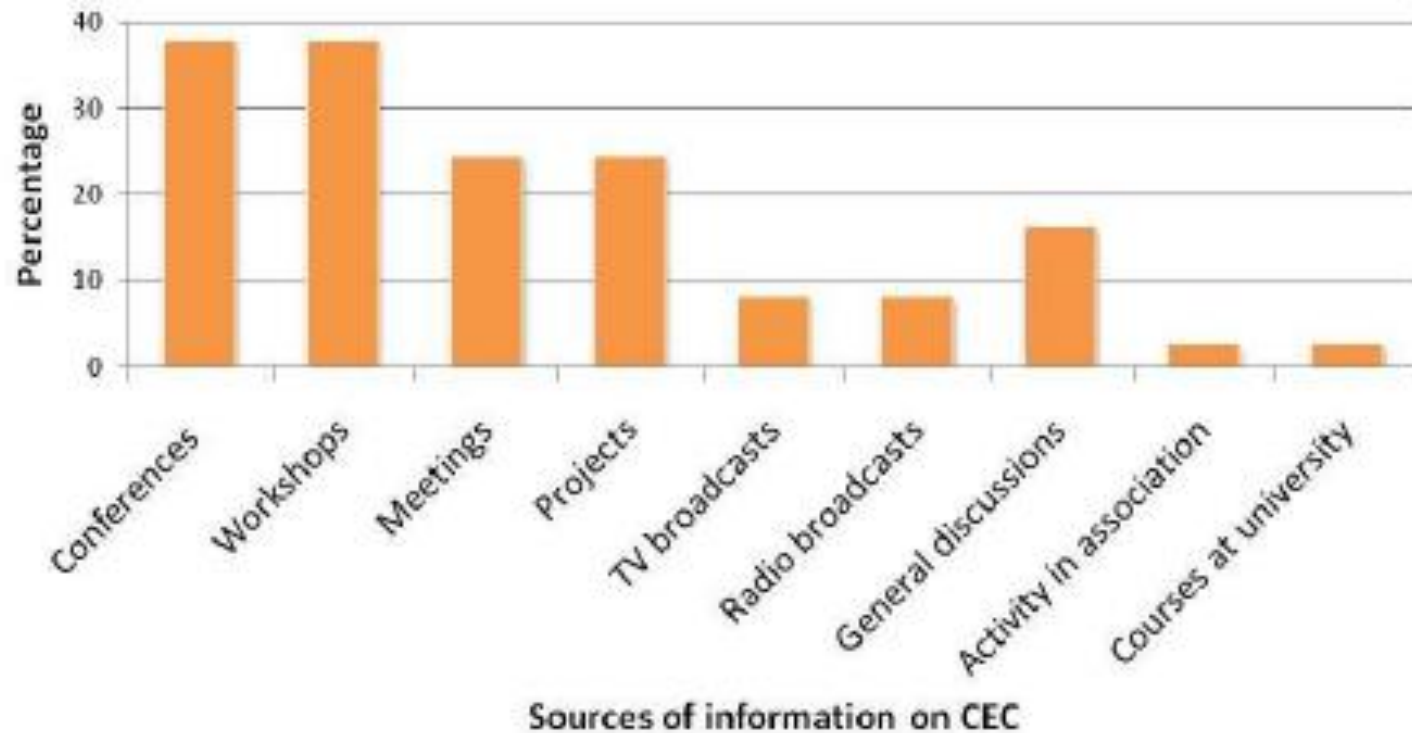


## Background

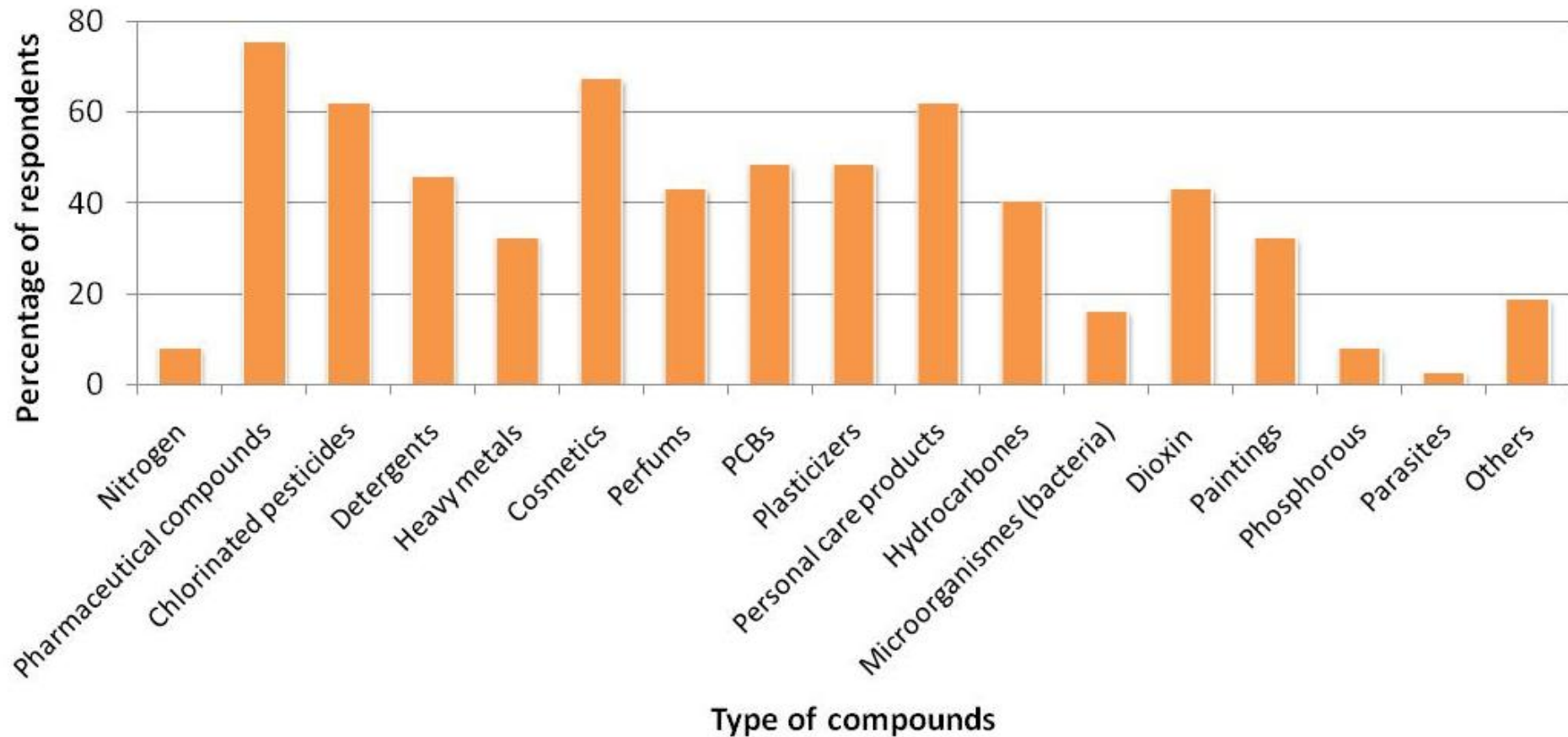


# General knowledge

- 32% have heard about EP for the first time.
- Scientific events (conferences, workshops, meetings) and involvement in research projects are the main sources of information. However, they are for restricted public.



# General knowledge



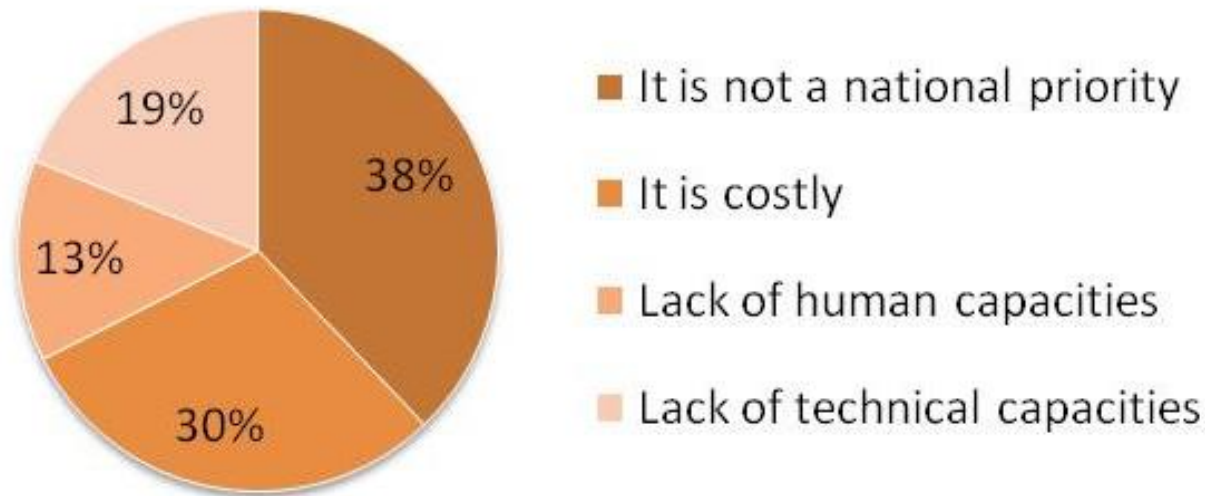
- 40-70% included the right compounds in the list of EP.
- < 20% listed new compounds (hormones, Bisphenol A, etc.)

# Technical capacities and human skills

- 35% were working for well institutions equipped with advanced analytical instruments to analyze EP.
- Major challenges:
  - Lack of skilled (permanent) technical staff,
  - Inefficient use of available equipment,
  - Inefficient/lack of maintenance service,
  - Lack of consumable to run analysis,
  - Lack of dedicated budget to run the equipments, etc.

## Regulations and policy

- > 60% do not know whether the country has a policy or is committed to reduce EP in the environment.
- 5% think that there is a national strategy aiming at reducing EP in the environment; 57% think there is no regulation.
- For 38% protecting the environment against EP is not a priority.





## Mean concentrations of selected antibiotics in TWW and GW (ng/L)

Compound	Well 1	Well 2	Well 3	Well 4	Well 5	TWW
Sulfamethoxazole	65.7	<LOQ	264.7	41.5	<LOD	64.5
Ofloxacin	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	482.6
Ciprofloxacin	n.d	n.d	n.d	n.d	<LOD	205.4
Azithromycin	<LOQ	<LOQ	53.0	<LOQ	<LOQ	77.3
Clarithromycin	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	77.1
Erythromycin	<LOQ	<LOQ	52.8	<LOD	<LOQ	51.1
Trimethoprim	<LOD	<LOD	<LOD	<LOD	<LOD	<LOQ
Enrofloxacin	n.d	<LOQ	<LOQ	n.d	<LOD	<LOQ
Tetracycline	n.d	n.d	n.d	n.d	n.d	<LOD

- Sulfamthoxazole (sulfonamides) and erythromycin + azithromicin (macrolides): humans and veterinary drugs.
- Comparable concentrations in TWW and GW → Reuse of TWW and potentially the use of manure as fertilizer.

## Mean concentrations of selected PR in TWW and GW (ng/L)

Compound	Well 1	Well 2	Well 3	Well 4	Well 5	WWTP
Caffeine	<LOQ	<LOQ	92.0	48.0	67.2	7099.5
Paracetamol	n.d	n.d	n.d	n.d	n.d	<LOD
Diclofenac	n.d	n.d	n.d	n.d	n.d	<LOQ
Naproxen	<LOD	<LOQ	<LOD	<LOQ	<LOQ	217.9
Ketoprofen	<LOD	<LOD	<LOD	<LOD	<LOD	446.0
Carbamazepine	<LOD	<LOQ	<LOD	n.d	<LOD	344.4
Famotidine	n.d	n.d	n.d	n.d	n.d	162.4
Atenolol	<LOD	<LOD	<LOD	<LOD	<LOD	295.5
Metoprolol	n.d	n.d	n.d	n.d	n.d	<LOD
Propranolol	<LOD	<LOD	<LOD	<LOD	<LOD	36.9
Sotalolol	n.d	n.d	<LOD	<LOD	<LOD	<LOQ
17 $\alpha$ -ethynilestradiol	n.d	n.d	n.d	n.d	n.d	<LOD
17 $\beta$ -estradiol	n.d	n.d	n.d	n.d	n.d	<LOD
Estrone	n.d	n.d	n.d	n.d	n.d	<LOD

- Caffeine: tracer of contamination of water resources by WW.

# Identified pharmaceutical residues by non-target analysis and range of concentrations

Compounds	Therapeutic Class	Wastewater (>100 ng/L)		Groundwater (>10 ng/L)	
		WWTP outlet	Storage Basin	Well 1	Well 5
Niflumicid	NSAID	X	X		
Tramadol	Narcotic analgesic	X	X	X	X
Codein		X	X		
Sulfamethazine	Antibiotic	X	X	X	X
Ciprofloxacin		X			
Tetracycline		X			
Hydrochlorothiazide	Diuretic			X	X
Bezafibrate	Antilipidic	X			
Atenolol	$\beta$ -Blockers		X		
Venlafaxin	Antidepressant		X		

- Sulfamethazine: used humans and growth promoter for animals  
 ➔ Reuse of TWW and use of manure.

# Conclusions and recommendations

- A relatively large gap of knowledge among decision-makers, scientists, and stakeholders of the water and water-related sectors
  - ➔ Better communication, dissemination of research results, raising awareness about EP and PR.
- Analytical and human capacities are lacking and/or not valued enough to produce data on EP
  - ➔ Joint monitoring programmes and integrated research projects to produce reliable data for a science-based decision-making and for setting realistic regulation.
- The concentrations of PR (antibiotics) are relevant in the TWW and GW used for irrigation
  - ➔ Further monitoring programme is worthwhile in the TWW irrigated areas for further risk assessment.



# THANK YOU

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