Innovative and versatile integrated solution to remove contaminants of emerging concern in water treatment systems

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INTRODUCTION & METHODOLOGY

PRISTINE SOLUTION

UV-LED AOP

- Low energy.
- Instantaneous activation (<1 sec), treatment train can be selected based on real-time influent data.
- H_2O_2/O_3 residue- free empowering reagents.

MARKET ACCEPTANCE

Encapsulated adsorbents

- Customized for wide-range CECs adsorption.
- Resistance to abrasion.
- Material losses <2% because of magnetic recovery.

ROBUSTNESS

AI soft sensor & DSS

- CECs sensor based on AI techniques to estimate concentration.
- DSS to optimize the process integration.

FLEXIBLE

HF - Nanofiltration

- Low energy (<0.3 kWh/m^3) requirements.
- Low fouling, footprint and maintenance requirements.
- Concentrate to be treated by AOP or adsorption.

REDUCED ENERGY

80% CECs REMOVAL

TACKLING THE PROBLEM OF CONTAMINANTS OF EMERGING CONCERN (CECS)

Contaminants of emerging concern (CECs) are compounds of different origin and chemical nature that are disseminated in the environment. In most cases they are unregulated contaminants, which may be candidates for future regulation, depending on monitoring data regarding their incidence and potential health and environmental effects.

- Bioaccumulation
- Persistence
- Toxicity
- Risks for the immune system
- Endocrine disrupting effects
- Carcinogenicity and/or mutagenicity

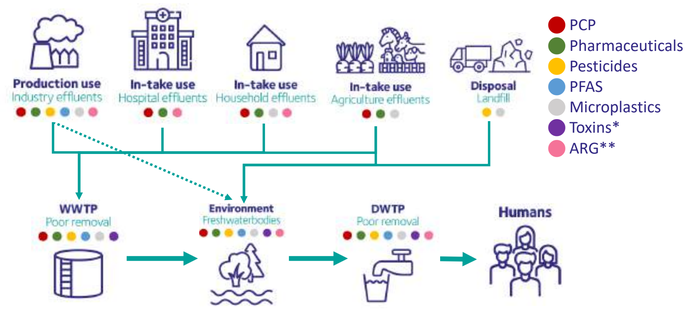

Figure 1 - Main (but not exclusive) entry pathways of CECs into the water cycle. *Toxins are naturally produced by algae, especially when the ecosystem is stressed by external pollution, entry of nutrients, etc. Wastewater Treatment Plant (WWTP), Drinking Water Treatment Plant (DWTP). **In human contexts ARG presence is related to the presence of antibiotics and their metabolites, produced, or taken and then excreted, in use-intensive contexts, such as industry of hospitals.

DEMONSTRATION

2 years pilot scale demonstration treating 1m^3/h

WASTEWATER

WWTP Murcia Region

PRISTINE as tertiary treatment

DRINKING WATER

Advanced Centre for Water Treatment Bilbao-Bizkaia (CATABB)

PRISTINE as principal drinking water treatment

APPROACH

Can regular online process parameters be used to estimate CECs concentrations?

CECs LONGLIST (29)

- Policies and legislation
- Literature & previous data

PRIORITIZATION

- Approach definition
- Similar strategy for both sites

CHARACTERIZATION CAMPAIGN

- 1 year
- Data AI softsensor
- 134 CECs, MPs, ARG
- Physicochemical parameters

CECs SHORTLIST & AI SOFT SENSOR

- Acording to prioritization
- Define CECs PRISTINE focus
- Develop AI soft sensor

PRISTINE DEMONSTRATION

What CECs will need to be treated by the PRISTINE Integrated Solution and under which conditions?

RESULTS *(Analytical campaign WW site)*

From the 134 CECs analyzed, 34 were detected in the WW site and 28 in the effluent of the secondary carifier (future influent of the pilot demonstration). Pharmaceutials and pesticides were the most abundant, persistent and occurent CECs detected in the effluent of the secondary clarifier

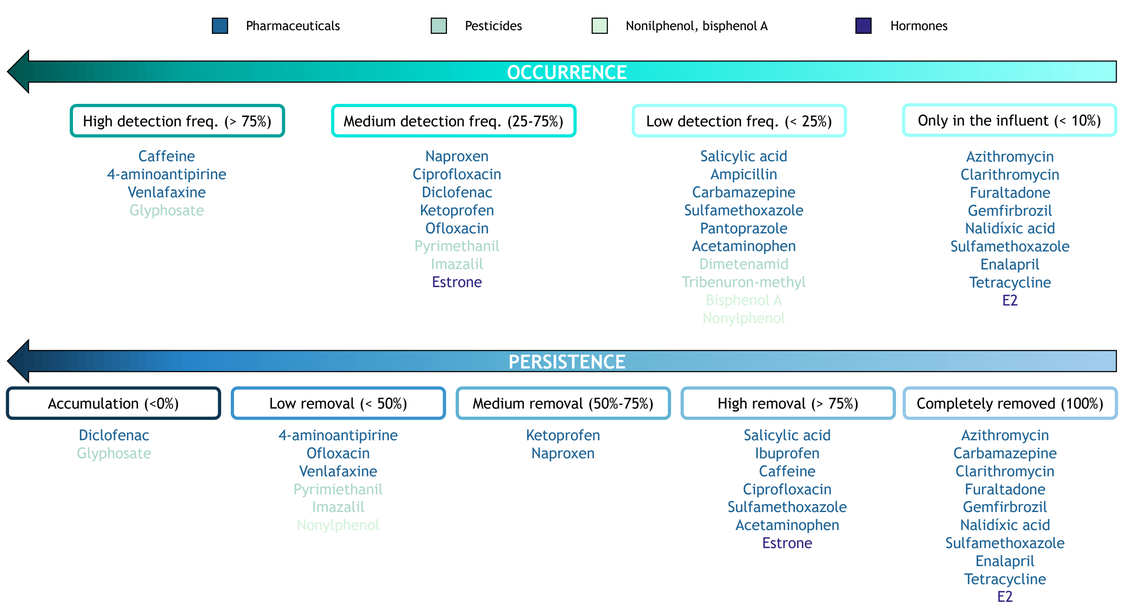

Figure 2 - Summary of the CECs detected in the WW site according to their occurrence in the effluent of the secondary clarifier, after the biological treatment and also the persistence according to the CECs elimination within the biological treatment. The results were gathered during the one-year campaign (November 2022 to October 2023).

Monthly tendencies were observed for some CECs, correlating with the site particularites

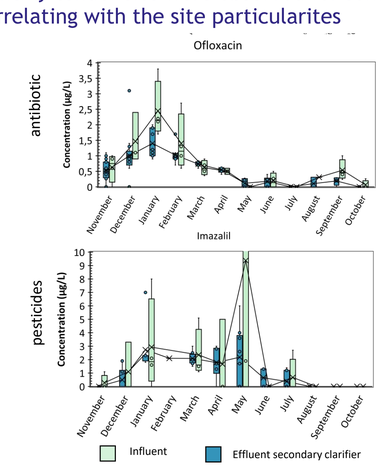

Figure 3 - WW sitemonthly variations in the concentration of the antibiotic ofloxacin (top)and the pesticide imazalil (right) (results from November 2022 – October 2023).

ARG genes decrease within the WWTP, but DNA containing antibiotic resistance genes are not fully removed

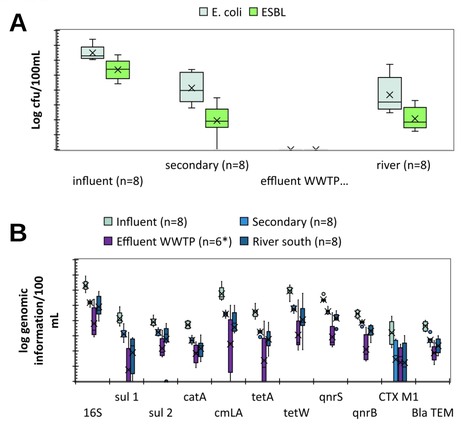

Figure 4- Antibiotic resistance genes results with different analysis techniques: A) Plate counting, B) qPCR genomic copies of each amplified gene.

The AI softsensor using a random forest algorithm were developed based on online process parameters for the selected CECs with relative errors between 15-40%, which will be improved during the demonstration

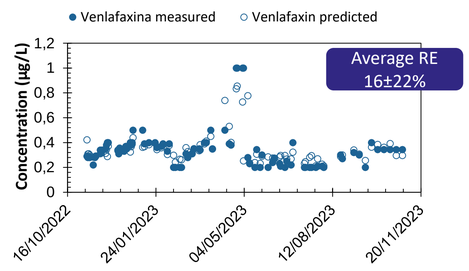

Figure 5 - Example of the AI soft sensors results for venlafaxine with measured and AI soft sensor simulated data based on Random Forest.

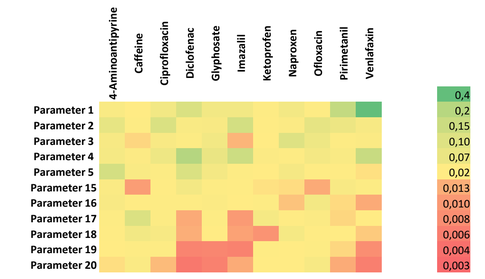

Figure 6 - Feature importance heat map of physicochemical parameters 1-5 and 15 to 20 out of the 47 that were used with the random forest model algorithm for the CECs concentration simulation.

CONCLUSION & NEXT STEPS

What CECs will need to be treated by the PRISTINE Integrated Solution and under which conditions?

- **Pharmaceuticals** will be the principal focus of PRISTINE due to their high occurrence, concentration and variability.
- Glyphosate, pyrimethanil and imazalil are the **pesticides** that will be included in the PRISTINE shortlist.
- **Seasonality** was seen to be important in both sites for certain pesticides and pharmaceuticals but also physicochemical parameters. Thus, it will be important to demonstrate the technology for a full year.

Can regular online process parameters be used to estimate CECs concentrations?

- AI soft sensors have been developed for selected CECs with relative errors between 15-40% using regular process parameters.
- More data, that will be gathered during the pilot demonstrations, will allow to further improve the AI soft-sensor.

PRISTINE CECs SHORTLIST

PHARMACEUTICALS

1. Ibuprofen
2. Caffeine
3. Ampyrone
4. Naproxen
5. Ofloxacin
6. Ciprofloxacin
7. Venlafaxin
8. Diclofenac
9. Sulfamethoxazol
10. Ketoprofen
11. Acetaminophen

PESTICIDES

12. Glyphosate
13. Imazalil
14. Pyrimethanil

OTHERS

15. Nonylphenol
16. Bisphenol A
17. Haloacetic acids
18. Microplastics
19. ARG

PRISTINE UP TO DATE NEWS!

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