



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

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Pontes e Parcerias nos Países de Língua Portuguesa

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O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

Emerging Pollutants

“Pollutants currently not included in routine monitoring programmes at Union level but which could pose a significant risk requiring regulation, depending upon their potential ecotoxicological and toxicological effects and on their levels in the aquatic environment”

Directive 2013/39/EU

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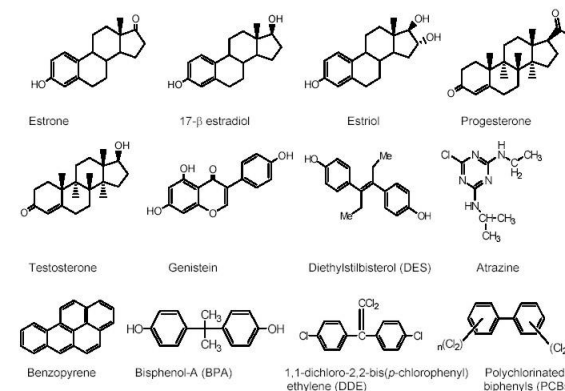


Pharmaceuticals

EMERGING POLLUTANTS



Surfactants



Endocrine disruptors



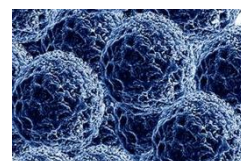
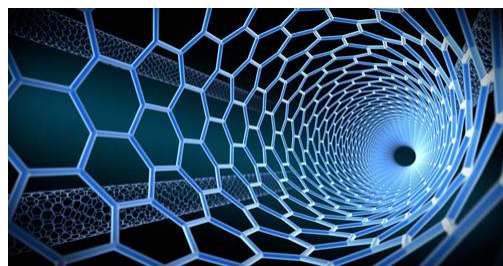
Personal care products



Drugs of abuse



Fuel additives



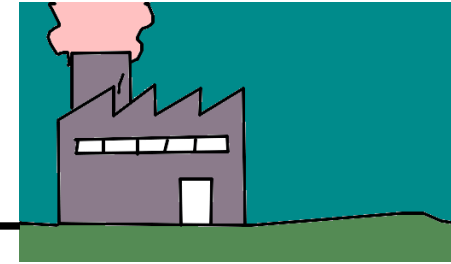
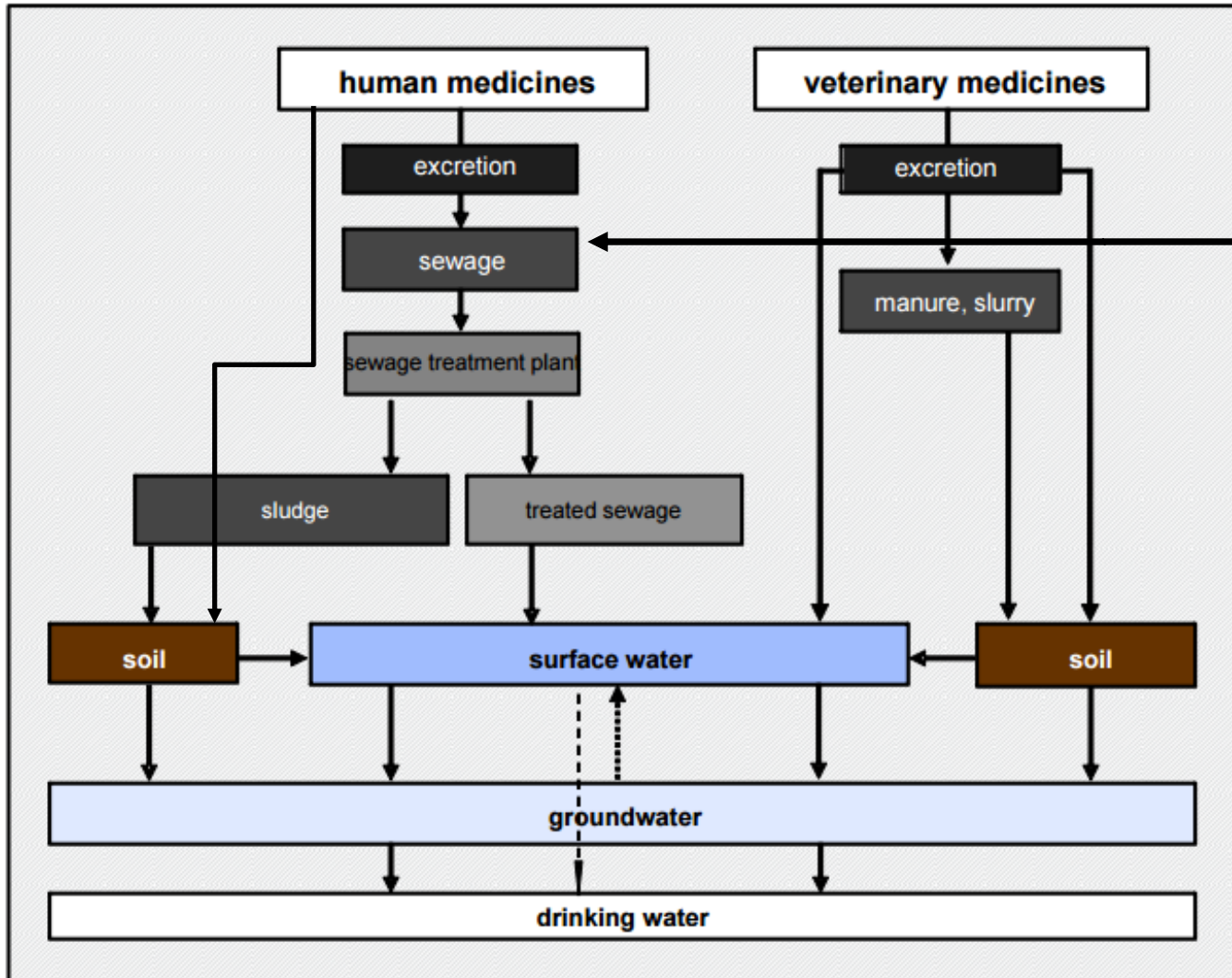
Nanomaterials



Disinfection byproducts

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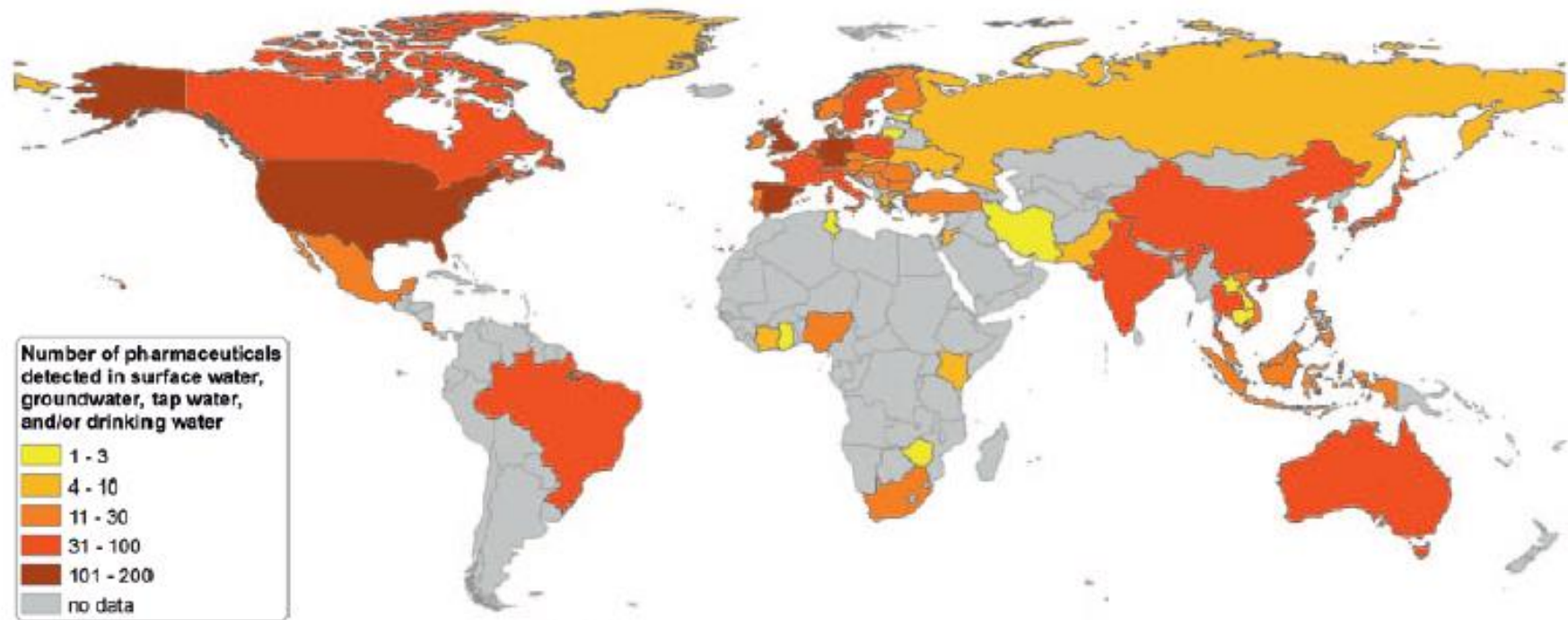
SOURCES AND FATE IN THE ENVIRONMENT



Pharmaceuticals do not need to persist in the environment, since they are continuously introduced

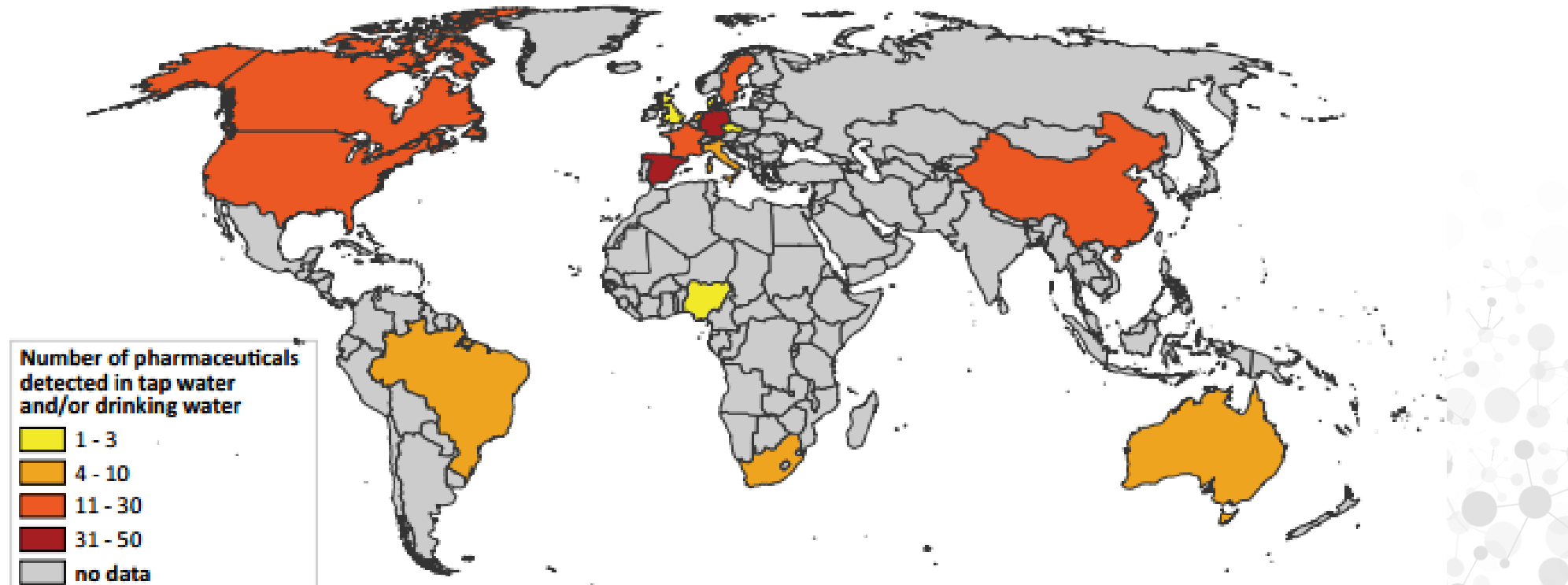
O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

- Pharmaceuticals have been detected in the environment worldwide
- Nowadays there are a few data of the presence of pharmaceuticals in developing countries



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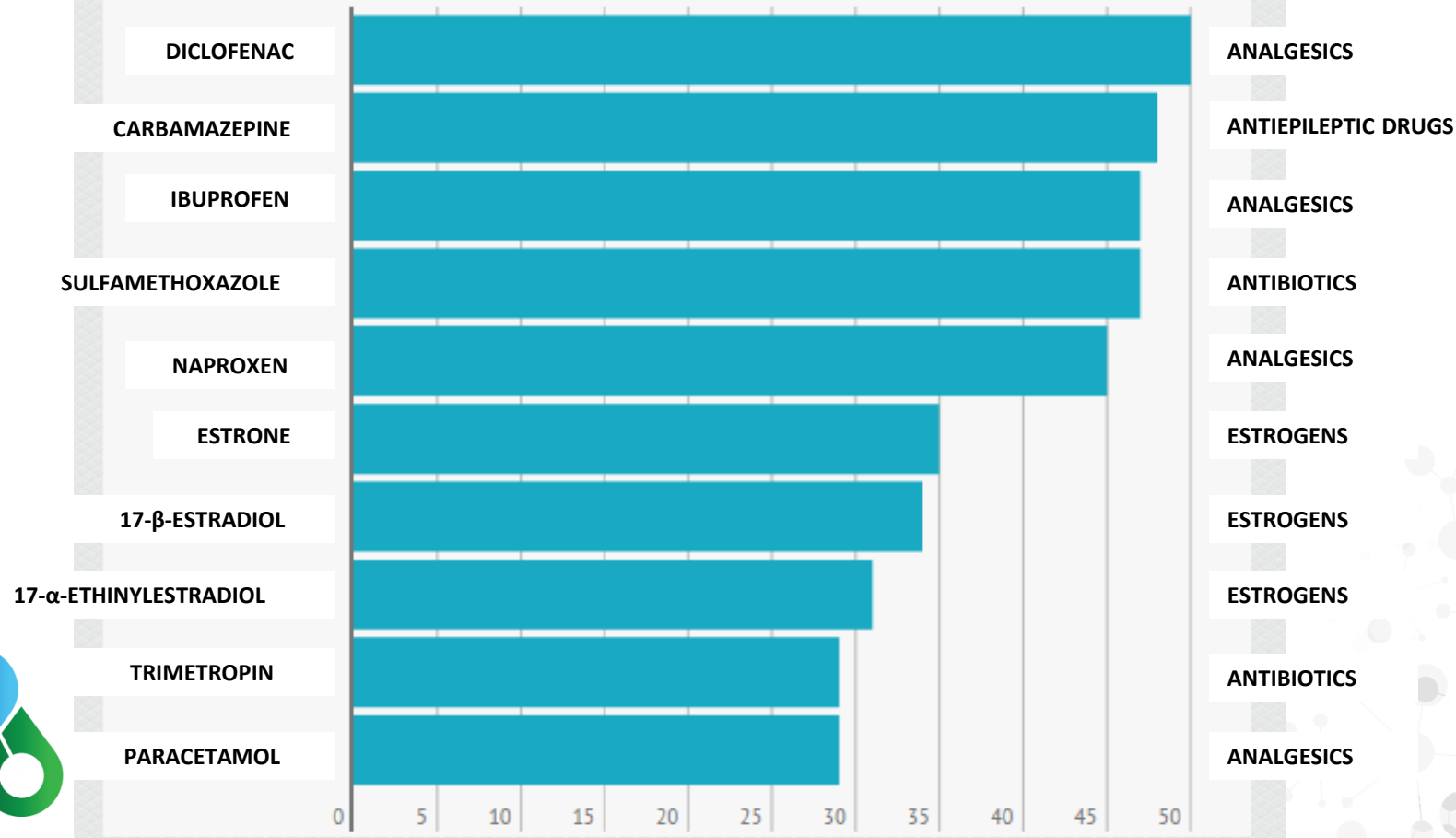
- Number of pharmaceuticals found in drinking water worldwide.



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

Number of pharmaceuticals detected in surface water, ground water, tap water and/or drinking water

Top 10 pharmaceuticals and the number of countries in which they have been found in the aquatic environment



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ANALYTICAL PROCEDURE

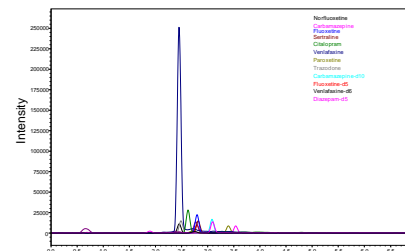
Sampling

Sample preparation

Chromatographic separation

Detection

Results



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

PHARMACEUTICALS DETECTED BY OUR GROUP REQUIMTE/LAQV-ISEP

- ✓ PRESENCE OF PHARMACEUTICALS IN PORTUGUESE RIVERS: **IBUPROFEN**
- ✓ PRESENCE OF PHARMACEUTICALS IN PORTUGUESE RIVERS: **PARACETAMOL, PARACETAMOL-GLUCURONIDE AND P-AMINOPHENOL**
- ✓ EVALUATION OF THE PRESENCE OF PHARMACEUTICALS IN PORTUGUESE SEAWATERS
- ✓ CONTRIBUTION OF HOSPITAL EFFLUENTS TO THE LOAD OF PHARMACEUTICALS INTO URBAN WASTEWATERS
- ✓ IMPACT OF URBAN WASTEWATERS TO THE LOAD OF PHARMACEUTICALS INTO SURFACE WATERS



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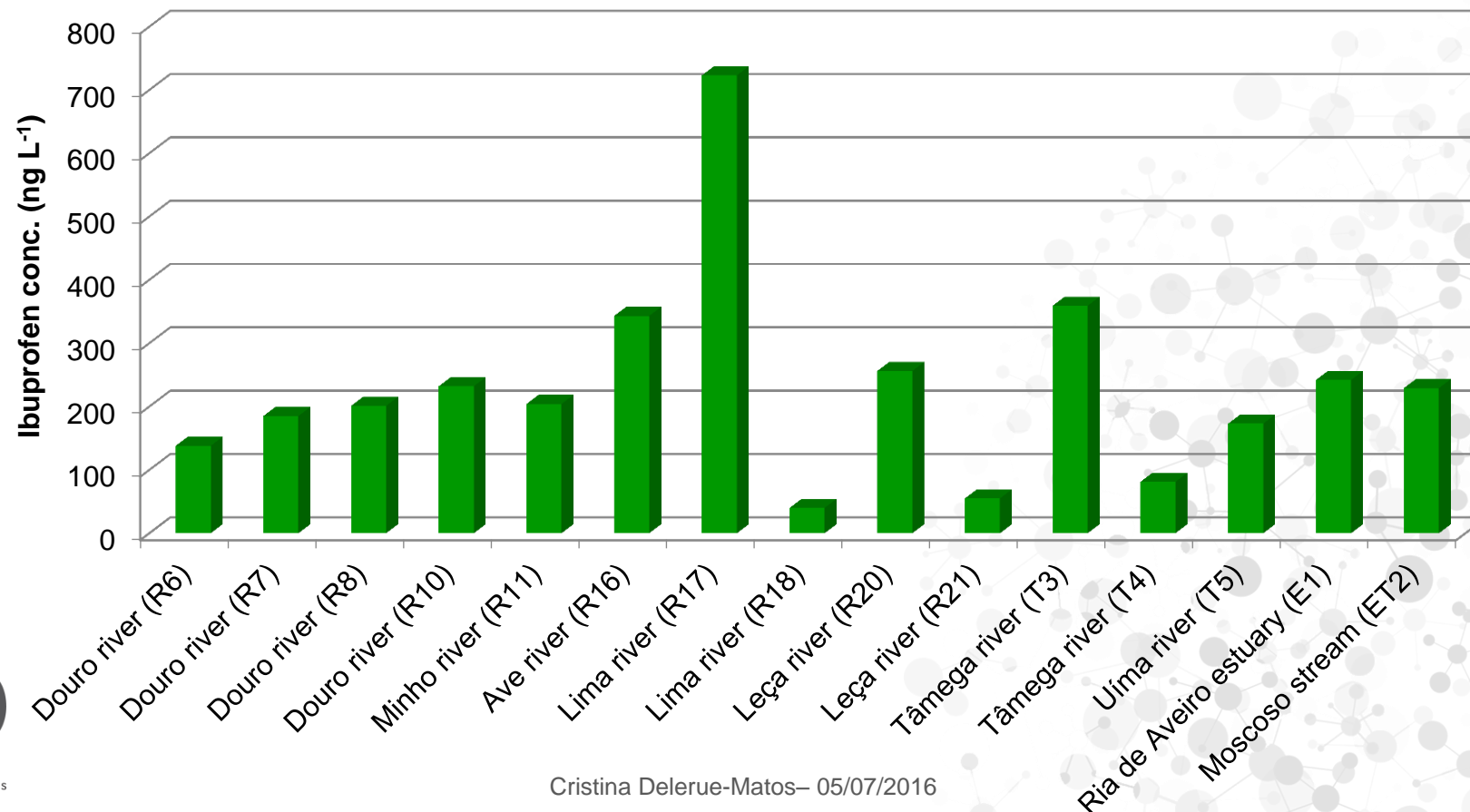
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O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

PRESENCE OF PHARMACEUTICALS IN PORTUGUESE RIVERS: IBUPROFEN

- 33 surface water samples (rivers, stream, estuaries)
- **15 positive samples** for the presence of **ibuprofen**



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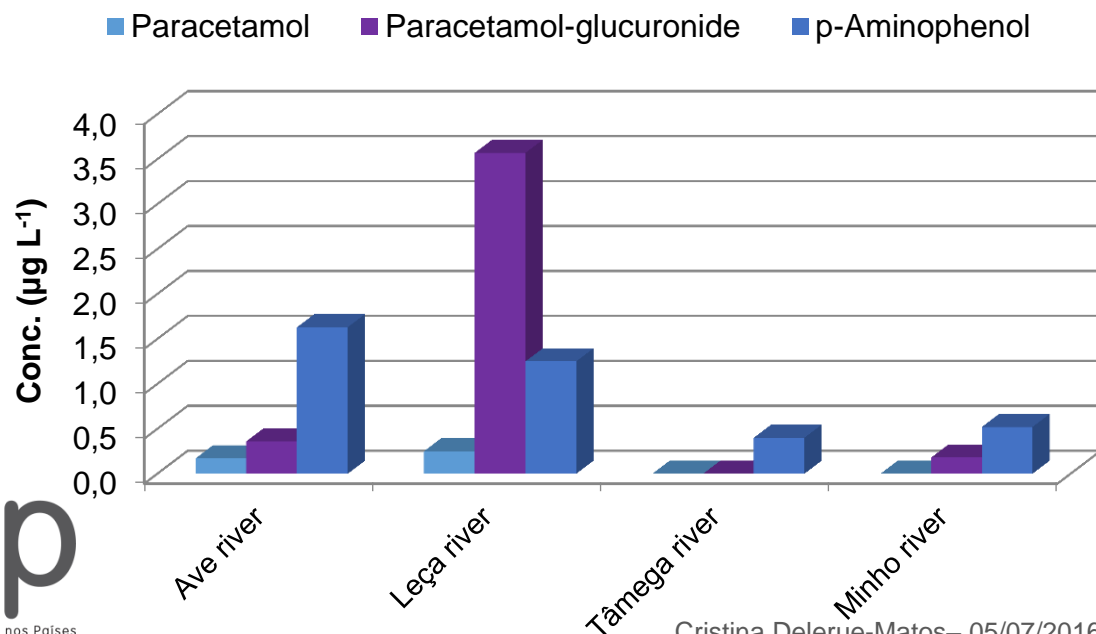


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PRESENCE OF PHARMACEUTICALS IN PORTUGUESE RIVERS: PARACETAMOL, PARACETAMOL-GLUCURONIDE AND P-AMINOPHENOL

- 7 Rivers of the North of Portugal
- At least one compound detected in all the studied rivers
- **Metabolite and transformation product** detected in **higher concentrations** than the parent compound



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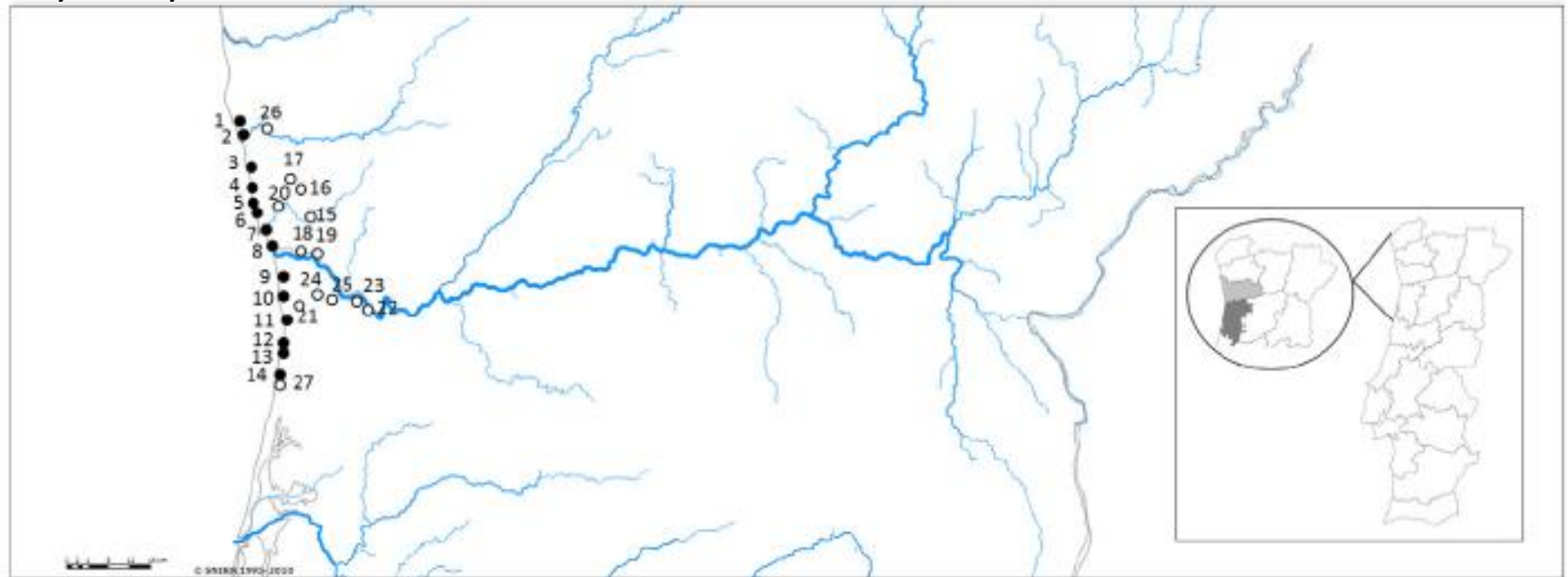
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O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

EVALUATION OF THE PRESENCE OF PHARMACEUTICALS IN PORTUGUESE SEAWATERS

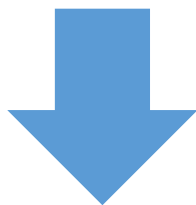
- **101 Seawater samples** were collected in **Atlantic Ocean**
- **14 Beaches** with different bathing water quality (excellent, good, sufficient)
- **5 Cities** and surrounding area (Vila do Conde, Matosinhos, Porto, Vila Nova de Gaia, Espinho)
- Analyzed by SPE-UHPLC-MS/MS



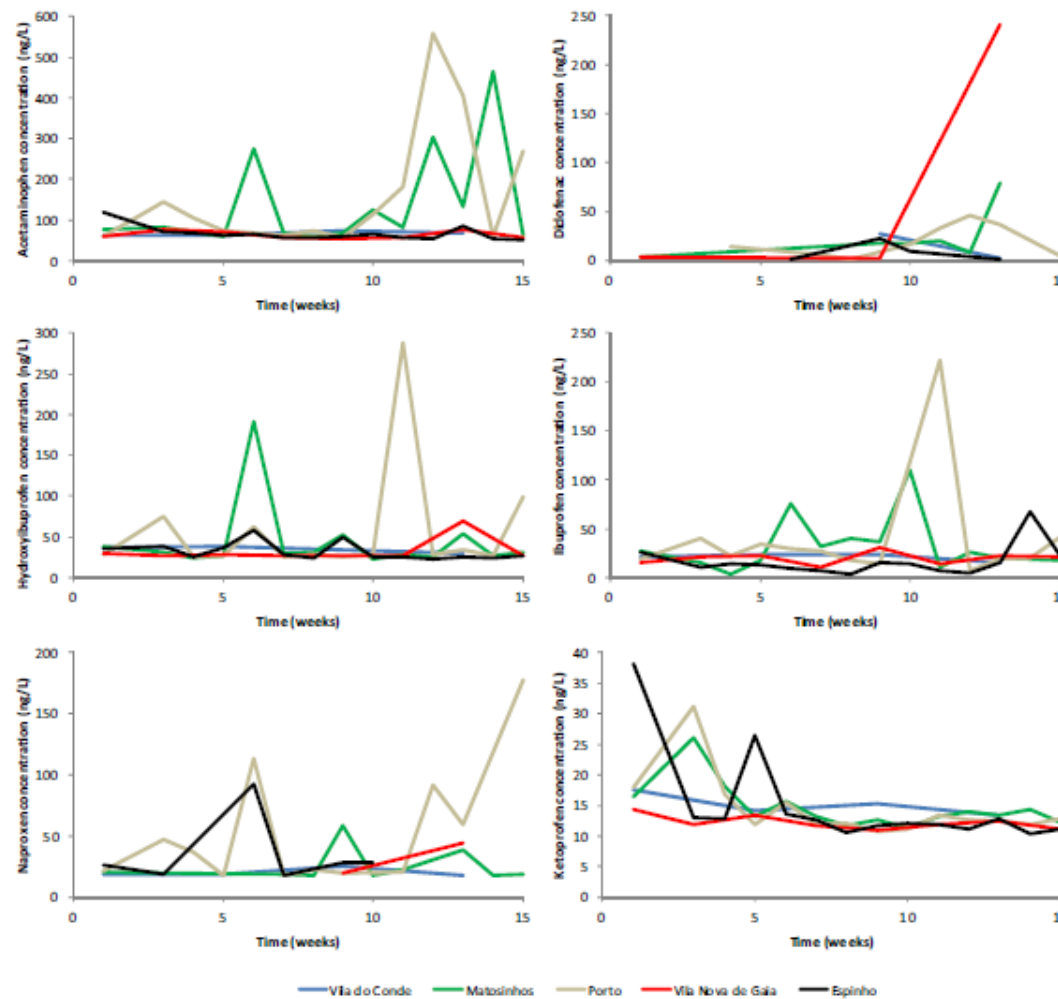
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TEMPORAL DISTRIBUTION OF AINES/ANALGESICS ALONG BATHING SEASON 2013

Highest concentrations detected in August and September

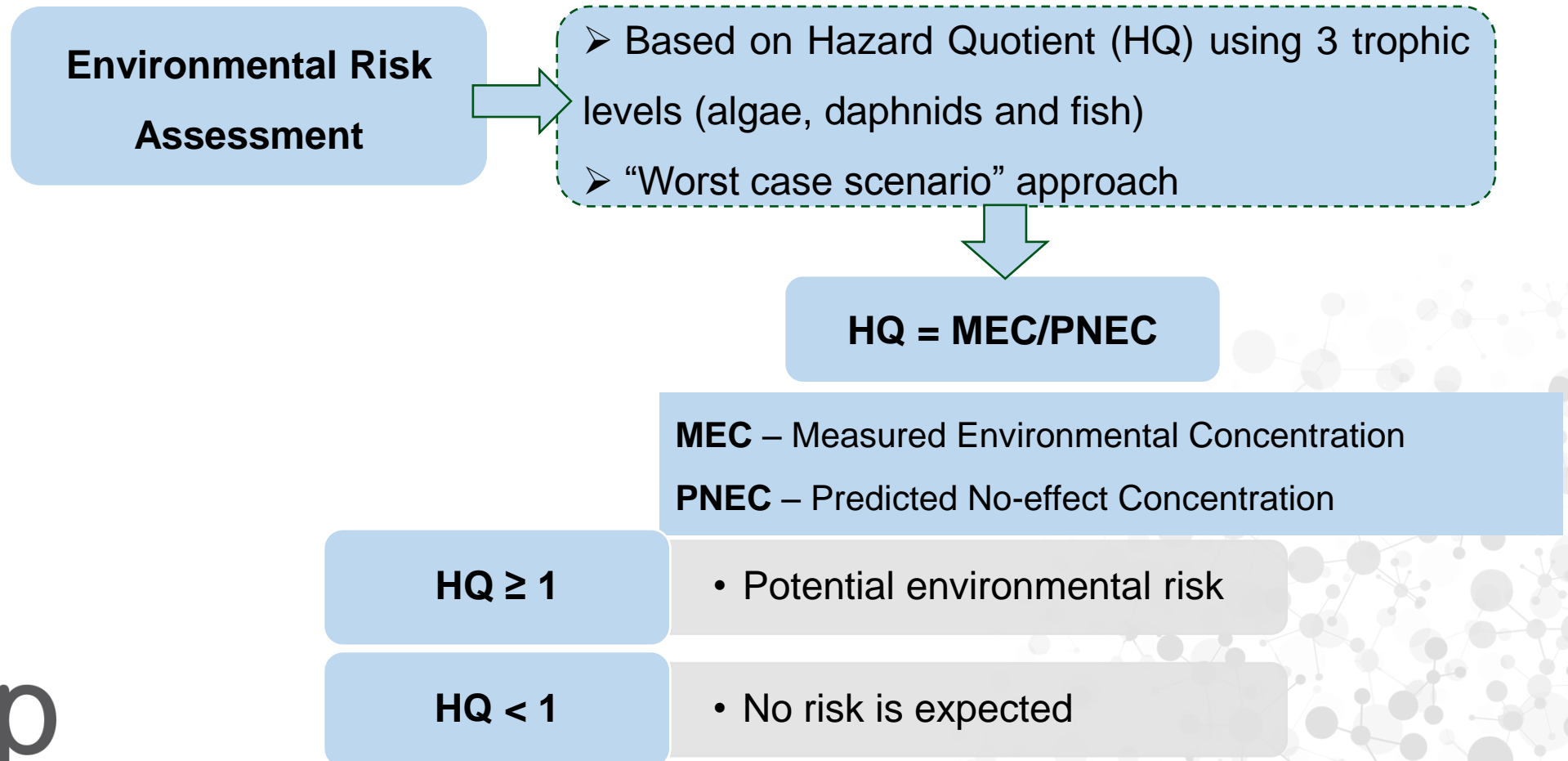


Increase of the population in the studied area during these months



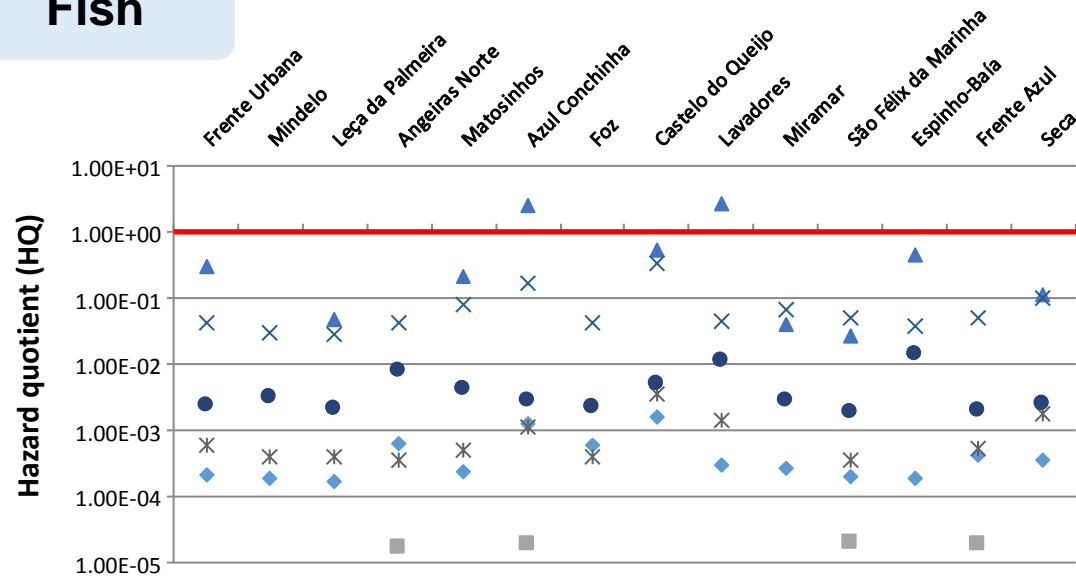
O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

ENVIRONMENTAL RISK ASSESSMENT



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

Fish

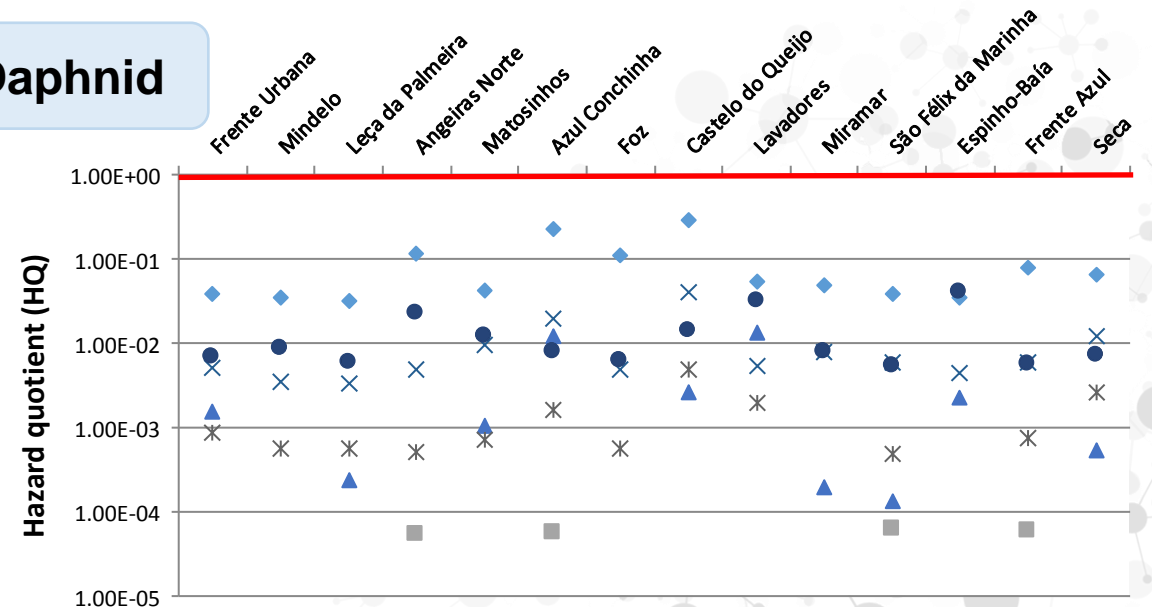


- ◆ Acetaminophen
- Acetylsalicylic acid
- ▲ Diclofenac
- × Ibuprofen
- * Naproxen
- Ketoprofen

ENVIRONMENTAL RISK ASSESSMENT - SEAWATERS

➤ Diclofenac

Daphnid



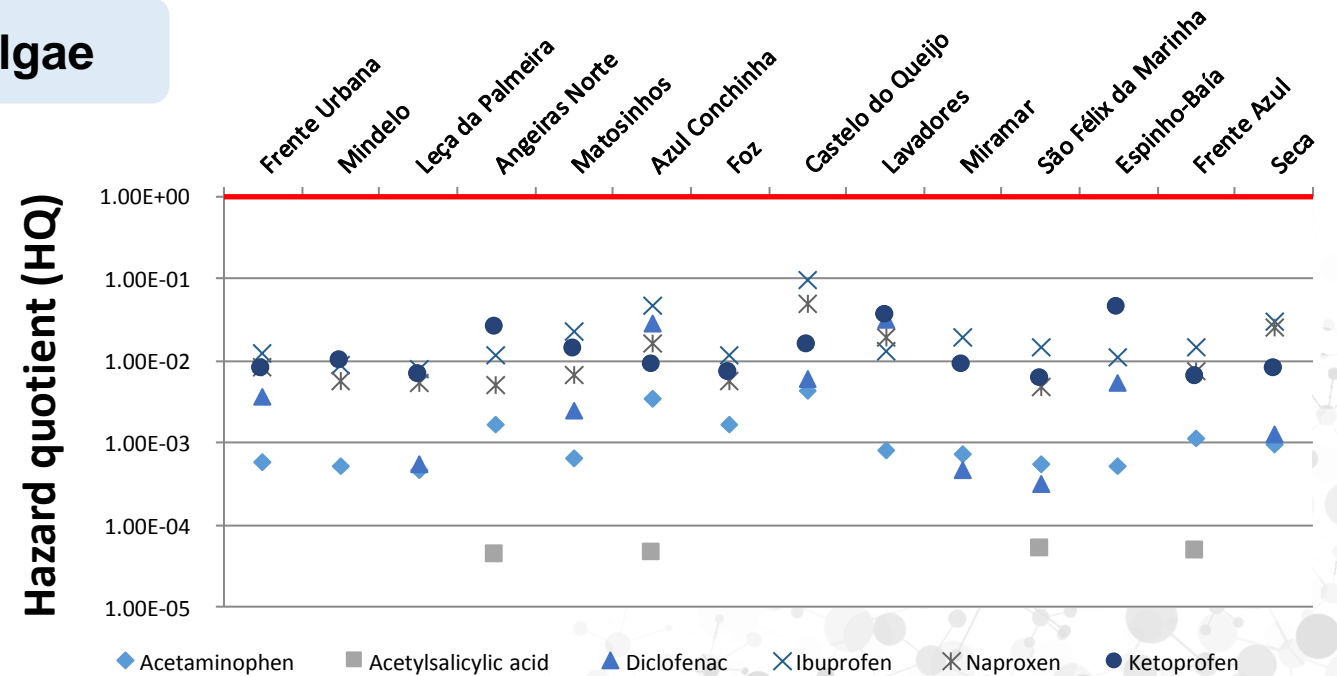
O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais



Algae

- ◆ Acetaminophen
- Acetylsalicylic acid
- ▲ Diclofenac
- × Ibuprofen
- ✖ Naproxen
- Ketoprofen

ENVIRONMENTAL RISK ASSESSMENT - SEAWATERS



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

PHARMACEUTICALS DETECTED BY OUR GROUP REQUIMTE/LAQV-ISEP

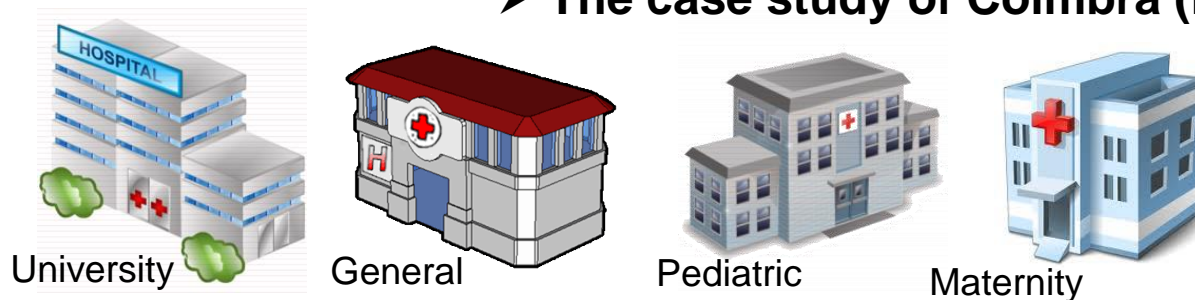
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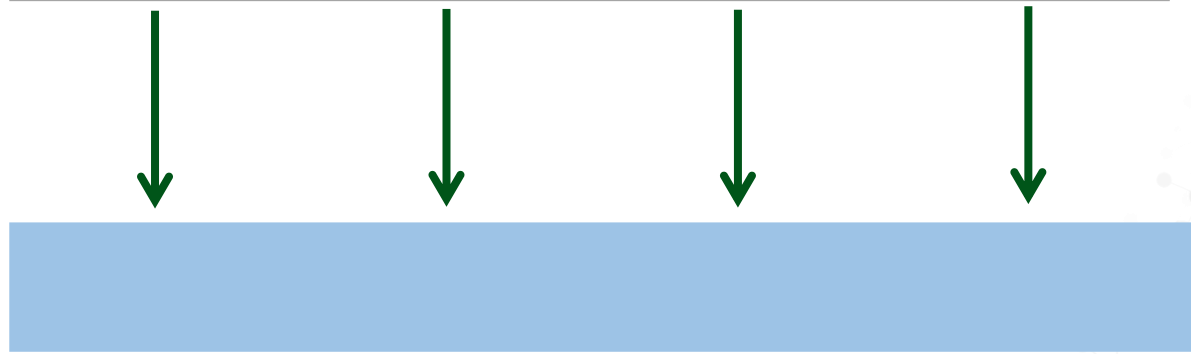
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CONTRIBUTION OF HOSPITAL EFFLUENTS TO THE LOAD OF PHARMACEUTICALS INTO URBAN WASTEWATERS

➤ The case study of Coimbra (Portugal)



Number of beds			
1456	350	110	96



- ✓ 78 pharmaceuticals
- ✓ 20 therapeutic classes
- ✓ SPE-UHPLC-MS/MS
- ✓ Sampling period: February-May 2011

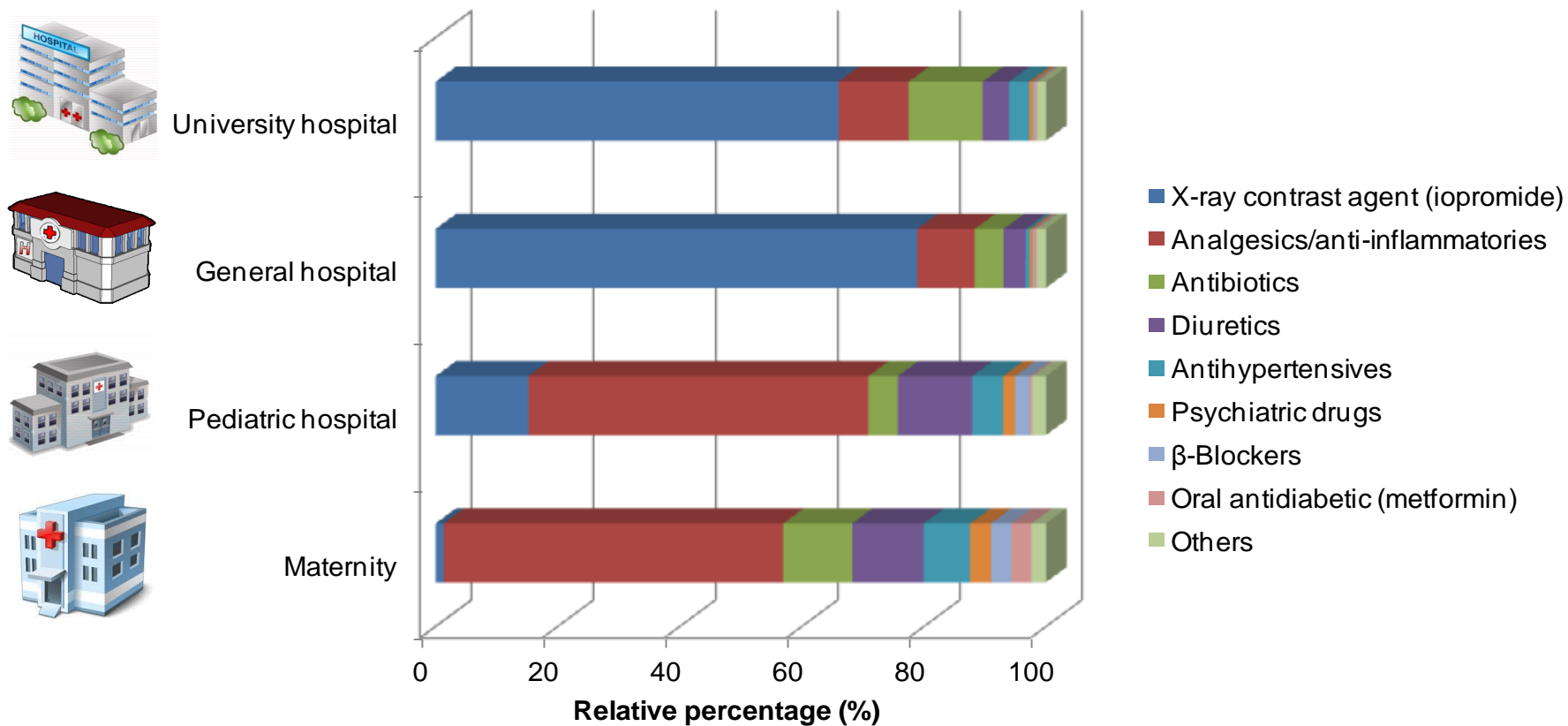


WWTP

O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

CONTRIBUTION OF HOSPITAL EFFLUENTS TO THE LOAD OF PHARMACEUTICALS INTO URBAN WASTEWATERS

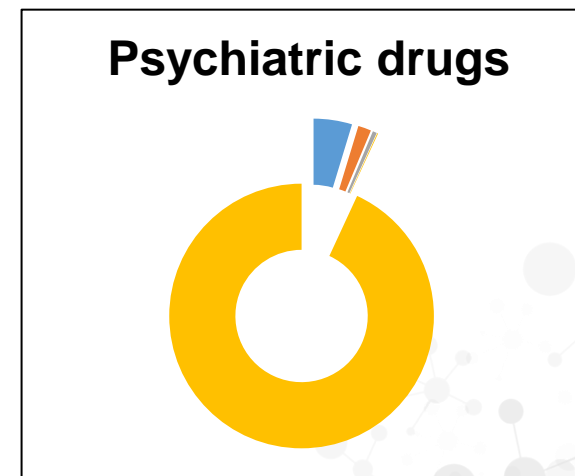
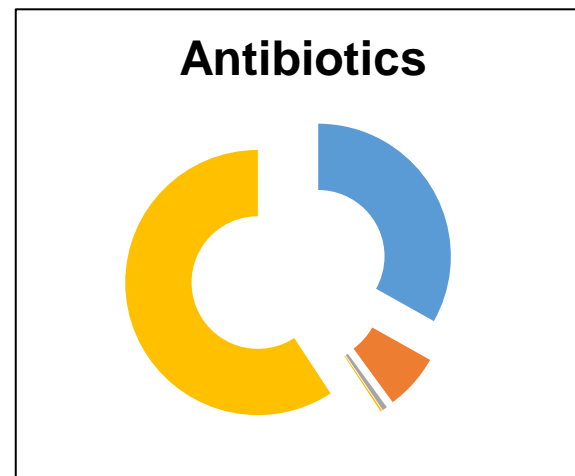
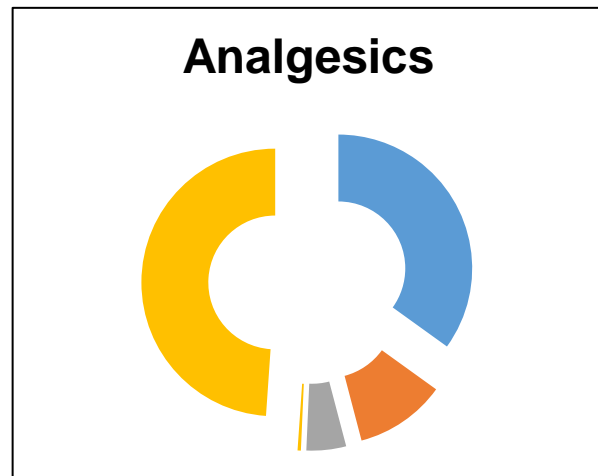
➤ Contamination pattern (relative concentration (%)) for each therapeutic class



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IMPACT OF HOSPITAL EFFLUENTS INTO URBAN WASTEWATERS

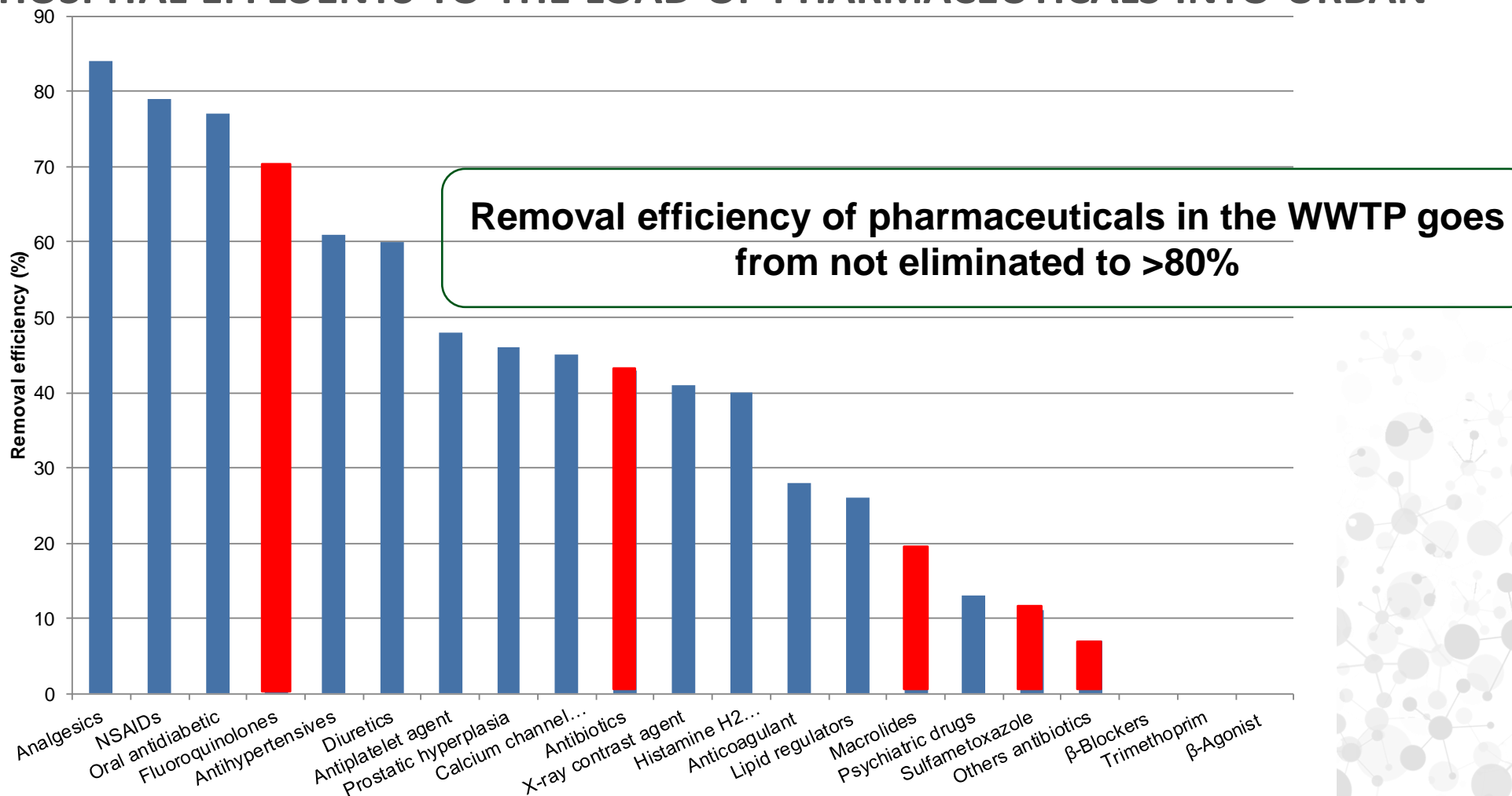
➤ Higher impact of hospital effluents



- University hospital
- General hospital
- Pediatric hospital
- Maternity hospital
- Urban input

O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

CONTRIBUTION OF HOSPITAL EFFLUENTS TO THE LOAD OF PHARMACEUTICALS INTO URBAN WASTEWATERS



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

ENVIRONMENTAL RISK ASSESSMENT – WWTP EFFLUENTS

- Pharmaceuticals that have a potential environmental risk (HQ > 1)

The level of pharmaceuticals found in WWTP effluents showed a more pronounced potential risk for algae



Pharmaceutical	HQ algae
Sulfamethoxazole	62.6
Ciprofloxacin	279
Ofloxacin	22.9
Azithromycin	15.6
Clarithromycin	3.34
Setraline	1.20

- **Antibiotics** are among pharmaceuticals that have a high potential environmental risk

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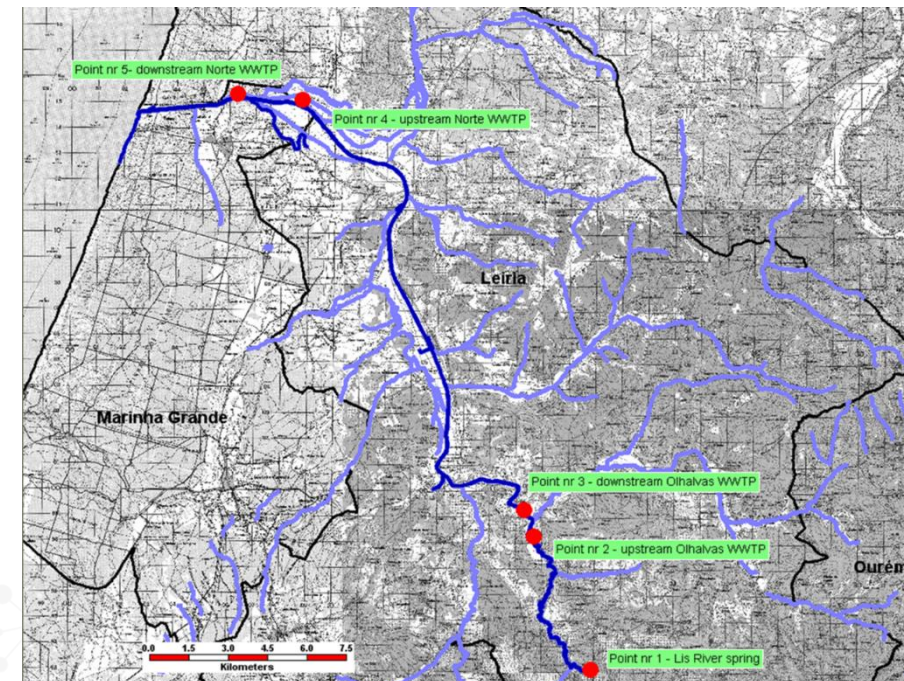
IMPACT OF URBAN WASTEWATERS TO THE LOAD OF PHARMACEUTICALS INTO SURFACE WATERS

- The impact of WWTP effluents was evaluated using Lis river as a case study
- Sampling points were selected through the river
- WWTPs that discharge their effluent into the river were also monitored

✓ 9 Sampling points:

- Source of Lis River
- Upstream WWTP of Olhalvas
- Downstream WWTP of Olhalvas
- WWTP of Olhalvas (influent and effluent)
- Upstream WWTP Norte
- Downstream WWTP Norte
- WWTP Norte (influent and effluent)

✓ Sampling period: August 2013-June 2014



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

WWTP 1



- Designed for 49,315 p.e.
- Secondary treatment by activated sludge
- Average capacity: 6250 m³/day

WWTP 2



- Designed for 248,685 p.e.
- Secondary treatment by activated sludge
- Tertiary treatment by UV during bathing season
- Average capacity: 37,997 m³/day

O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

Pharmaceuticals

Anti-inflammatories/Analgesic

- ❖ Ibuprofen
- ❖ Hydroxyibuprofen
- ❖ Carboxyibuprofen
- ❖ Acetaminophen
- ❖ Naproxen
- ❖ Ketoprofen
- ❖ Nimesulide
- ❖ Diclofenac
- ❖ Acetylsalicylic acid
- ❖ Salicylic acid

Psychiatric drugs

- ❖ Citalopram
- ❖ Diazepam
- ❖ Sertraline
- ❖ Fluoxetine
- ❖ Trazodone
- ❖ Venlafaxine
- ❖ Norfluoxetine
- ❖ Paroxetine
- ❖ Carbamazepine
- ❖ 10, 11-Epoxycarbamazepine

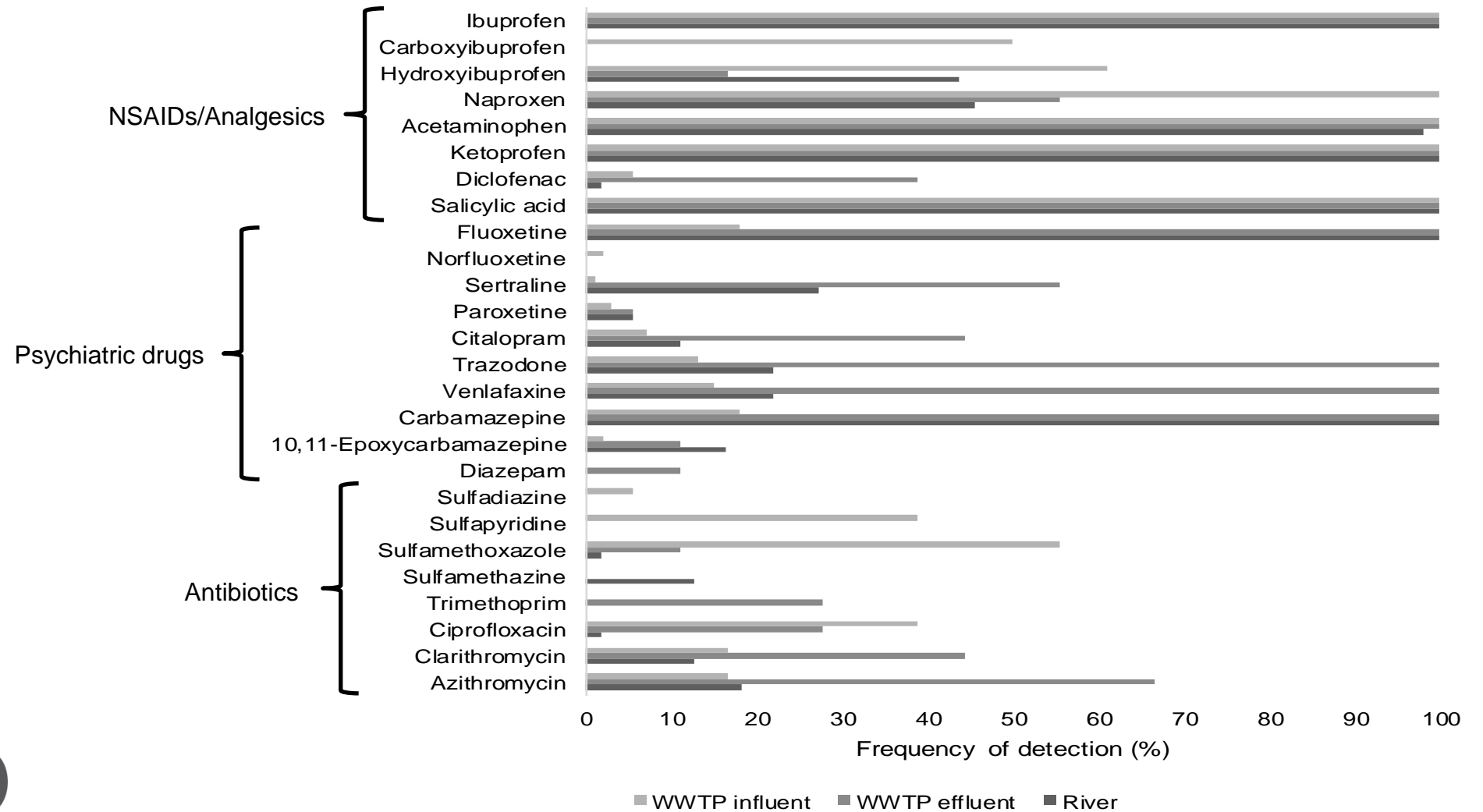
Antibiotics

- ❖ Clarithromycin
- ❖ Sulfadiazine
- ❖ Sulfadimethoxine
- ❖ Sulfamethazine
- ❖ Sulfamethoxazole
- ❖ Trimethoprim
- ❖ Ciprofloxacin
- ❖ Sulfapyridine
- ❖ Enrofloxacin
- ❖ Sulfamethoxypyridazine
- ❖ Azithromycin
- ❖ Ofloxacin

SPE-UHPLC-MS/MS



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

Source

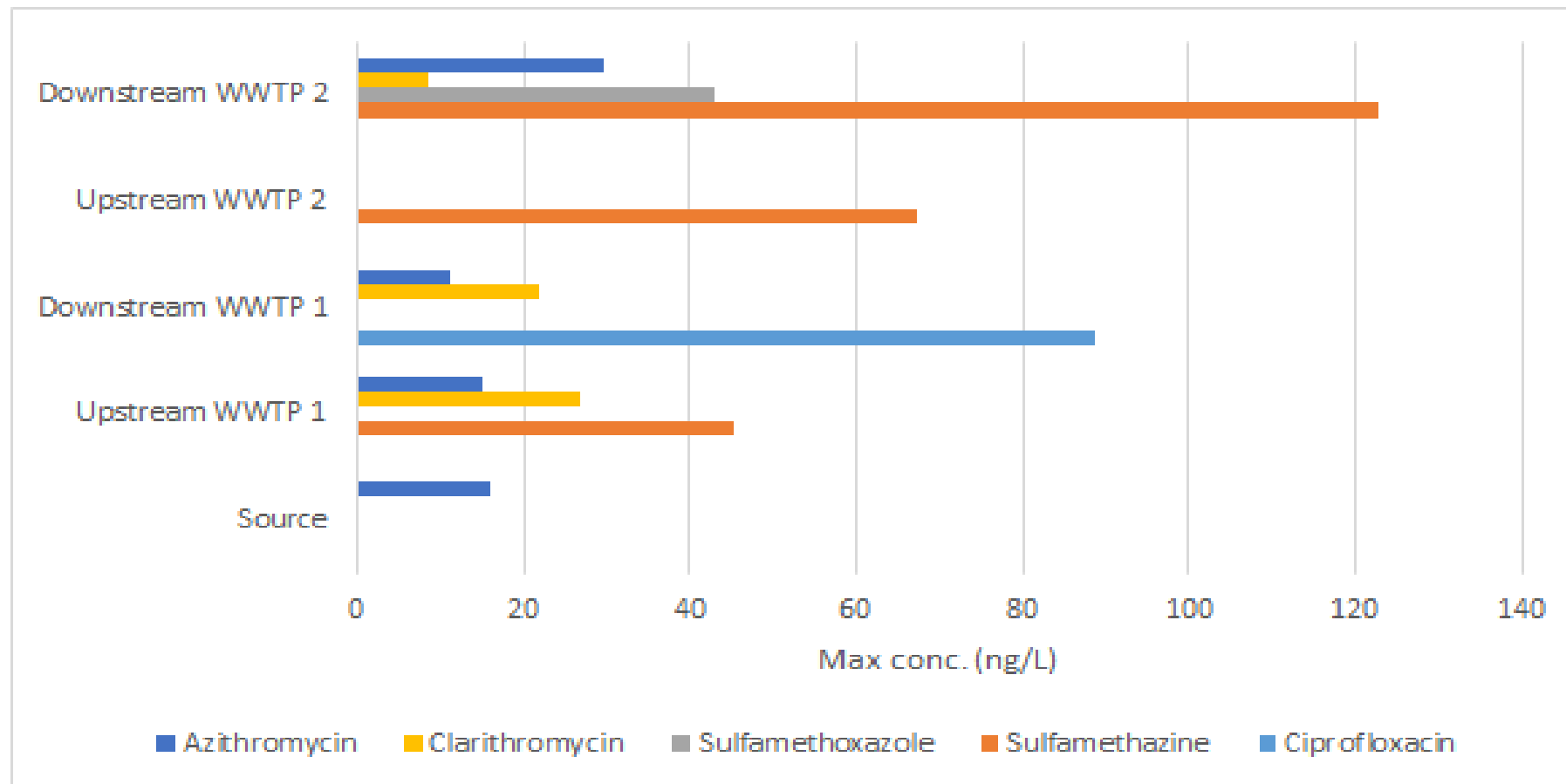
Downstream WWTP1

Downstream WWTP2

Upstream WWTP1

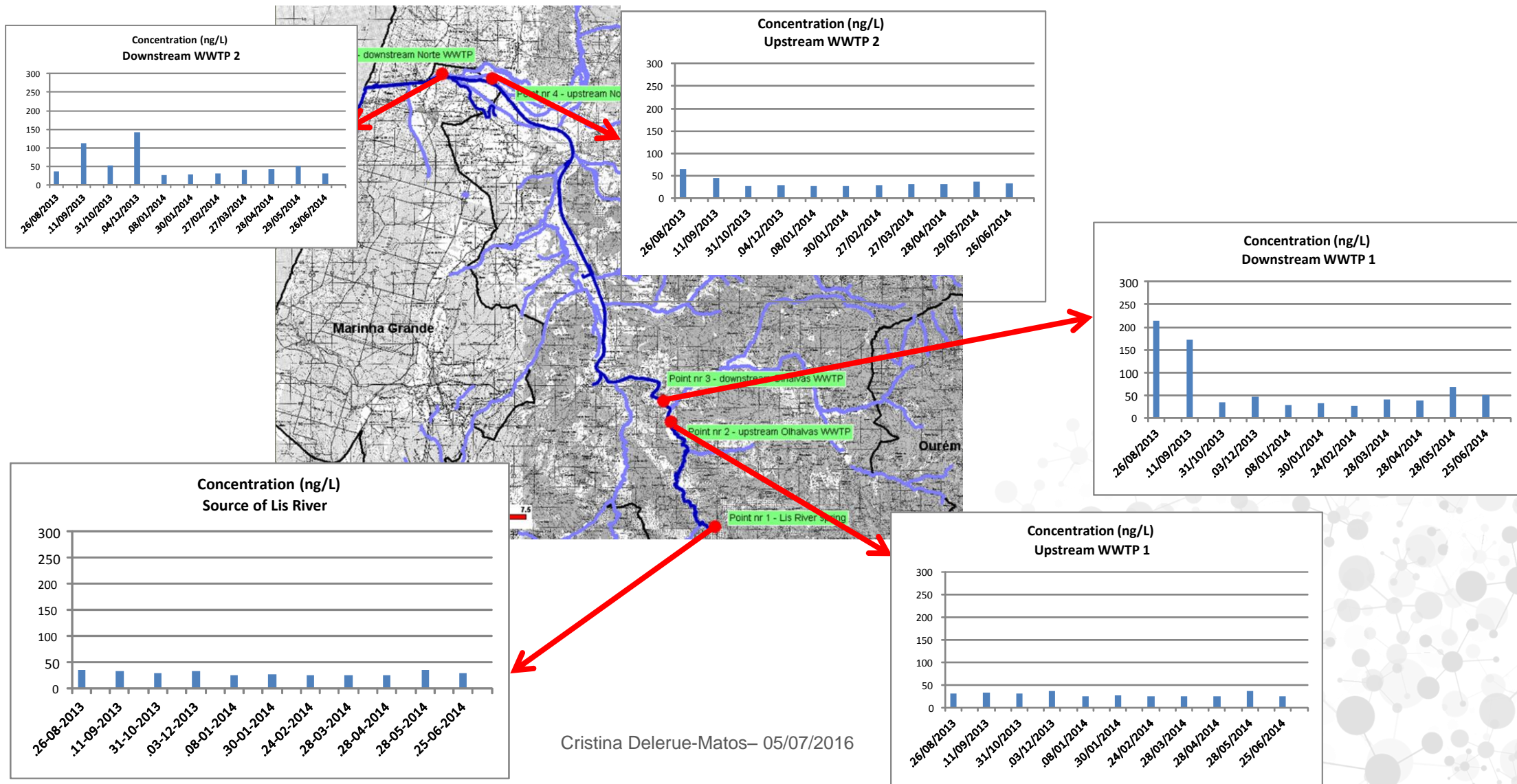
Upstream WWTP2

Antibiotics



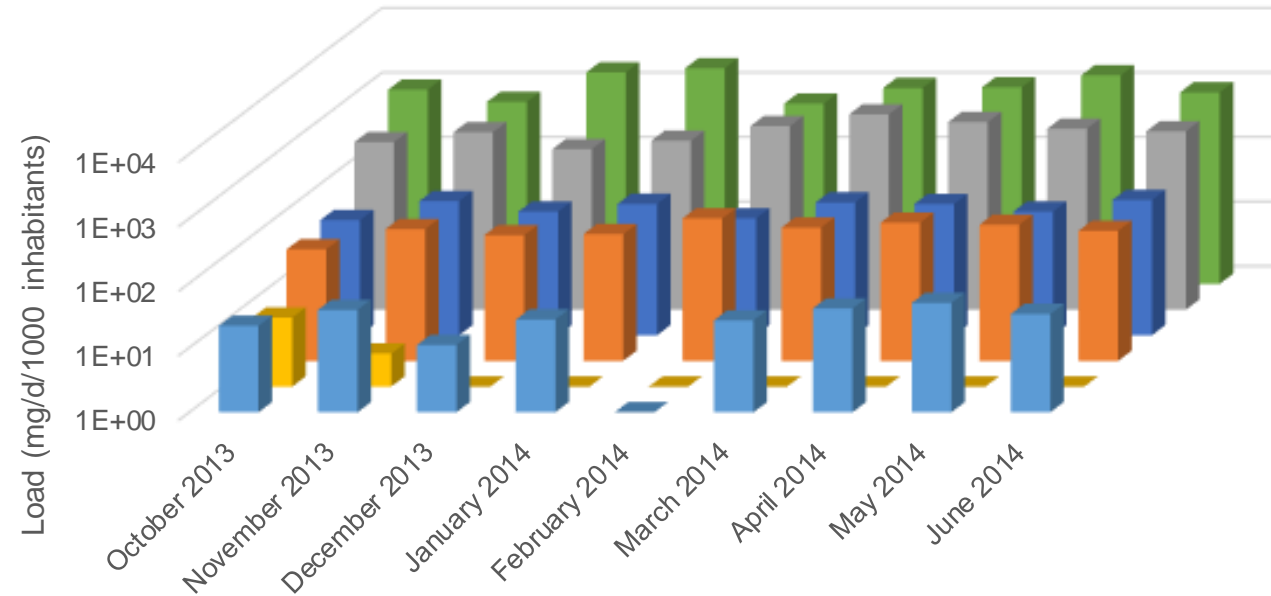
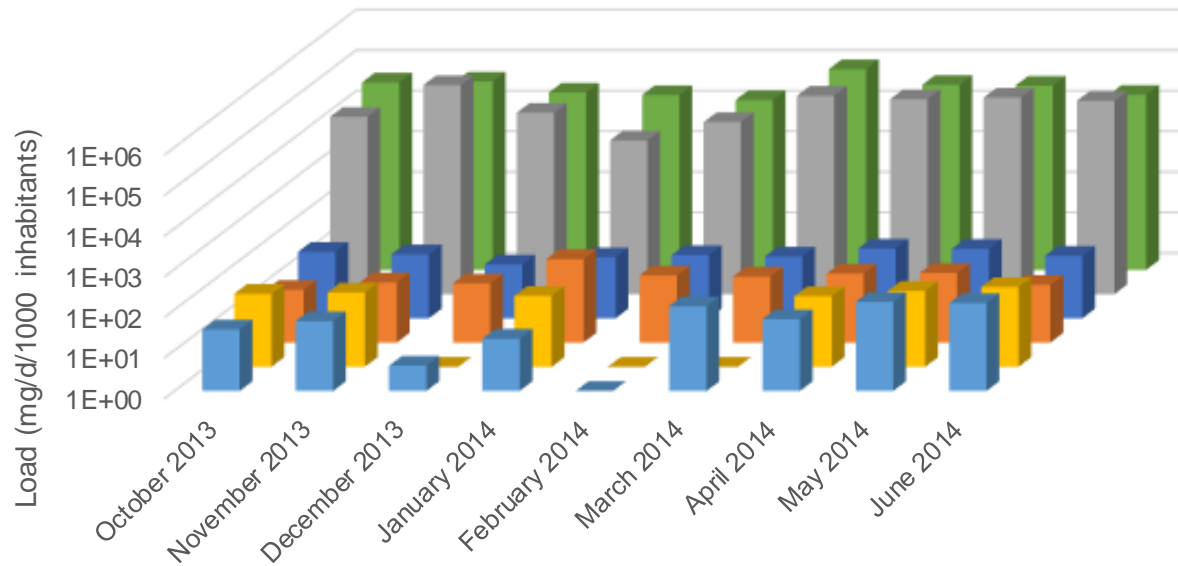
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Carbamazepine



Cristina Delerue-Matos– 05/07/2016

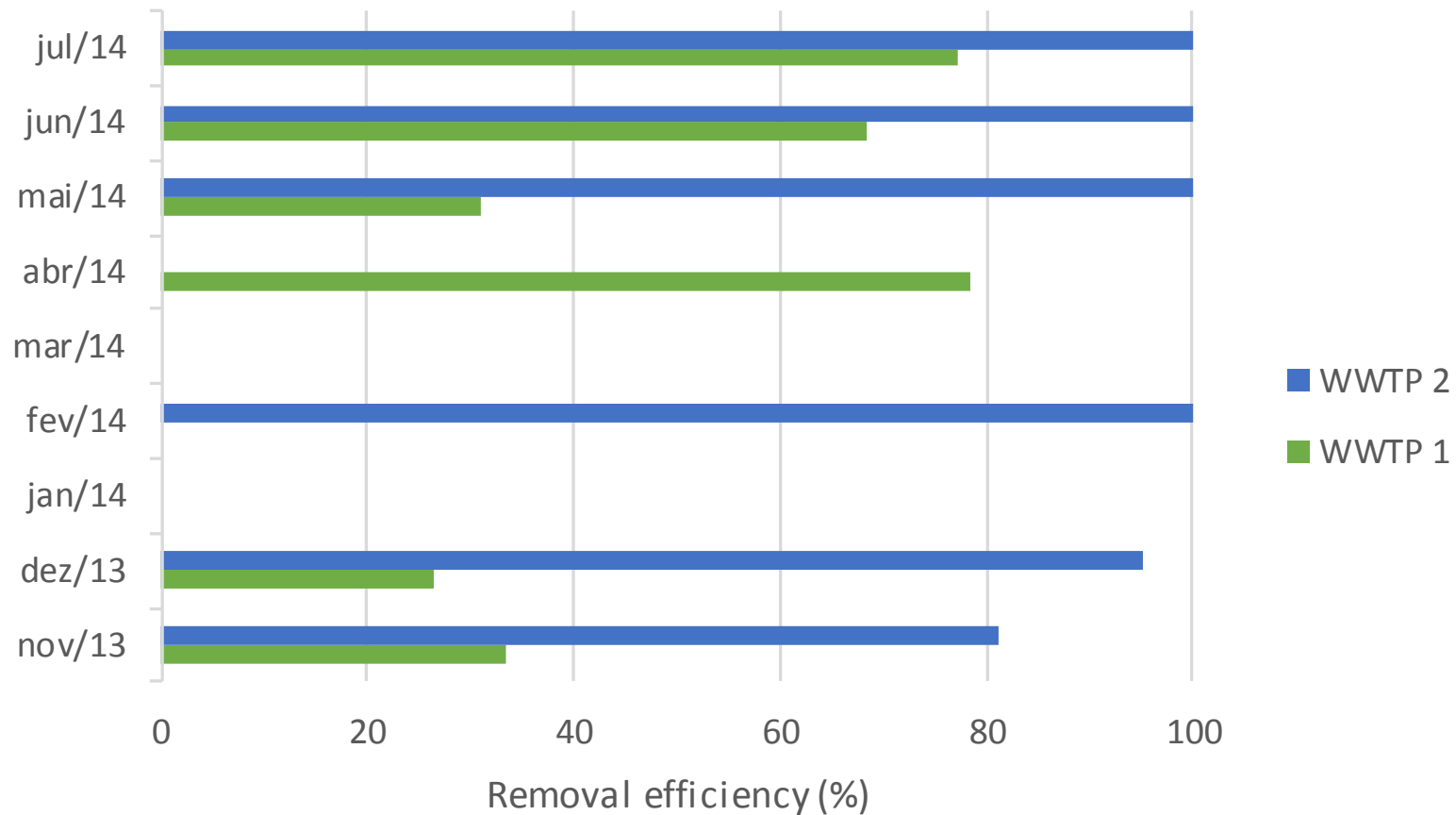
O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais



- Antibiotics (WWTP 1) ■ Antibiotics (WWTP 2)
- Psychiatric drugs (WWTP 1) ■ Psychiatric drugs (WWTP 2)
- NSAIDs/analgesics (WWTP 1) ■ NSAIDs/analgesics (WWTP 2)

O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

Antibiotics



➤ **WWTP 2 shows a higher removal efficiency of antibiotics than WWTP 1**

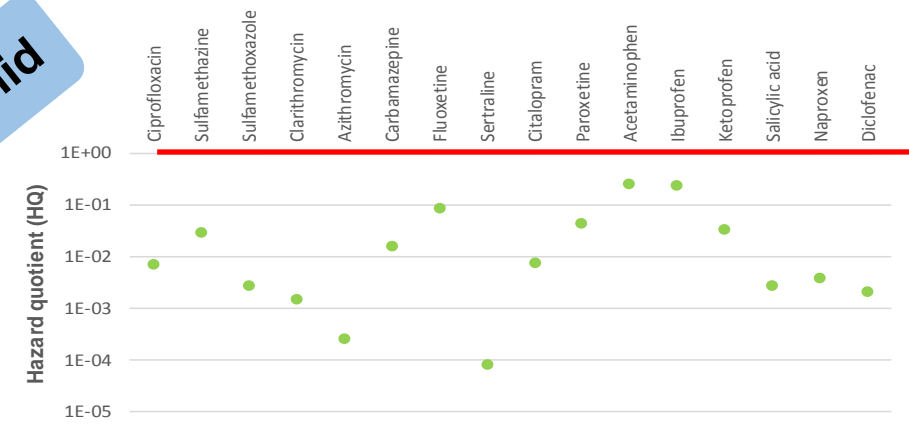
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ENVIRONMENTAL RISK ASSESSMENT – LIS RIVER

Fish

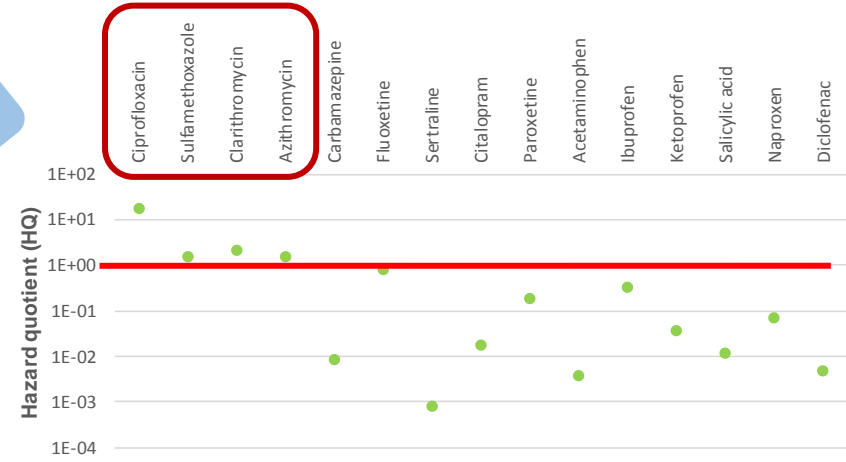


Daphnid



➤ **Ibutrofen**

Algae



- **Ciprofloxacin**
- **Sulfamethoxazole**
- **Clarithromycin**
- **Azithromycin**



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

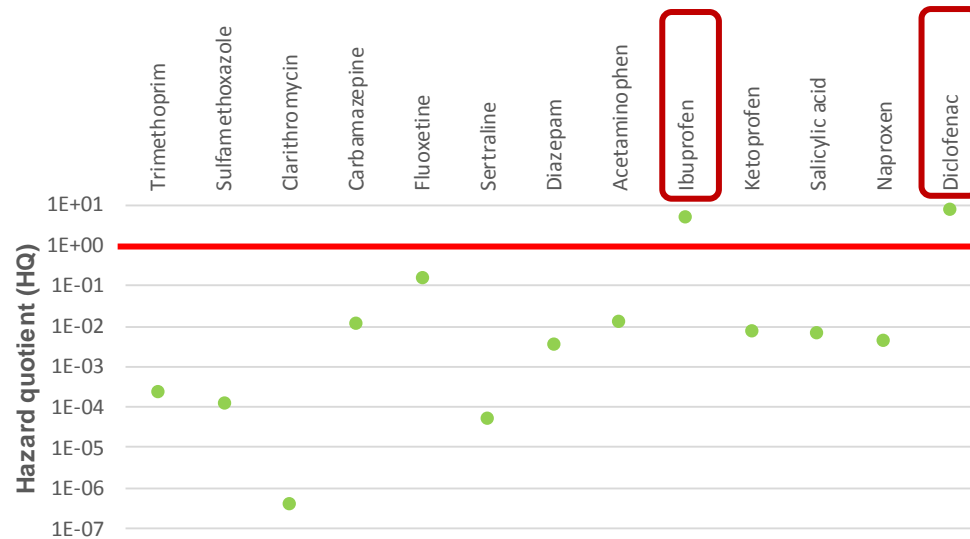
WWTP 1



ENVIRONMENTAL RISK ASSESSMENT WWTP EFFLUENTS

Fish

WWTP 2



- Ibuprofen
- Diclofenac

O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

WWTP 1

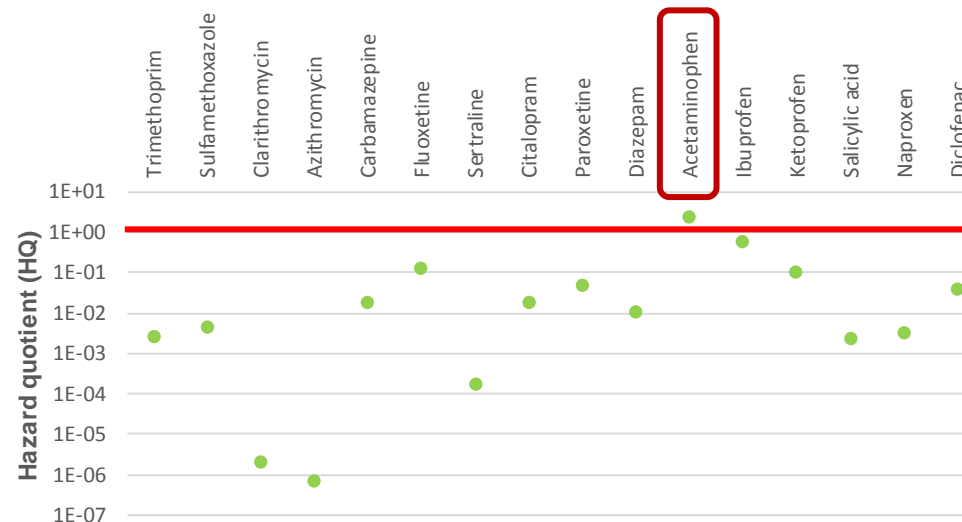


ENVIRONMENTAL RISK ASSESSMENT WWTP EFFLUENTS

Daphnid

➤ Acetaminophen

WWTP 2



O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

WWTP 1



- Ciprofloxacin
- Sulfamethoxazole
- Clarithromycin
- Azithromycin
- Fluoxetine

WWTP 2



- Sulfamethoxazole
- Fluoxetine

ENVIRONMENTAL RISK ASSESSMENT WWTP EFFLUENTS

Algae

O problema dos poluentes emergentes e a sua presença em águas superficiais e águas residuais

CONCLUSIONS:

- ✓ The presence of different therapeutic classes was quantified in portuguese surface waters (rivers, stream, estuaries, seawaters)
- ✓ Wastewaters are an important source of entrance of pharmaceuticals into the environment
- ✓ The contribution of hospital effluents to the load of pharmaceuticals to urban wastewaters varies among therapeutic classes and from hospital to hospital
- ✓ More monitoring studies should be made in order to better understand the level of environmental pollution
- ✓ Green pharmacy approach is a challenge in nowadays
- ✓ New remediation technologies and solutions have to be found

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ACKNOWLEDGEMENTS

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- **Paula Celeste Batista Paíga**



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Muito Obrigada/o pela Vossa Atenção/ Thank you for your attention

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