

# Removal of emerging pollutants in conventional and microalgae based biotechnology urban wastewater treatment plants



E. Villar-Navarro<sup>1,2</sup> R. M. Baena-Nogueras<sup>2</sup>, M. Paniw<sup>3</sup>, C. Garrido-Perez<sup>1</sup>, P.A. Lara-Martin<sup>2</sup>, J.A. Perales<sup>1</sup>  
 elena.villarnavaro@alum.uca.es//joseantonio.perales@uca.es

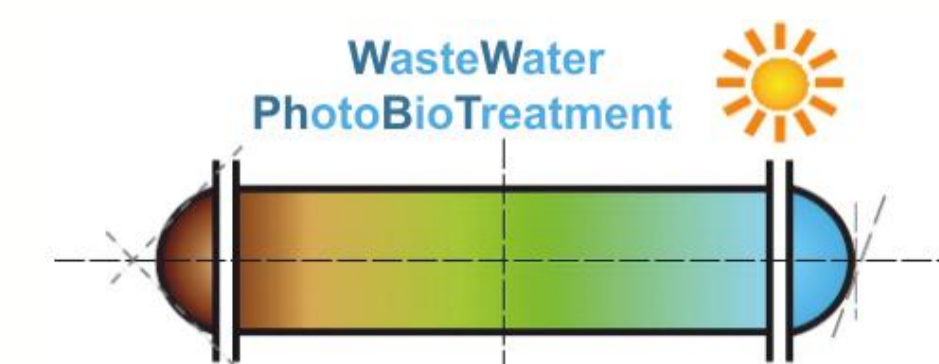
<sup>1</sup>Environmental Technologies Department – Centro Andaluz de Ciencia y Tecnologías Marinas (CACYTMAR)

<sup>2</sup>Physical Chemistry Department – Centro Andaluz de Ciencia y Tecnologías Marinas (CACYTMAR)

<sup>3</sup>Biology Department – Centro Andaluz Superior de Estudios Marinos (CASEM)

Universidad de Cádiz. Campus Rio San Pedro, 11510, Puerto Real, Spain.

Campus de Excelencia Internacional del Mar (CEI-MAR) y Campus de Excelencia Internacional de Agroalimentación (ceiA3)



## INTRODUCTION

Emerging Contaminants are a myriad of trace organic compounds including prescription and over-the-counter pharmaceuticals, veterinary, personal care products like cosmetics, sunscreens and fragrances [1]. One of the biggest contributors of pharmaceuticals in the environment are wastewater treatment plants (WWTPs) [2]. The removal of some pharmaceuticals in conventional wastewater treatment plants is rather low due to their high solubility and low biodegradability [3]. Microalgae biotechnology offers an interesting solution to tertiary treatments due to the ability of use inorganic nitrogen and phosphorus as well as their capacity to remove heavy metals and some organic chemicals [4].

## Emerging pollutants studied

- Pharmaceutically Active Compounds (PhACs)
- Analgesics & antiinflammatories
  - Antihypertensives
  - Lipid Regulators
  - Psychiatric drugs
  - Antibiotics
  - Others

## Experimental technologies

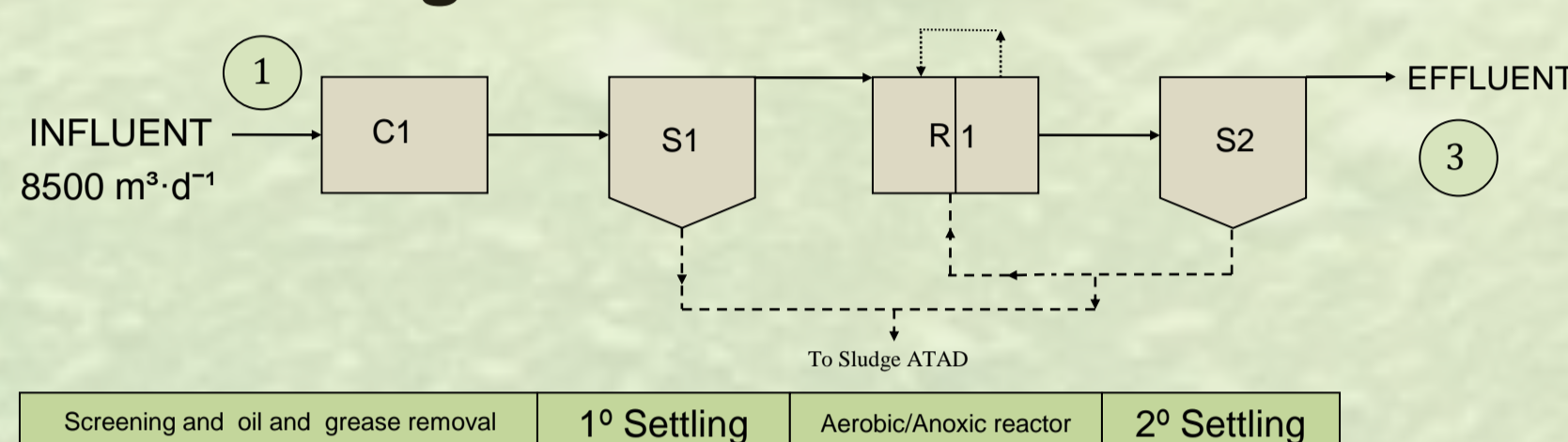
- Upflow Anaerobic Sludge Blanket (UASB)
- Useful volume: 20 m<sup>3</sup>
  - HRT: 14.6 – 18 hours
- High Rate Algae Pond (HRAP)
- Useful volume: 9 m<sup>3</sup>
  - HRT: 6 - 7 days
- HOW DO THEY REMOVE PhACs?

## OBJECTIVE

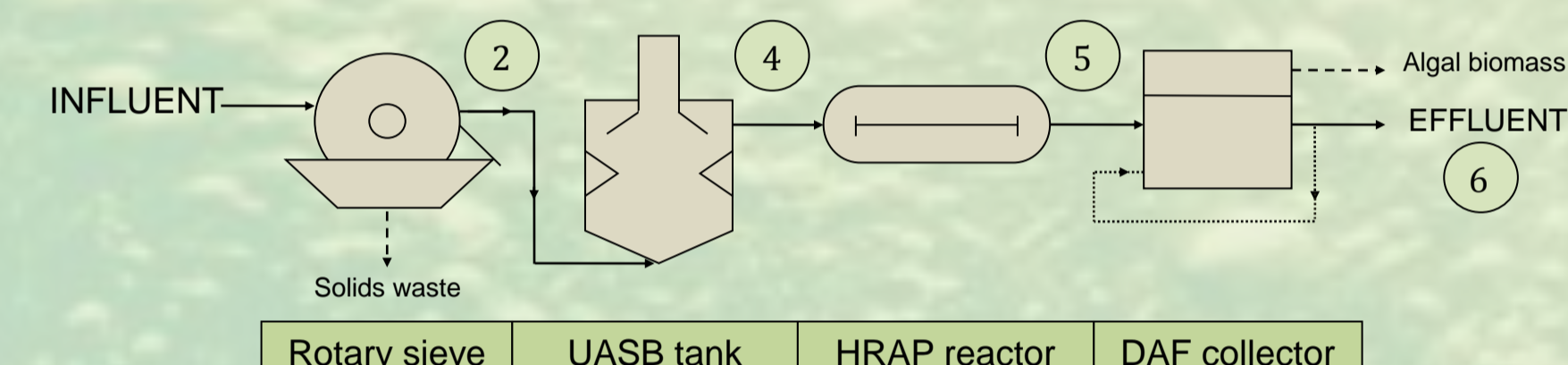
The main objective of this work is to **quantify** and **compare** the removal of **pharmaceuticals (n=81)** using **conventional** and **microalgae based treatment technologies** in **outdoor large pilot scale**.

## MATERIAL & METHODS

Figure 1: WWTP monitored



The **conventional** Municipal WWTP, *El Torno*, is located in Chiclana de la Frontera (Spain) (36°25'38"N 6° 9'21"W), serves a population of **45000 equivalent inhabitants** and actually treats an average flow rate of **8500 m<sup>3</sup>·d<sup>-1</sup>**.



The **non conventional** WWTP, was a pilot scale installation located in the WWTP *El Torno*. This experimental treatment process (ALL-GAS Project) consist of **three UASB** operated at ambient temperature followed by **six HRAP** that treat an average flow rate of **9 m<sup>3</sup>·d<sup>-1</sup>**.

## Monitoring program

**FEBRUARY**  
**2015**  
**JULY**

Time-integrated sampling was started at different times of the day in the six sampling points (figure 1) to approximately compensate for the HRT of each treatment step.

During sample collection, ice gel box was placed on auto-sampler to prevent degradation. The same day of sample collection water samples (700 mL) were filtered through Whatman GF/C glass fiber filters (0.45 µm pore size).



600 mL of filtered sample were destined to pharmaceuticals analysis while 100 mL of filtered and 100 mL of non filtered sample were used for conventional wastewater characterization analysis; Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Nitrogen (TDN) and Total Dissolved Phosphorus (TDP).

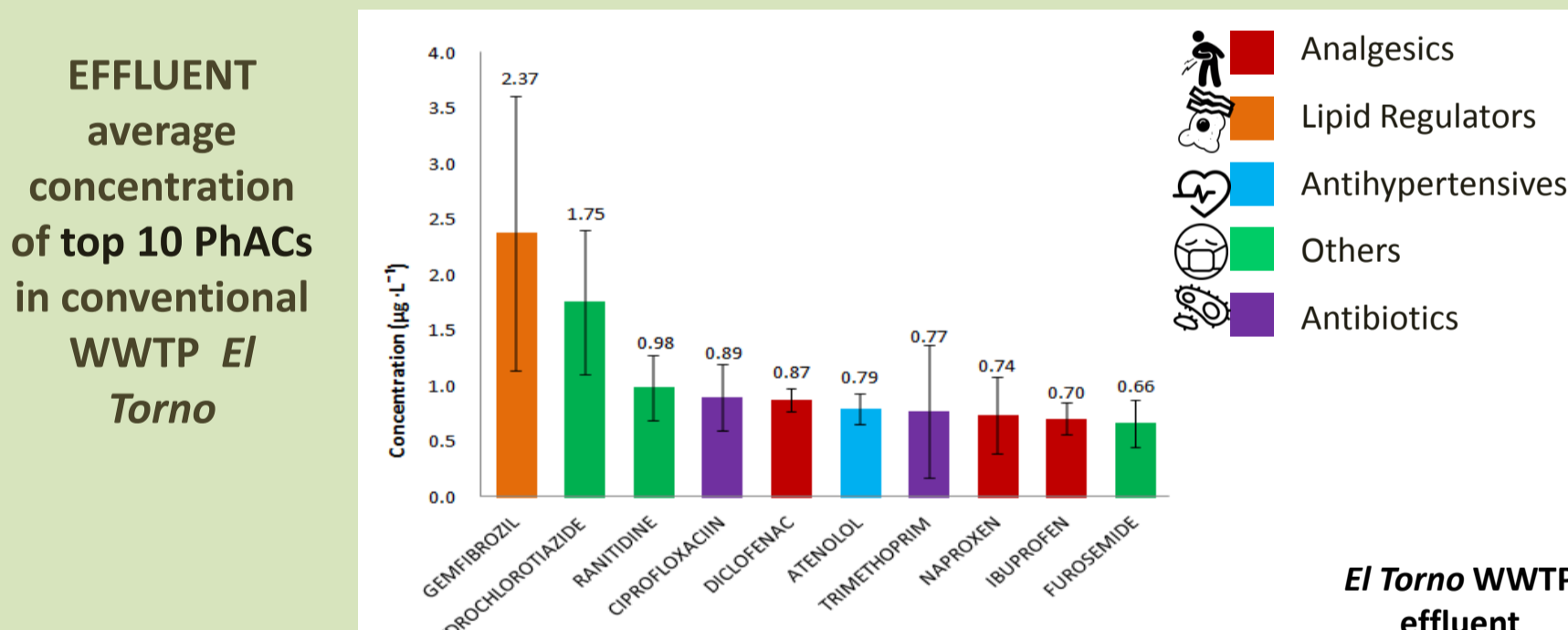
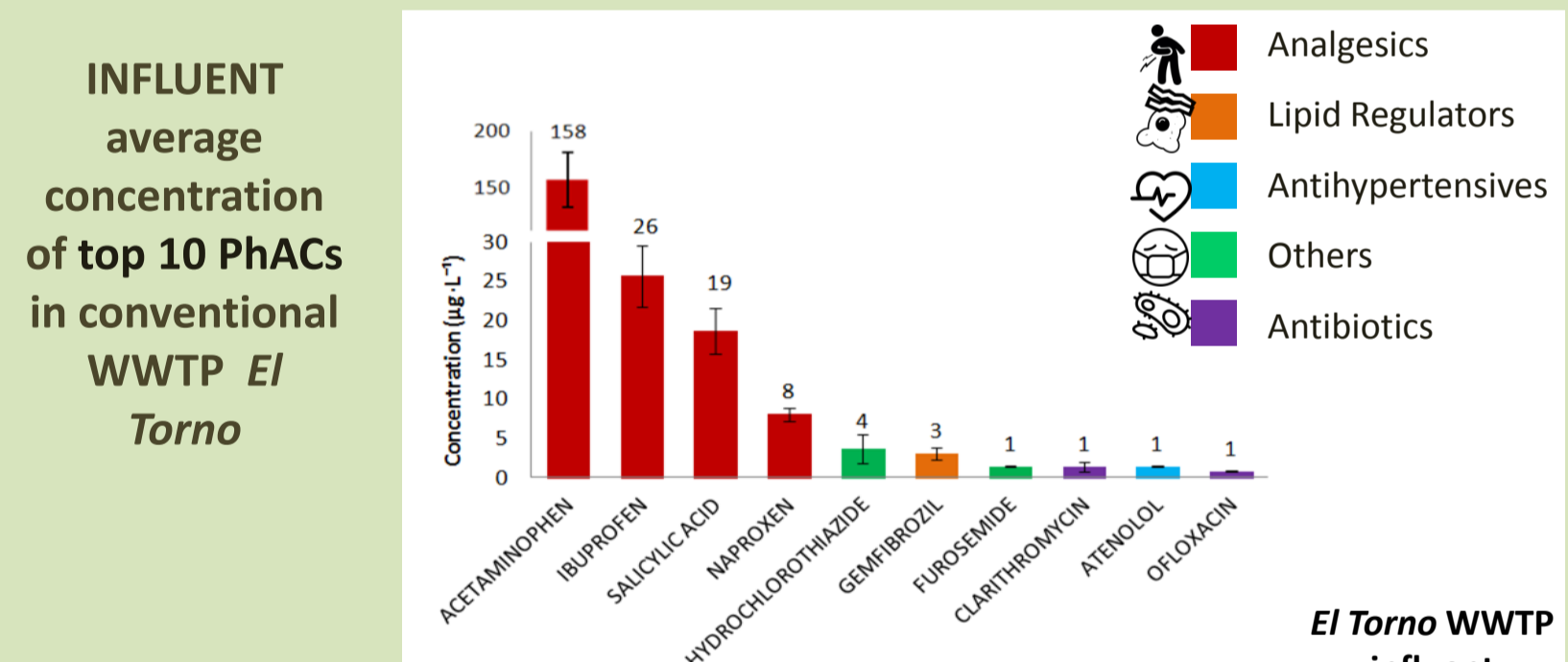
## Sample preparation and analytical method

- TSS
- [5] APHA, AWWA, WPCF (2008) – Gravimetric analysis
- COD  
TDN  
TDP
- [6] Köthe & Bitsch (1992) – Colorimetric analysis
- PhACs
- [7] Baena-Nogueras et al. (2016) – Solid Phase Extraction & UPLC-MS/MS

## RESULTS & DISCUSSION

	Chemical Oxygen Demand (COD)	Total Suspended Solids (TSS)	Total Dissolved Nitrogen (TDN)	Total Dissolved Phosphorus (TDP)
Influent (mg·L <sup>-1</sup> )	697 ±176.2	230 ±85.8	44 ±4.6	4 ±1.5
Conventional (% Removal)	92 ±1.9	92 ±2.9	25 ±14.8	70 ±11.4
UASB (% Removal)	49 ±10.6	32 ±29.4	12 ±18.7	7 ±11.4
HRAP (% Removal)	63 ±29.2	0 ±0	61 ±26.9	48 ±30.6
DAF (% Removal)	78 ±12.2	59 ±51.5	75 ±19.9	85 ±10.5

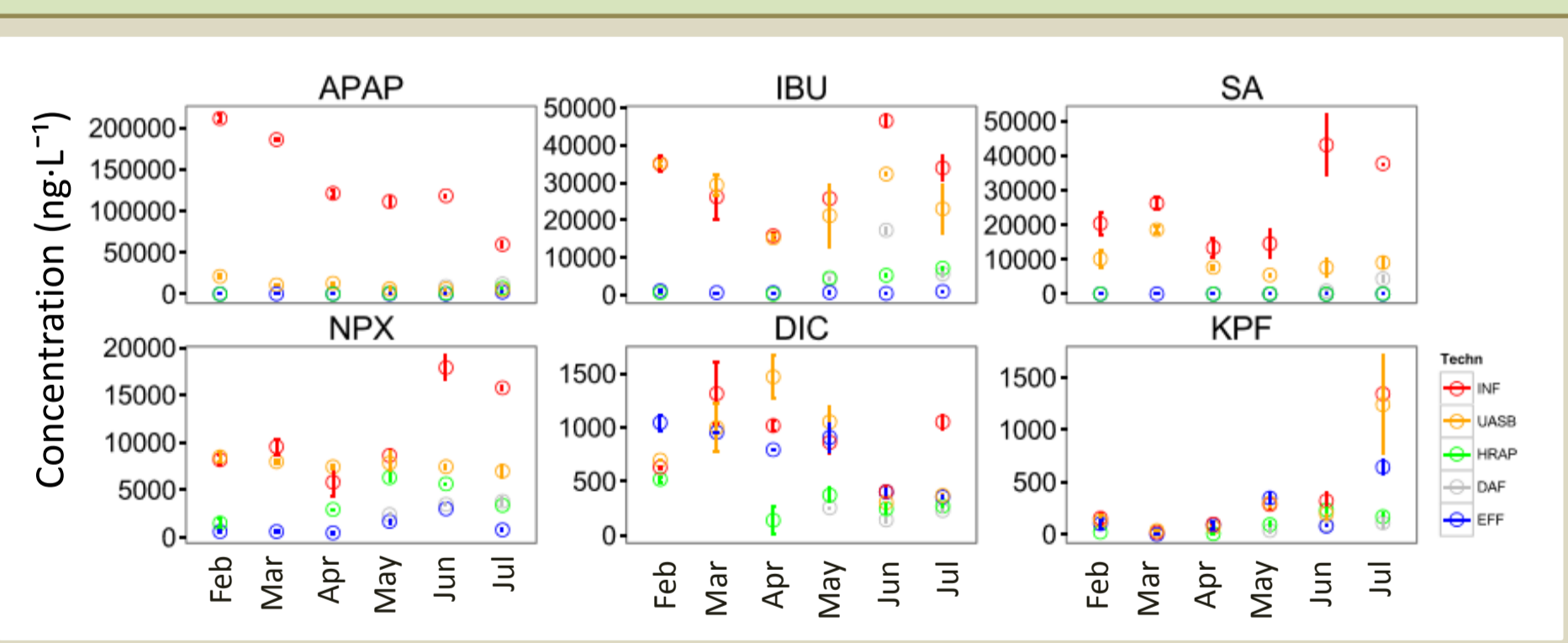
Acronym	Chemical Name	Acronym	Chemical Name	Sampling Point	Location
APAP	Acetaminophen	AMT	Amitriptiline	INF	Conventional Influent (1)
DIC	Diclofenac	CBZ	Carbamazepine	UASB	Upflow Anaerobic Sludge Blanket (4)
IBU	Ibuprofen	FLX	Fluoxetine	HRAP	High Rate Algae Pond (5)
KPF	Ketoprofen			DAF	Dissolved Air Flotation (6)
NPX	Naproxen			EFF	Conventional Effluent (3)
SA	Salicylic Acid				



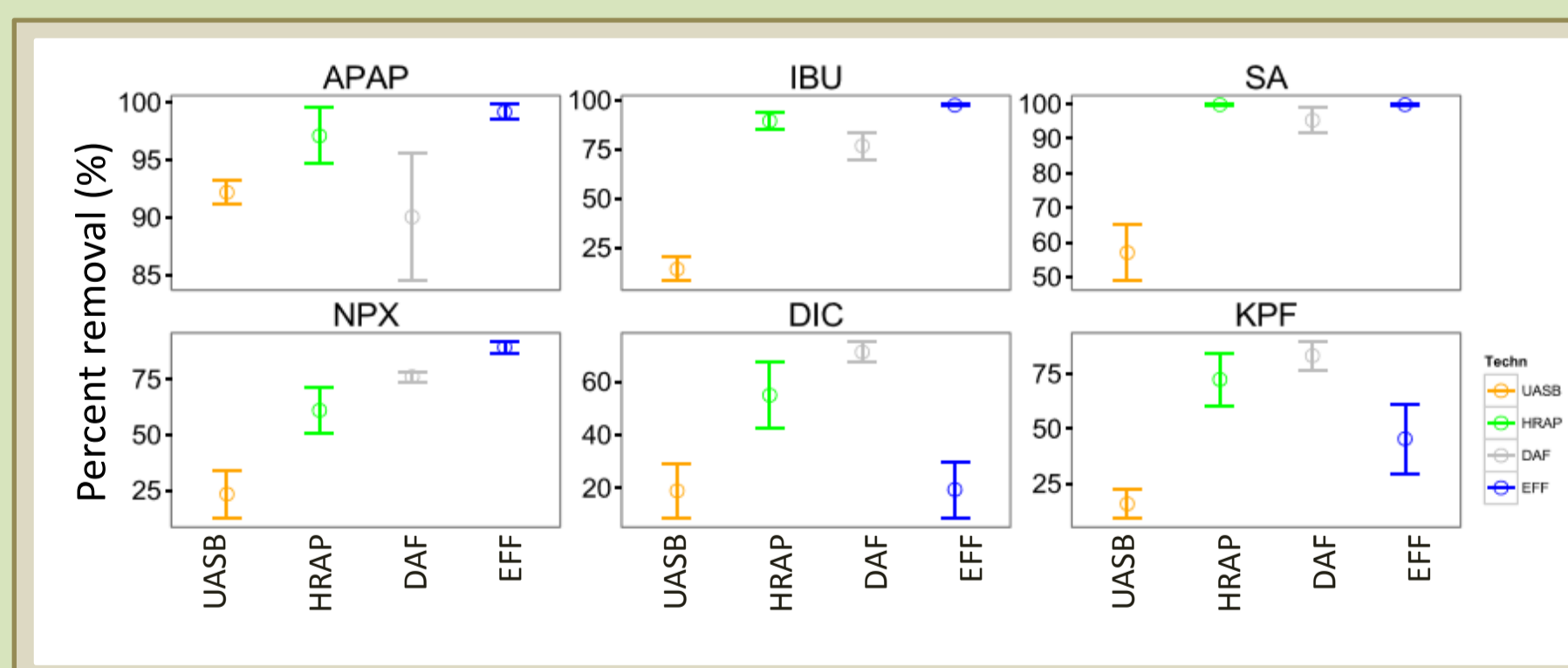
## CONCLUSIONS

- Both processes (conventional and non conventional) have a similar PhACs removal percentage (>90%). Nevertheless, there are significant differences in the removal of specific PhACs. Some analgesics & antiinflammatories presented removal percentages as high as 95% while some psychiatric drugs show removal percentages as low as 10%.
- Depending on the chemical, the removal capacity using conventional wastewater treatment can be equal (Salicylic Acid), higher (Naproxen) or lower (Diclofenac) than using UASB and microalgae biotechnologies.
- Further in-depth studies on the pharmaceutical removal using microalgae technology must be performed to determine the specific removal mechanisms for selected target compound (sorption, photolysis, biodegradation, bioaccumulation...).

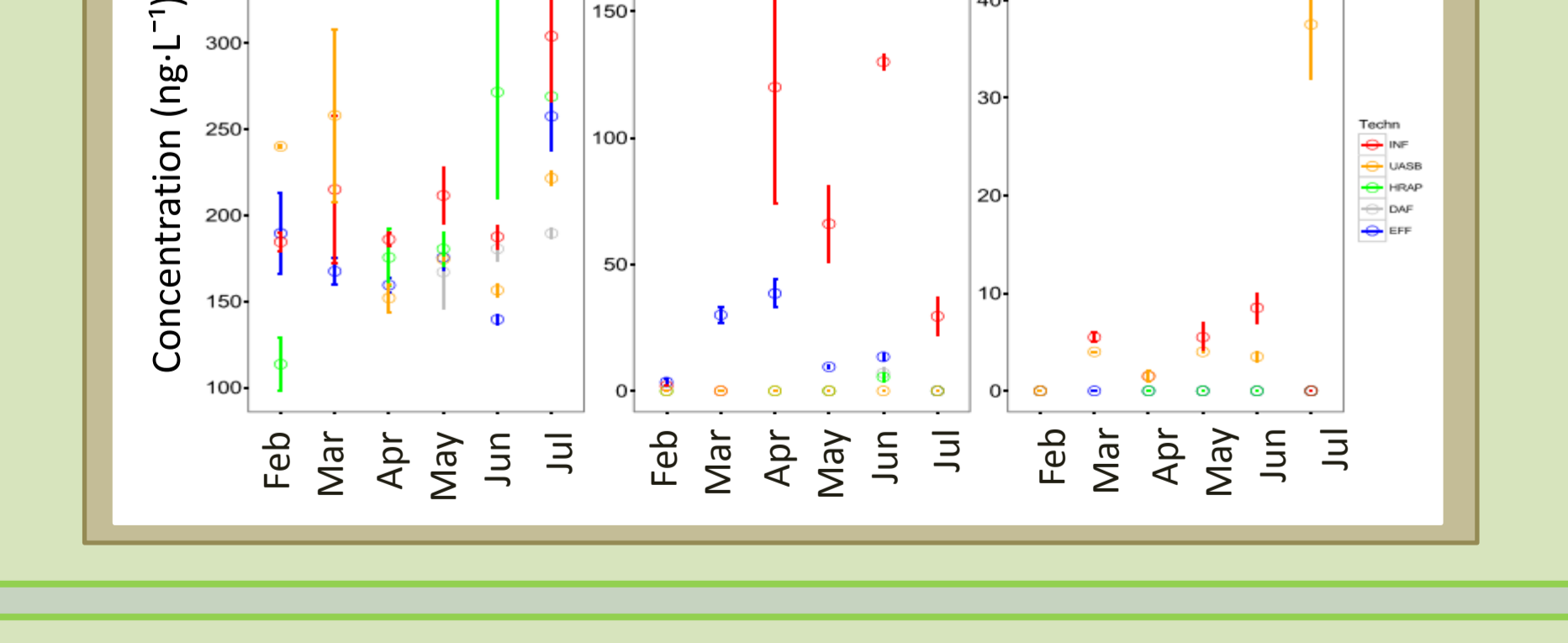
## CONCENTRATION IN WASTEWATER



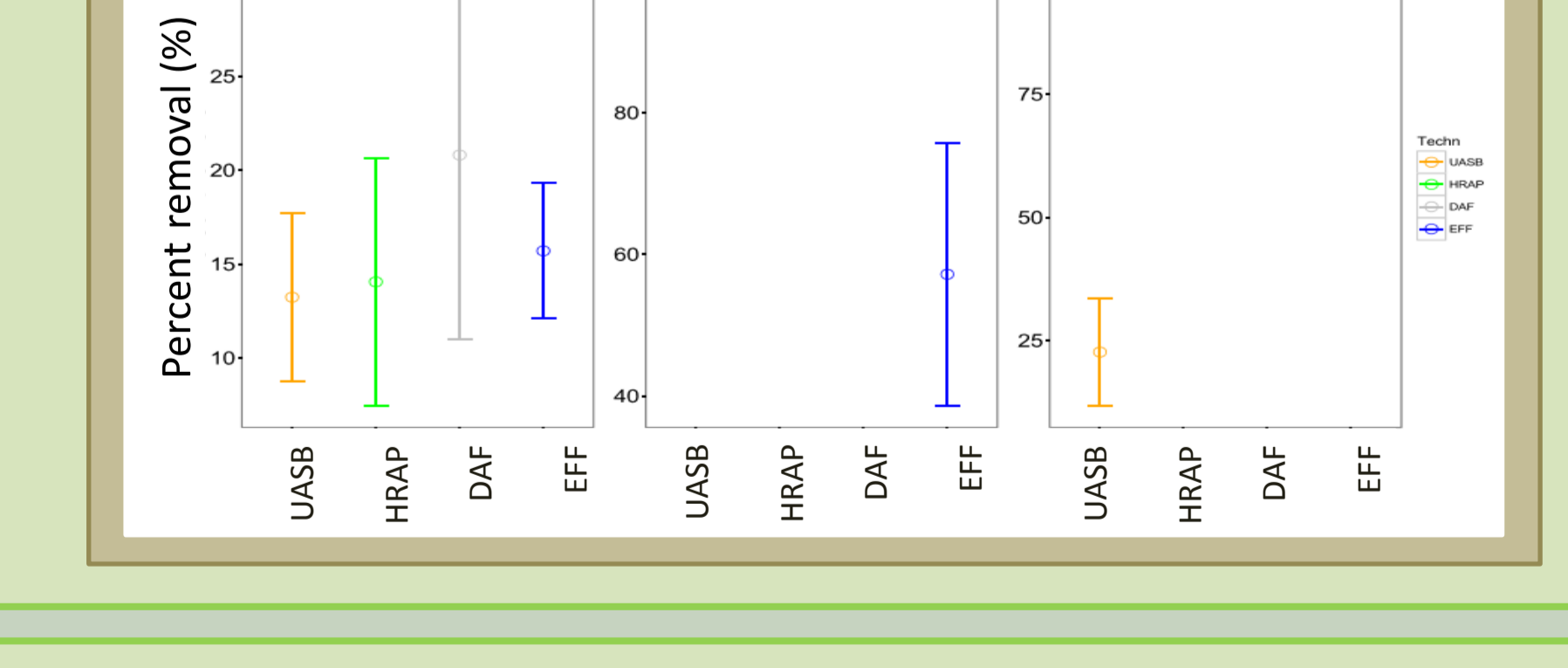
## REMOVAL EFFICIENCY



## CONCENTRATION IN WASTEWATER



## REMOVAL EFFICIENCY



The group with higher concentration in the WWTP influent is "analgesics & antiinflammatories". Seasonal variations in some chemicals such as APAP (decreases in summer) or SA (decreases in winter) has been observed.

Although more than 75% of COD was reduced in both, conventional and experimental WWTPs, only between 20 to 60% of five pharmaceuticals groups including antihypertensives, lipid regulators, psychiatric drugs, antibiotics and others were removed.

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## ACKNOWLEDGEMENT

This work has been carried out within a regional research project (RNM 6613) funded by Consejería de Innovación, Ciencia y Empresa (Junta de Andalucía).



We express our gratitude to D. Jesús Barragán (Chiclana Natural S.A.), D. Zouhayr Arbib and D. Maikel Fernandez (Aqualia S.A.) for their support.

