Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment
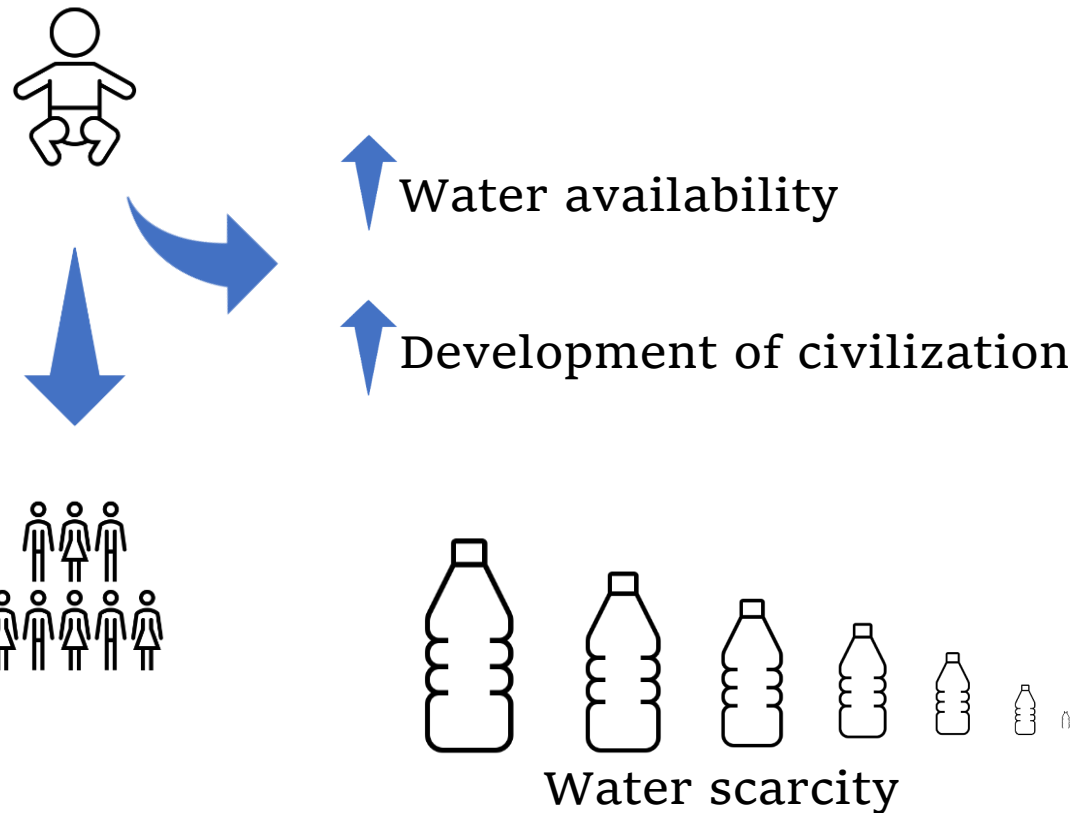
Direct potable reuse: a prioritization of emerging contaminants for monitoring strategies and pilot-scale advanced treatment

Vinicíus Diniz

January 19th, 2023, 12:35

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Let's talk about water in Brazil

↑ Water availability

↑ Development of civilization

Water scarcity

In 2014, a severe water crisis in São Paulo state, Brazil, showed a fragile water distribution system

Reuse water treatment plant

(RWTP)

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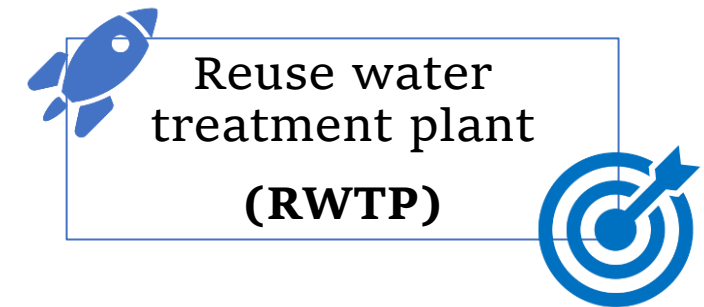
15 **Antimicrobials**

Sulfamethoxazole Tetracycline
Ciprofloxacin Cloxacillin
Azithromycin Levofloxacin
Cefepime Imipenem
Ampicillin Amoxicillin
Trimethoprim Chloramphenicol
Penicillin Cefazoline
Piperacillin

Antidiabetics Metformin

Antihypertensives Atenolol
Propranolol
Captopril

45+6

11 **Antipsychotics**

Fluoxetine Nortriptilina
Bupropion Amitriptyline
Escitalopram Sertraline
Clonazepam Trazadone
Carbamazepine Alprazolam
Diazepam

Antiallergic Fexofenadine

Corticosteroid Dexamethasone

Diuretic Hydrochlorothiazide

Cytotoxic Capecitabine

Antiacid Ranitidine

Anthelmintics Albendazole
Ricobendazole

4 **NSAIDs** Diclofenac
Ibuprofen
Acetaminofem
Piroxicam

6 **Artificial sweeteners** Sucralose
Saccharin
Acesulfame
Cyclamate
Neotame
Stevioside

SAIDs Prednisolone

Antilipidemic Simvastatin

Anesthetics Lidocaine

Stimulant Caffeine

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EPAR Capivari II

Non-potable reuse treatment plant

Preliminary treatment → Activated sludge → Anaerobic chamber

Anaerobic chamber ↓ Anoxic chamber

Ultrafiltration membrane ← Aerobic chamber ← Anoxic chamber

Membrane bioreactor technology

Parameter	Effluent of the EPAR Capivari II
Color (mg Pt-Co L^{-1})	46
pH	7.59
Turbidity (NTU)	0.2
Conductivity (μS cm^{-1})	622.0
Biological oxygen demand (mg L^{-1})	<1
Chemical oxygen demand (mg L^{-1})	32
Total phosphorus (mg-P L^{-1})	3.90
Ammoniacal Nitrogen (mg L^{-1})	< 0.01
Total Kjeldahl Nitrogen (mg L^{-1})	2.16
Nitrate Nitrogen (mg L^{-1})	4.29
Nitrite Nitrogen (mg L^{-1})	<0.015

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What do we monitor in the EPAR Capivari II? And How did we do it?
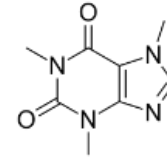

Albendazole
LOQ: 100 ng/L
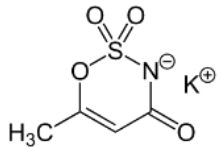
Acesulfame
LOQ: 1,000 ng/L
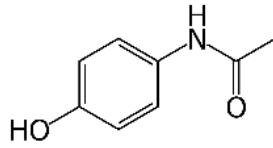
Acetaminophen
LOQ: 500 ng/L

Caffeine
LOQ: 100 ng/L

Carbamazepine
LOQ: 10 ng/L

Diclofenac
LOQ: 500 ng/L

Hydrochlorothiazide
LOQ: 1000 ng/L

Propranolol
LOQ: 500 ng/L

Ricobendazole
LOQ: 500 ng/L
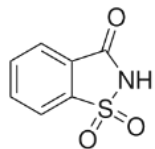
Saccharin
LOQ: 1000 ng/L
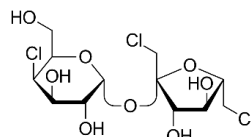
Sucralose
LOQ: 1000 ng/L
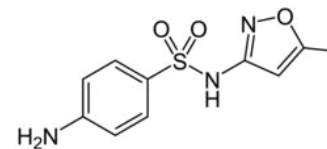
Sulfamethoxazole
LOQ: 100 ng/L

Bidimensional liquid chromatography coupled to tandem mass spectrometry

(LC-UHPLC-MS/MS)

1st dimension: Sample concentration
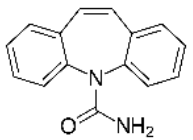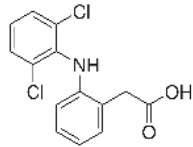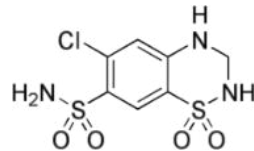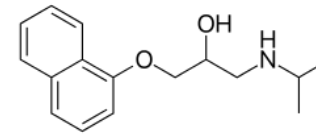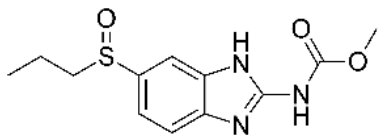
2nd dimension: Analytical separation

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The prioritization process
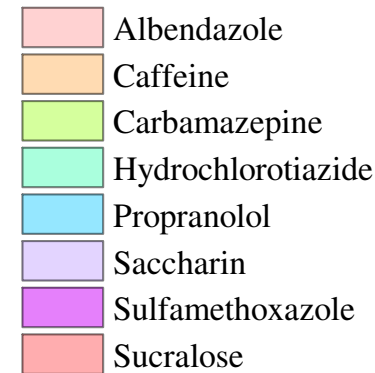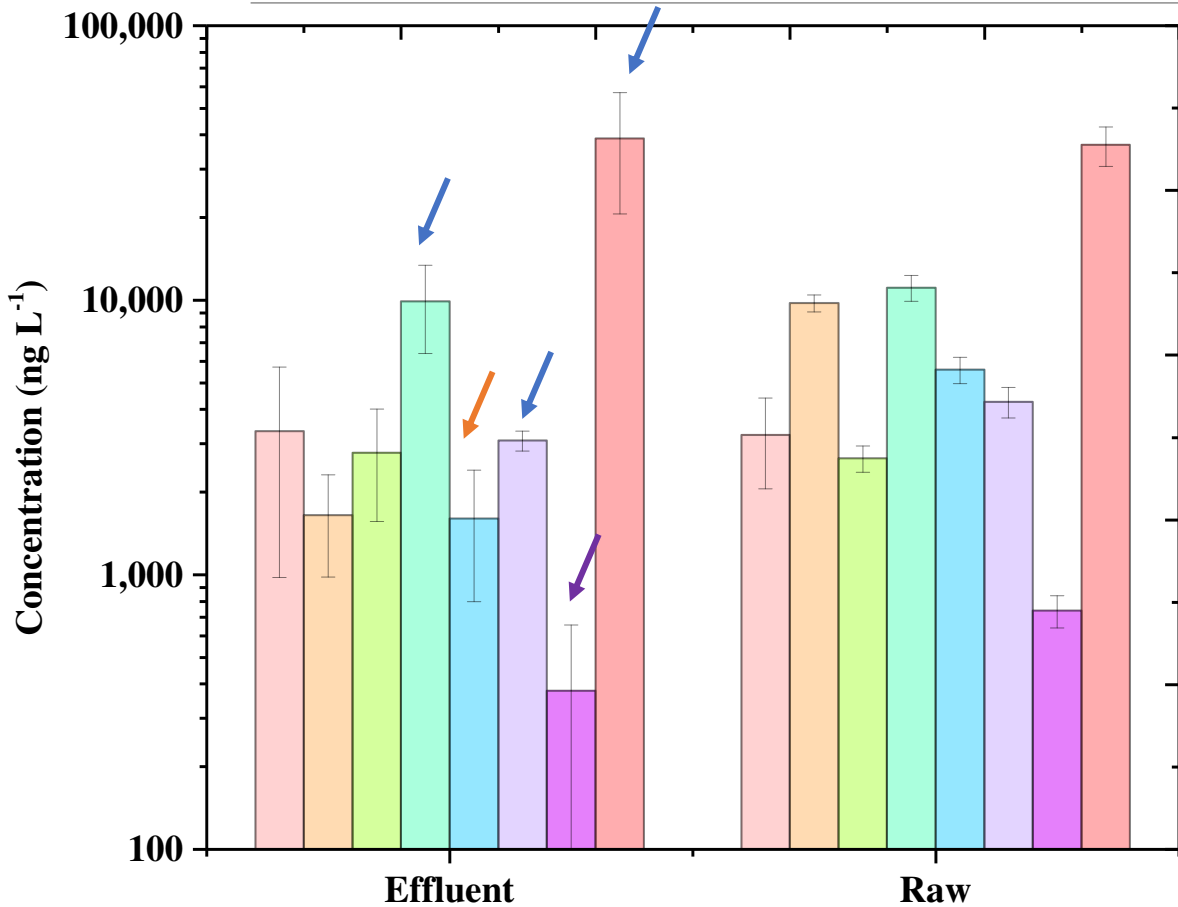
Selected due to the high concentration in the effluent;

Selected due to its use as an anthropogenic marker;

Selected due to the risk of development of antimicrobial resistance genes in bacteria;

- Acetaminophen (raw: 4,121.1 – 4,746.8 ng L^{-1})
- Acesulfame (raw: 1,787.9 – 2,154.1 ng L^{-1})
- Diclofenac (raw: 746 – 1031.1 ng L^{-1})
- Ricobendazole was observed neither in raw nor effluent.

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What do we need in a RWTP?

Redundancy

Robustness

Resilience

Reliability

Multibarrier process

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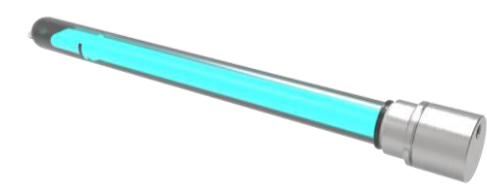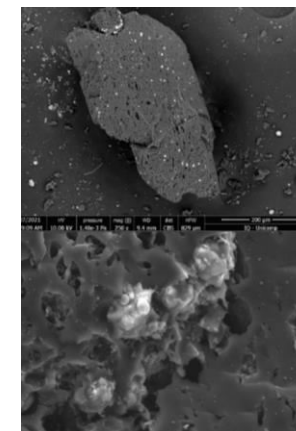
8

So, what tests did we carry out here?
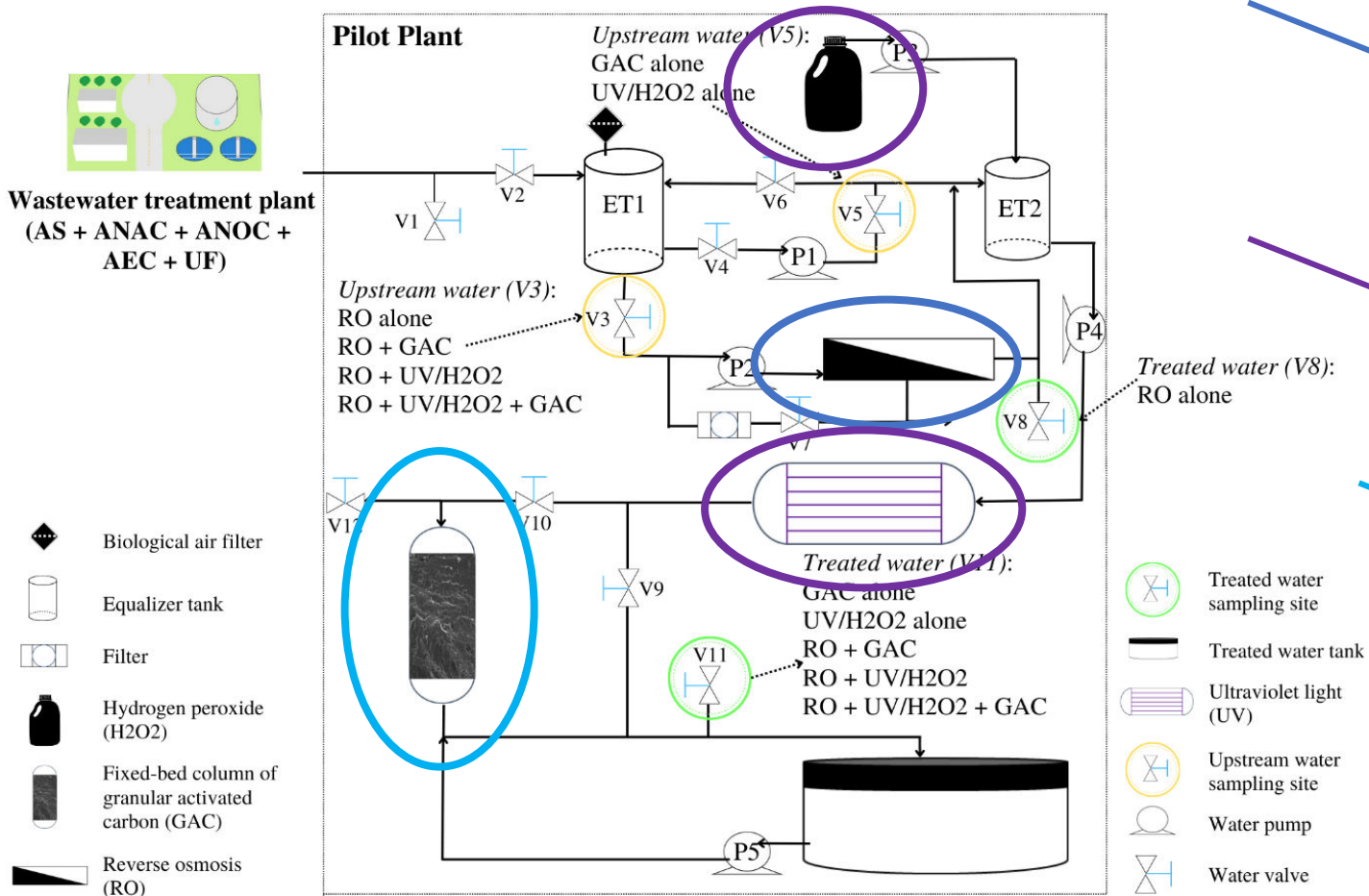
Reverse osmosis membrane

12 UV-C lamps (55 W) and

6 mg/L H_2O_2

Fixed bed column loaded with granular activated carbon (2.2 x 0.2 m)

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What results did we get?

What results did we get?

Legend:
- Caffeine
- Hydrochlorothiazide
- Saccharin
- Sulfamethoxazole
- Sucralose

Y-axis: Removal (%)

Reverse osmosis and Photoperoxidation and Fixed bed column
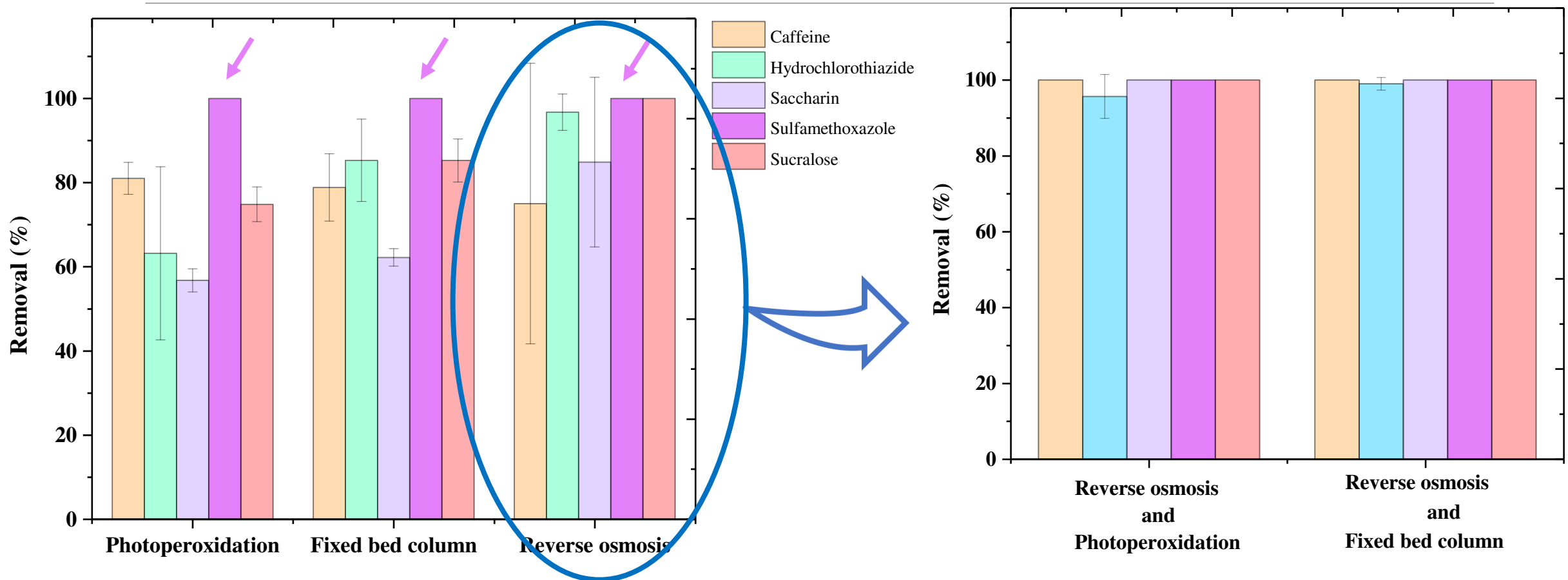
Effluent of the EPAR Capivari II
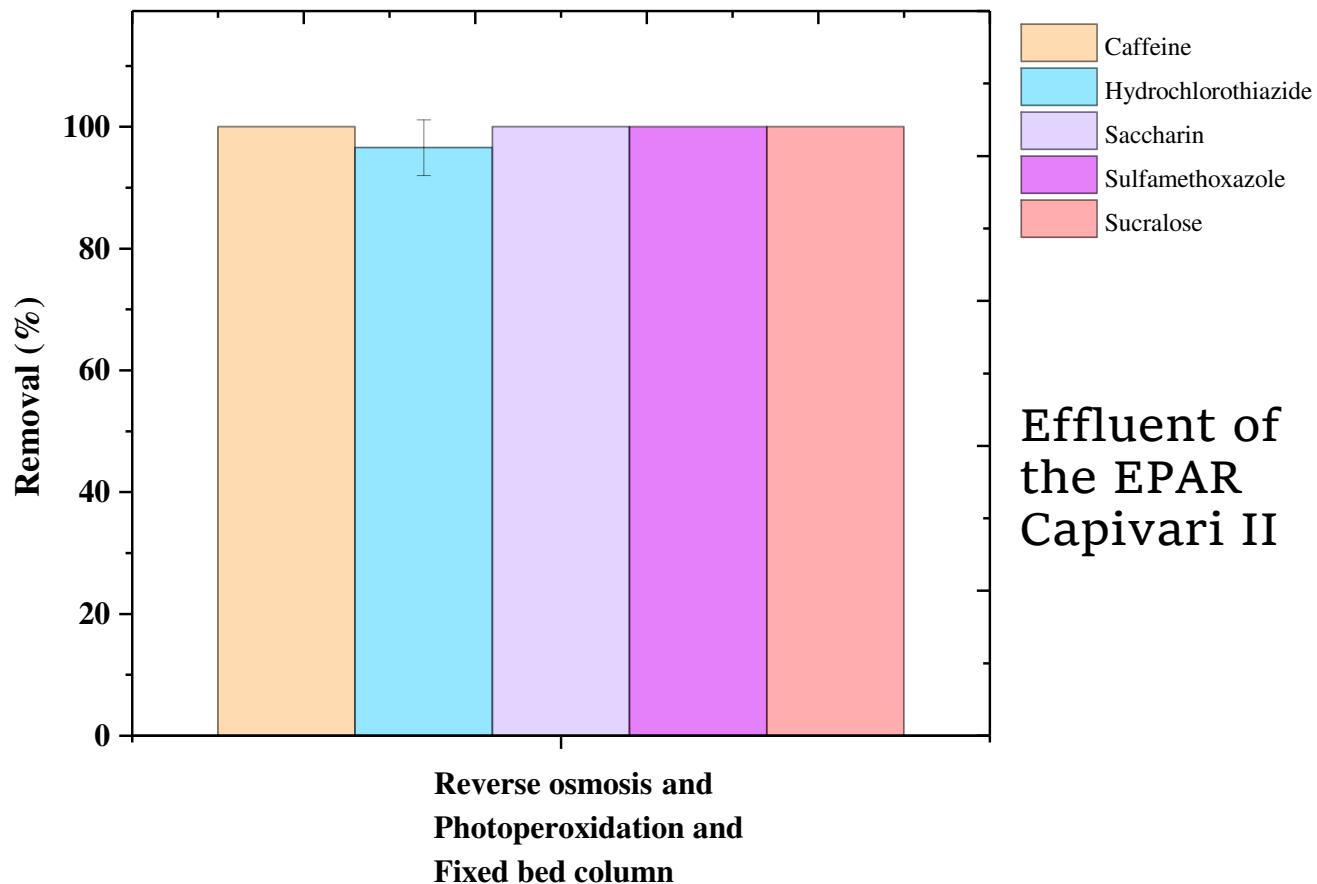
Effluent of the pilot plant

The effluent met all the parameters of the Brazilian guidelines for potability purposes!

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Take home messages

- The demand for potable water is increasing;

- **Direct potable reuse** is complex but can battle **against water scarcity**;

- The **prioritization** of emerging contaminants is essential to **drive government efforts**;

- In Brazil, DPR is on its first steps for being implemented;

- **Caffeine and Sucralose** are interesting emerging contaminants for monitoring purposes;

- The multibarrier process (reverse osmosis, photoperoxidation, and fixed bed columns loaded with activated carbon) of the pilot plant met Brazilian guidelines for potability.

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Acknowledgments

Thank you for your attention?

Questions?

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