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Use of constructed wetlands to prevent overloading of wastewater treatment plants

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Abstract:	The fluctuation in the number of people in tourist areas affects the wastewater quality and quantity. Constructed wetlands (CWs) aim to simulate physical, chemical, and biological processes occurring in natural environments for wastewater treatment and are considered a sustainable system. The current study aimed at evaluating the effectiveness of containerized CWs for supporting the wastewaters treatment plants in periods of overloading. Such approach can be quickly implementable, economic, and the CWs can be fast regenerated in the framework of sustainable good practices. Three CWs were prepared in as many containers layering 10 cm of gravel, 60 cm of sand and 10 cm of gravel, and placing pieces of giant reed rhizomes in the upper layers. The bottom of each CW had a tap, and CWs were irrigated with a real municipal sewage three times a week. Before each new irrigation, the tap was opened, and the effluent collected for determining gross parameters, elemental composition and contaminants of emerging concern (CECs). CWs significantly reduced almost all gross parameters considered and half the CECs, except for a couple of metabolites of corresponding parental compounds. With regards to the potentially toxic elements, all reduced their concentration from the influents to the effluents. The results of this study were promising and highlighted good efficiency of constructed wetlands as pre-treatment of real municipal sewage to reduce the overloading of the wastewater treatment plant.
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Use of constructed wetlands to prevent overloading of wastewater treatment plants

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Abstract

The fluctuation in the number of people in tourist areas affects the wastewater quality and quantity. Constructed wetlands (CWs) aim to simulate physical, chemical, and biological processes occurring in natural environments for wastewater treatment and are considered a sustainable system. The current study aimed at evaluating the effectiveness of containerized CWs for supporting the wastewaters treatment plants in periods of overloading. Such approach can be quickly implementable, economic, and the CWs can be fast regenerated in the framework of sustainable good practices. Three CWs were prepared in as many containers layering 10 cm of gravel, 60 cm of sand and 10 cm of gravel, and placing pieces of giant reed rhizomes in the upper layers. The bottom of each CW had a tap, and CWs were irrigated with a real municipal sewage three times a week. Before each new irrigation, the tap was opened, and the effluent collected for determining gross parameters, elemental composition and contaminants of emerging concern (CECs).

CWs significantly reduced almost all gross parameters considered and half the CECs, except for a couple of metabolites of corresponding parental compounds. With regards to the potentially toxic elements, all reduced their concentration from the influents to the effluents.

The results of this study were promising and highlighted good efficiency of constructed wetlands as pre-treatment of real municipal sewage to reduce the overloading of the wastewater treatment plant.

Keywords: Contaminants of emerging concern; potentially toxic elements; *Arundo donax*; vertical constructed wetlands

1. Introduction

Tourist areas are commonly characterized by a considerable increase of people during the holiday season, which leads to an intense seasonal water demand (Salgot and Tapias, 2004). The fluctuation in the number of people affects not only water demand but also wastewater quality and quantity. In fact, in comparison with a typical municipal sewage, the sewages generated in tourist areas are usually more concentrated in terms of typical pollutant parameters, more variable in terms of both flow and contaminant variation, and less disintegrated in terms of particulate matter because of the shorter sewerage system (Odegaard, 1989). Wastewater treatment plants operated in tourist areas often suffer from a series of problems, including shock loads and and flow fluctuations, which may affect effluent quality (Christoulas and Andreadakis, 1989). Therefore, a more reliable and robust wastewater treatment train is needed in tourist areas for coping with the organic load variations typical of these areas.

Constructed wetlands (CWs) aim to simulate physical, chemical and biological processes occurring in natural environments for wastewater treating (Bakhshoodeh et al., 2017), and, due to their significant reduction in energy demand, economic costs, less operational and maintenance requirements and environmental pollution, they can be considered a sustainable system capable to enhance the treatment of municipal sewage in tourist areas (Nuamah et al., 2020). With respect to conventional treatment systems, CWs require renewable sources, emit very low amount of greenhouse gas, do not produce by-products, and have small problems of odours and insects (Stefanakis et al., 2014).

The physical and chemical processes that occur in CWs are adsorption, oxidation, chemical degradation, photodegradation, volatilization and hydrolysis of contaminants, while biodegradation and plant absorption are the main biological processes (Hijosa-Valsero et al., 2016). These processes can occur simultaneously and lead to several advantages, such as plant nutrients cycling, adsorption of potentially toxic elements (PTE) and organic pollutants.

The components of CWs that contribute to the partial or total removal of pollutants are the substrate, the plant, the quality of the influent and the microbial population associated to the CWs (Kosolapov et al., 2004). The substrate plays the most important role in removing contaminants through filtration and adsorption of contaminants, electron donor process, support for microorganisms and wetland plants. Gravel is the most common substrate used in CWs (Li et al., 2014) because provides sufficient hydraulic conductivity, supports the vegetation, retains suspended solids and affects the percolation and infiltration of contaminants (Nuamah et al., 2020; Vymazal et al., 2021) and is largely used also in combination with sand for their affordability and large availability. In addition, sand provides an ideal texture for the establishment of plants, even if it requires frequent addition of wastewater because dries out quickly.

Plants play an important role both alive and dead; when alive they deflect flows and provide attachment sites for microorganisms, while when dead they release organic carbon usable by microorganisms for their metabolism (Davis, 1995). In this regard, giant reed (*Arundo donax*) is a perennial herbaceous plant widely spread all over the world that requires high amount of water, and is highly tolerant to salinity, with a fast growth rate and a large amount of biomass produced that make it suitable for use in CWs (Allinson, 2017). Giant reed is also capable to absorb PTE and to improve saline soils (Herrera-Alamillo and Robert, 2012; Quinn et al., 2015) and, due to its great biomass production, can be suitable for the anaerobic digestion for production of energy and digestate (Shilpi et al., 2019; Zhang et al., 2021).

The microbial diversity depends on the configuration and design of the CWs (Rajan et al., 2019), and is a function of the concentration of different forms of nitrogen and carbonaceous materials, amount of plant litter, amount of oxygen and available nutrients, and the type of plant used (Liang et al., 2003; Ligi et al., 2014).

The level of contamination of influents affects the efficiency of CWs in the removal of contaminants influencing the composition of the microbial community. In fact, several studies have reported the presence of certain microorganisms in presence of specific compounds (Guo et al., 2020; Li et al., 2020; Liu et al., 2020). In addition, CWs can also allow a partial removal of compounds of emerging concern (CECs), such as pharmaceuticals and personal care products, among others. Indeed, this is a side benefit that can be also obtained in the soli due to some components present in it having catalytic behaviour (Pizzigallo et al., 1998; Herrera et al., 2001). CECs, in fact, are poorly removed by the activated sludge process in conventional wastewater treatment plants (WWTPs) and the long-term exposure to them could cause reproductive and hormonal disorders as potential health problems and the increase of bacterial antibiotic resistance (Gonsioroski et al., 2020). Therefore, CECs removal usually requires an additional process (tertiary treatment) after the biological step that can be effectively carried out employing one of the advanced oxidation processes (Murgolo et al., 2021; Maniakova et al., 2020).

The current study aims at evaluating the effectiveness of containerized CWs for supporting the wastewaters treatment plants in periods of overloading. Such approach can be quickly implementable, economic, and the CWs can be fast regenerated in the framework of sustainable good practices.

2. Materials and Methods

2.1. Experimental site and constructed wetlands

The study was carried out with three verticals containerized CWs that were built at the IRSA-CNR located in Bari, Southern Italy (5-meter a.s.l., 41°07′31″N, 16°52′00″E). The CWs have been set up according to Hoffmann et al. (2011). In details, from the bottom to the top of each CW, there were 10 cm of gravel, 60 cm of sand and 10 cm of gravel, and the volume of each CW was 0.8-1 m^3. The bottom of each CW had a tap and pieces of giant reed rhizomes have been placed in the upper layer. Each CW was irrigated with a real municipal sewage, collected from a local municipal wastewater treatment plant in Bari (a city of Southern Italy), three times a week keeping the tap closed until a 15-20 cm layer of wastewater was obtained on the surface (about 400-500 L for each irrigation per CW). Before each new irrigation, the tap was opened, and the effluent collected for further analyses.

According to the Köppen–Geiger climate classification (Kottek et al., 2006), the location is characterized by a warm temperate Mediterranean climate with dry and hot summers. With reference to time series 1921–2019, annual average rainfall is approximately 543 mm, mainly distributed between September and March. July is the driest month with 16.9 mm of rain, while November is the month with the greatest rainfall, having an average of 69.8 mm. With reference to time series 1926–2019, the annual average temperature was 17.0 °C, with average maximum temperature of 25.4 °C in July and average minimum temperature of 9.4 °C in January.

2.2. Gross parameters

Composite samples of influent and the effluent of the biological treatment of wastewater were collected three times a week and subjected to gross parameter analysis: electrical conductivity (EC), chemical oxygen demand (COD), soluble COD (sCOD), total suspended solids (TSS), volatile suspended solids (VSS), total nitrogen (TN), ammonia (NH_4^+), total phosphorus (TP), phosphates, chlorides, and sulphates. COD and TN were measured using DR Lange test kits. sCOD concentration was determined after sample filtration through a 0.45 μm nylon filter. TSS and VSS were analysed according to the procedure proposed by APHA (2005). For NH_4^+ determination, an online water/liquid L800 ammonia analyser was utilized (Hemera Analyzers, Meylan, France), while anion species such as PO_4^{3-}, Cl^- and SO_4^{2-} were measured by ion chromatography (Thermo Scientific Dionex Aquion; column IonPac™ AS23; carbonate/bicarbonate as eluent).

2.3. Elemental analysis

For the determination of the total content of PTE, plant micronutrients and the exchangeable bases, 3 mL of HNO_3 were added to 5 mL of influents or effluents and microwave digested (Multiwave Perkin Elmer 3000). Finally, all samples have been filtered through Whatman 42-filter paper and analysed by using an inductively coupled plasma optical emission spectrometer (ICAP 6300 Thermo Electron).

2.4. *Contaminants of emerging concern (CECs)*

The occurrence of CECs in both influent and effluent wastewater was performed according to an experimental procedure described elsewhere (Montagna et al., 2020). Briefly, influent and effluent samples where diluted 1:4 and 1:2, respectively. They were filtered (0.2 μm nylon filter) and aliquots of 2 mL were analyzed by on-line solid phase extraction (SPE) by a Hypersil GOLDaQ column (20 x 2.1 mm, 5 μm) that was used operating at a flow rate of 0.250 mL min^{-1} of 100 % water. The analytes retained on the SPE column were then separated and detected by ultra-high pressure liquid chromatograph (Ultimate 3000 System, Thermo Fisher Scientific) interfaced with a high-resolution tandem mass spectrometer (TripleTOF® 5600+ System, AB Sciex) by means of a duo-spray ion source operated in electrospray (ESI) positive mode was employed. All MS analyses were acquired by an acquisition method based on double experiments TOFMS/IDA (Information dependent Acquisition) in the mass scan range 50-1000 Da. In order to make the analytical method more robust, each analysed sample was added with the internal standard carbamazepine D10, prior to the analytical determination. In this way, it was possible to take into consideration the relative reduction of the signal intensity due to the matrix effect of each sample.

All the raw data obtained by the high-resolution mass spectrometry analysis were processed using a database of emerging pollutants from the NORMAN network and Sciex OS software (AB Sciex). Briefly, the data processing was performed as follows: each sample was screened, principally on the basis of the mass exact and isotopic pattern, using CECs list of the SusDat database (20 suspect lists comprising ~58000 compounds) compiled by the Norman network (Alygizakis et al., 2019). A confident identification of detected compounds in investigated samples was performed by comparing retention time and MS/MS fragmentation pattern of the suspect identified compounds with those of relative standard compounds, where available, analyzed employing the same analytical method. The list of identified compounds was then re-processed in Sciex OS software for confirmation of detected CECs. The screening allowed the confident detection of 20 compounds listed in Table 1.

2.5 *Statistical analysis*

Experimental data were tested against the normal distribution of variables (Shapiro—Wilk test) and the homogeneity of variance (Bartlett test) using R studio software. The variables normally distributed with homogeneity of variances verified were subjected to an ANOVA and HSD test. Data not normally distributed were subjected to the Levene test and a nonparametric ANOVA analysis (Kruskal-Wallis test) and Dunn test.

3. Results and discussion

3.1. Gross parameters

The main gross parameters of influents and effluents of the three vertical CWs are reported in Fig. 1. Inspecting Fig. 1A, it is possible to observe that a significant increase of EC was obtained after the percolation of wastewater through the CWs. This should be ascribed to the evapotranspiration process that increased the solute concentration in the effluents. This was also confirmed by chloride (Fig. 1B) which shows a similar trend, also because it is a soluble anion, a plant micronutrient and apparently the excess was not uptaken by *Arundo donax*.

The COD content was significantly and drastically reduced by CWs thanks to the action of sand used as adsorbent material. In fact, removal efficiencies in the range of 78.7%-85.7 % were observed with residual effluent concentrations always lower than 200 mg L^{-1} and sometimes even below 100 mg L^{-1}. Similar results have been obtained by Healy et al. (2007) who adopted a stratified sand filter for removal of COD from wastewaters. Other recent studies on CWs have shown a significant reduction in COD, even using different absorbent materials and different technologies (Tuttolomondo et al., 2020; Ruan et al., 2021). The soluble COD shows a trend similar to the COD but less pronounced.

TSS and VSS have practically zeroed out after crossing the wetlands due to the substrate's filtration and sedimentation (Batool and Saleh, 2020) with removal efficiencies comprise in the range

89-94.9% and 87.7-93.3%, respectively. Regarding the role of the plant, Toscano et al. (2015) found that *Arundo donax* showed the highest removal rate of TSS with respect to *Vetiveria, Miscanthus* and *Phragmites.*

As far as nitrogen is concerned, a significant removal of influent TN and ammonia content was also recorded. In fact, looking at Fig. 1B, it is possible to observe that TN and ammonia removal efficiencies from 86.1 to 93.2% and from 77.4 to 98.1%, respectively, were recorded. Considering the absence of an external aeration system, the atmospheric oxygen diffusion through the upper layer into the bed is normally low and therefore nitrification process will not occur. Hence, ammonia removed, included ammonia from ammonification process of organic nitrogen, should be ascribed mainly to the giant reed uptake and, secondarily, to ion exchange with cations in substrates (Ji et al., 2022; Jóźwiakowski et al., 2017).

Finally, phosphorous removal was almost completed with removal efficiencies higher than 95% and residual effluent concentration practically nil (Fig. 1B). A part of P was subjected to biotic uptake by plants and microorganisms, and another one was possibly retained by the substrate through abiotic processes such as co-precipitation, sedimentation, adsorption, and burial (Reddy et al., 1999). The abiotic P removal is mainly governed by the nature and the properties of substrates, by their content of Ca, Fe, and Al (Vohla et al., 2011; Park et al., 2017). Wang et al. (2008) tested the potential of seven plants in removal COD, total nitrogen and total phosphorus from sewage and found that giant reed was the most efficient.

3.2. Potentially toxic elements, plant micronutrients and exchangeable bases

This study highlighted different results related to the destiny of PTE, plants micronutrients and exchangeable bases in effluents (Figs. 2-3). Generally speaking, all PTE considered showed a large variability of concentration in the influents, while their content in the effluents was lower and less variable (Fig. 2). In particular, Cu and Zn content was reduced in effluents reaching almost zero (Fig. 2A), according to various Authors that considered *Arundo donax* promising for the removal of different metals from the environment (Miao et al., 2012; Delplace et al., 2020; Danelli et al., 2021). Birch et al. (2004) observed a significant reduction of Cr, Cu, Pb and Zn, and a variable removal of Ni from stormwater by CWs in accord with our study in which the removal of Ni did not present any trend (Fig. 2B). Another study supported the reduction of Cu, Pb and Zn content thanks to the CW (Walker and Hurl, 2002), and the mechanism proposed by Authors was the sedimentation. Kadlec et al. (2000) reported different processes involved in removal of PTE in CWs depending on the type of plants adopted, the substrate used and the type of water to restore. According to Ji et al. (2022), the substrate plays the most important role in the removal of PTE and the greater the contact surface, the greater the absorption (Yadav et al., 2010).

Apparently, B passed through the CWs without any interaction with the substrate (Fig. 3A), while Türker et al. (2014) found the removal of B from wastewater by adsorption onto the substrate, especially in the presence of organic matter. Therefore, the initial absence of organic matter in the inorganic substrate could explain the present result. The behaviour of Mn was different because it significantly increased in effluents with respect to influents (Fig. 3A), and a similar result has been found by Birch et al. (2004). These Authors hypothesized a release of Mn from the coarse-grained Mn-oxides coated grains during the periods of addition of the influent and more abundant flow. In addition, Mays and Edwards (2001) have shown a poor potential of plants in the removal of Fe and Mn because found in plants only 1% and 2% of the annual Fe and Mn loading in the wetlands. In fact, those elements are micronutrients, required in concentration of mg kg^{-1} in the plant tissues.

Figure 3B shows the content of exchangeable bases: Mg and Na content increased significantly in the effluents possibly because the plant uptake was lower than the sum of input and enrichment deriving from the cation exchange between the bases from the CW substrate and the PTE in wastewaters, as reported by Yu et al. (2021). In contrast, K and Ca concentration did not change significantly between influents and effluents due to their higher plant uptake with respect to Mg and Na. Anyway, the exchangeable bases are not of concern.

3.3. CECs removal

The screening for CECs in the influent wastewater revealed the presence of 20 main compounds that were detected in all samples, being both influent and effluent. They include pharmaceuticals, cosmetics and personal care products, metabolites of both pharmaceuticals and drugs of abuse, food additives and chemicals employed in various preparations. In Fig. 4 are depicted the box and whiskers plots of abundance of detected CECs in influent and effluents during the whole experimental campaign. Half the CECs showed a statistically significant reduction of abundance when flowing through the CWs.

The processes responsible for reducing the presence of organic pollutants in effluents are photodegradation, volatilization, adsorption/sorption, plant uptake and accumulation, and biodegradation (aerobic and anaerobic) (Zhang et al. 2014; Gorito et al. 2017), even if the volatilization and the photodegradation can be insignificant in the case of pollutants with relatively greater molecular weight and in cloudy wastewater, respectively (Wu et al., 2020). A crucial role in the removal of organic pollutants in vertical CWs is generally played by aerobic biodegradation (Ilyas and van Hullebusch, 2020) and plants influence the potential of CWs by creating suitable conditions for the pollutant's removal processes (Ji et al., 2022). Processes of adsorption and desorption of organic pollutants can also occur in the surface of substrates (Karimi et al., 2019).

Two CECs, namely Atenolol acid (Fig. 4A) and Deet-carboxylic acid (Fig. 4B), showed a significantly and numerically increase of abundance in the effluents, respectively. This is consistent with the concomitant statistically significant reduction of Atenolol and Deet that are the respective parent compounds of the aforementioned CECs. This finding supports the evidence that biodegradation processes are occurring in the CWs resulting in the transformation of some CECs. In any case, such biodegradation processes are not expecting to allow the complete mineralization of CECs due to the residence time in the CWs not being sufficiently long. The CECs biodegradation is also evident on some CECs metabolite, namely Benzoylecgonine that is a metabolite of cocaine (Fig. 4A), resulting in its numerically removal.

Overall, the CWs showed a reduction of detected CECs between 10 and 90 %, being the lowest removal percentage (10 %) for the 1,5-Dihydro-3-ethyl-4-methyl-2H-pyrrol-2-one and the highest removals for 2-(phenylmethylidene)octanal (83 %), Equol (89 %) and Deet (87 %) (Fig. 5). The two negative removal values are for the transformation of Deet and Atenolol (Fig. 5) into Deet-carboxylic acid and Atenolol acid, respectively, as reported before. It is worth noting that abundance of transformation products could not be directly compared to the respective parent compounds due to the different response in the mass spectrometer.

Conclusions

Containerized constructed wetlands can be useful as pre-treatment in case of overloading of the wastewater treatment plants. In fact, CWs significantly reduce the main gross parameters and PTE content of wastewater to be sent to the main wastewater treatment facility. In addition, the evapotranspiration of the CWs reduces slightly the volume of wastewater. With regards to the CECs, CWs contribute to lowering some organic contaminants significantly. The number of CWs can be adjusted to seasonal needs, they do not release anything into the environment, and can be set aside during periods of low load and regenerated for subsequent high load seasons.

Further studies are required to test their efficiency in longer periods of time, and to improve their features for obtaining safe effluents for irrigation.

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Figure captions

Figure 1. Gross parameters values in influents and effluents during the whole trial. Error bars correspond to the standard deviations and columns with the same letter are not statistically different.

Figure 2. Concentrations of potentially toxic elements in influents and effluents during the whole trial. Error bars correspond to the standard deviations and columns with the same letter are not statistically different.

Figure 3. Concentrations of micronutrients (A) and exchangeable bases (B) in influents and effluents during the whole trial. Error bars correspond to the standard deviations and columns with the same letter are not statistically different.

Figure 4. Box and whiskers plots of abundance of detected CECs in influents and effluents during the whole trial. Error bars correspond to the standard deviations and columns with the same letter are not statistically different.

Figure 5. Average percent removal of detected CECs as a result of percolation through the CWs.

Highlights

- Containerized constructed wetlands were used to pre-treat real municipal sewage
- Almost all gross parameters significantly reduced in effluents
- Almost all potentially toxic elements significantly reduced in effluents
- Ten contaminants of emerging concern out of 20 significantly reduced in effluents
- Two metabolites increased their concentration in effluents

Dipartimento di Scienze del Suolo, della Pianta e degli Alimenti - Di.S.S.P.A.

Bari, 5th of August, 2022

Dear Prof.
Yeomin Yoon, PhD
Editor
Chemosphere

Dear Editor,

On behalf of all Authors, I like to submit the manuscript entitled "Use of constructed wetlands to prevent overloading of wastewater treatment plants" by Claudio Cocozza, Claudio Di Iaconi, Sapia Murgolo, Andreina Traversa, Francesco De Mastro, Marco De Sanctis, Valerio Guido Altieri, Claudio Cacace, Gennaro Brunetti, Giuseppe Mascolo.

All the authors have read and approved the paper and it has not been published previously nor is it being considered by any other peer-reviewed journal.

I look forward to hearing from you about this matter at your nearest convenience.

With my best regards

Sincerely yours

Andreina Traversa, PhD
Corresponding Author
Dipartimento di Scienze del Suolo, della Pianta e degli Alimenti
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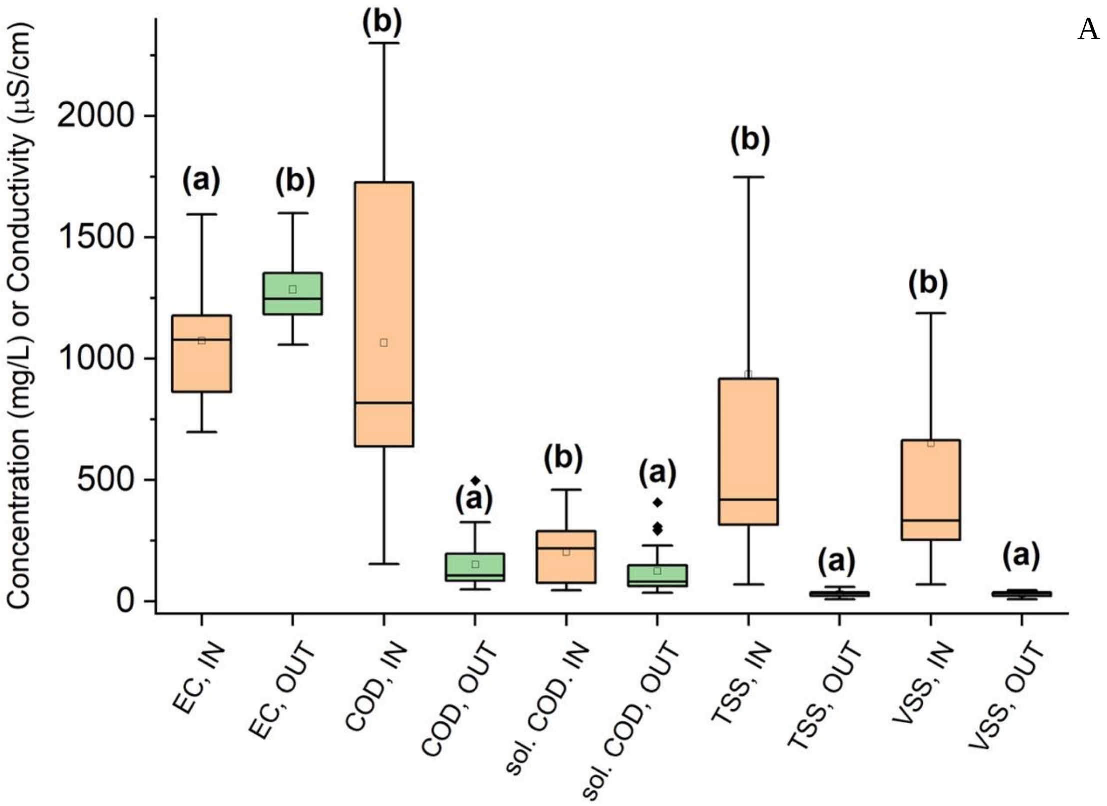
Declaration of interests

☒The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Figure 1



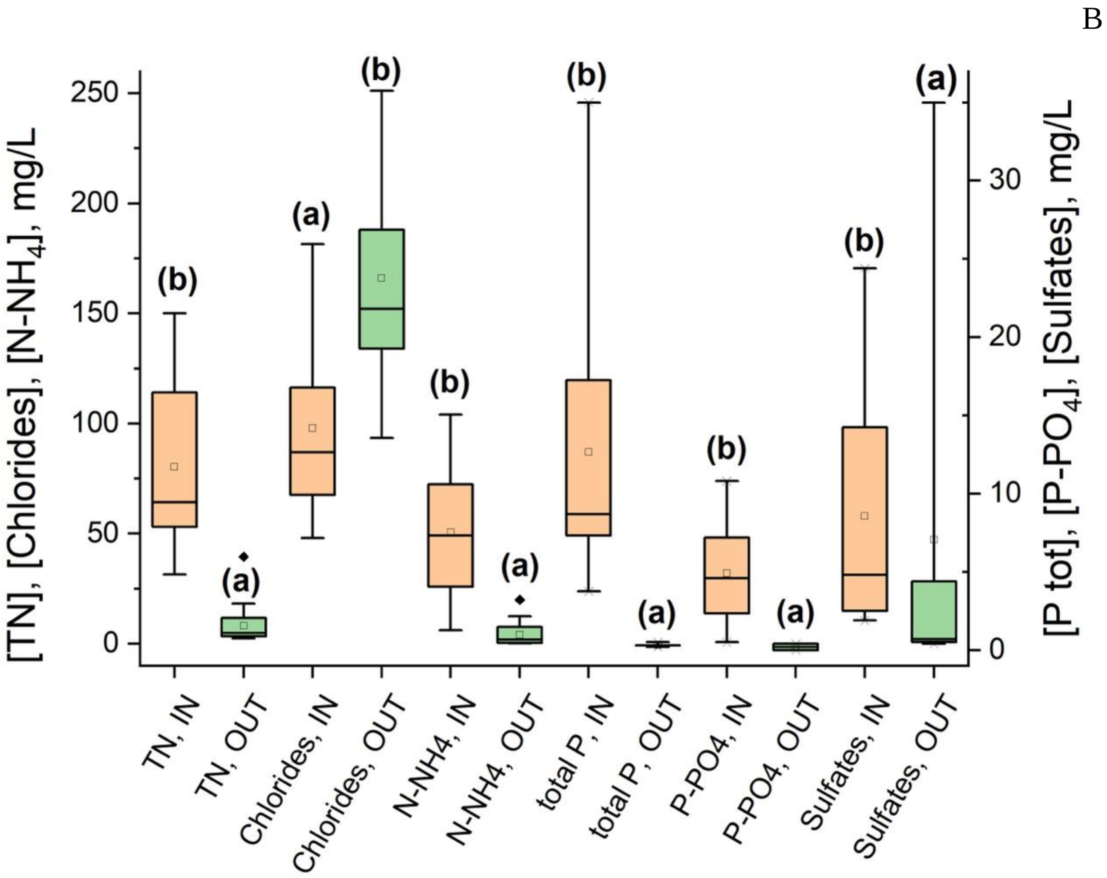
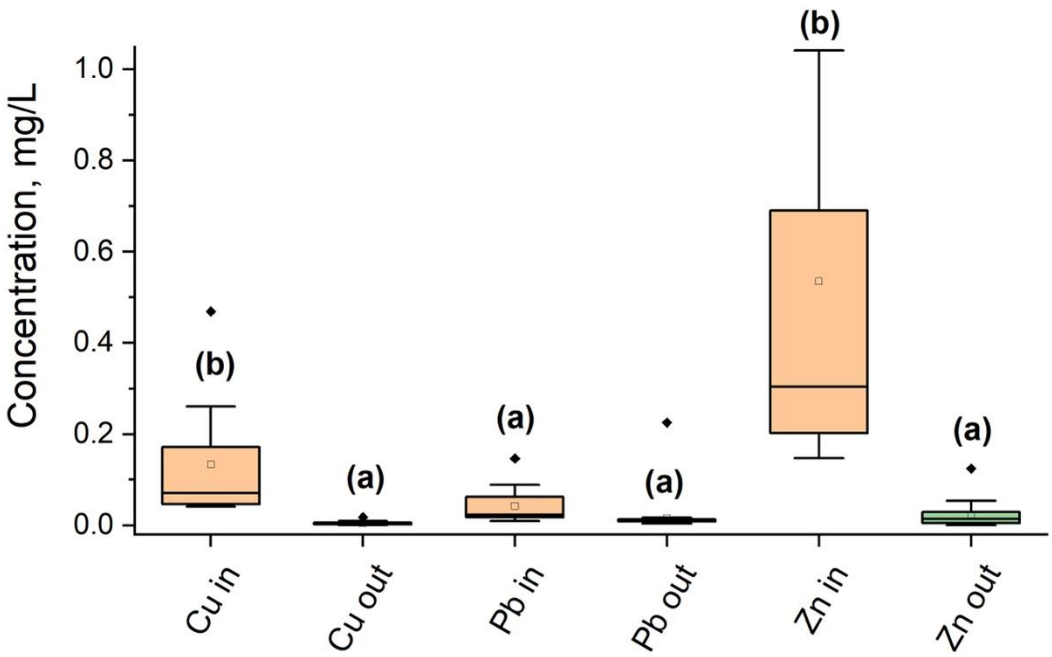


Figure 1

Figure 2

A



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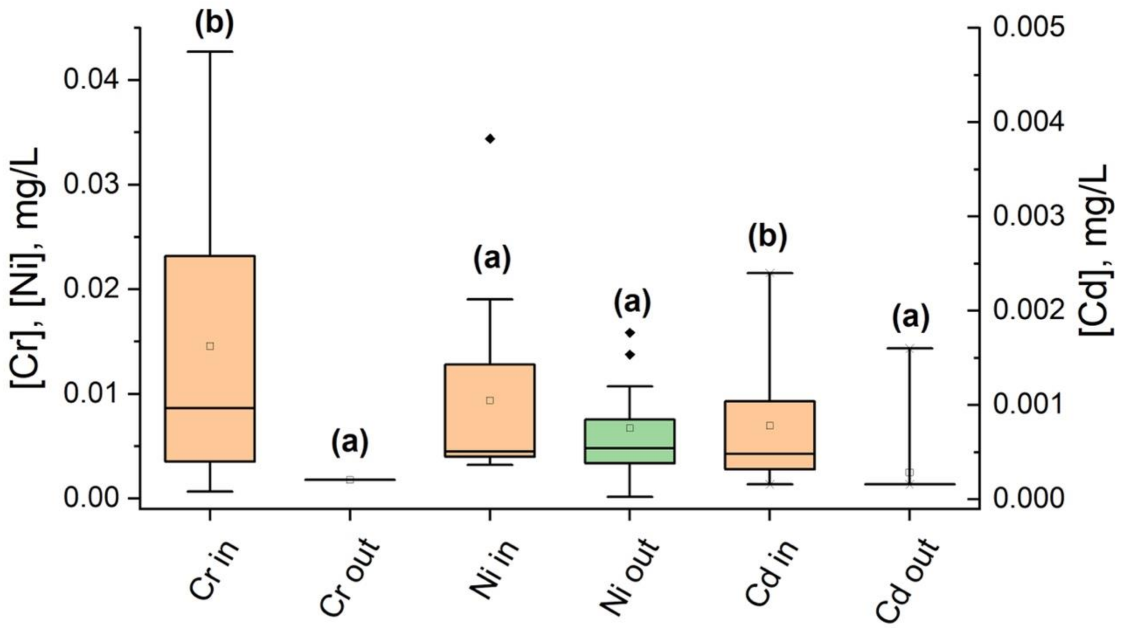
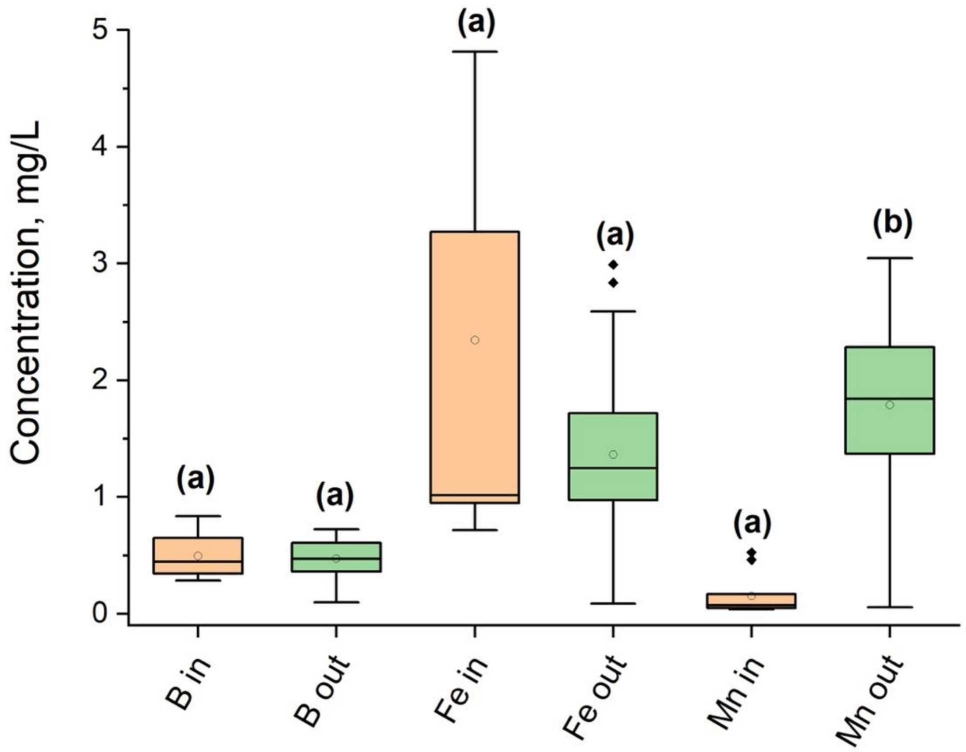


Figure 2

Figure 3

A



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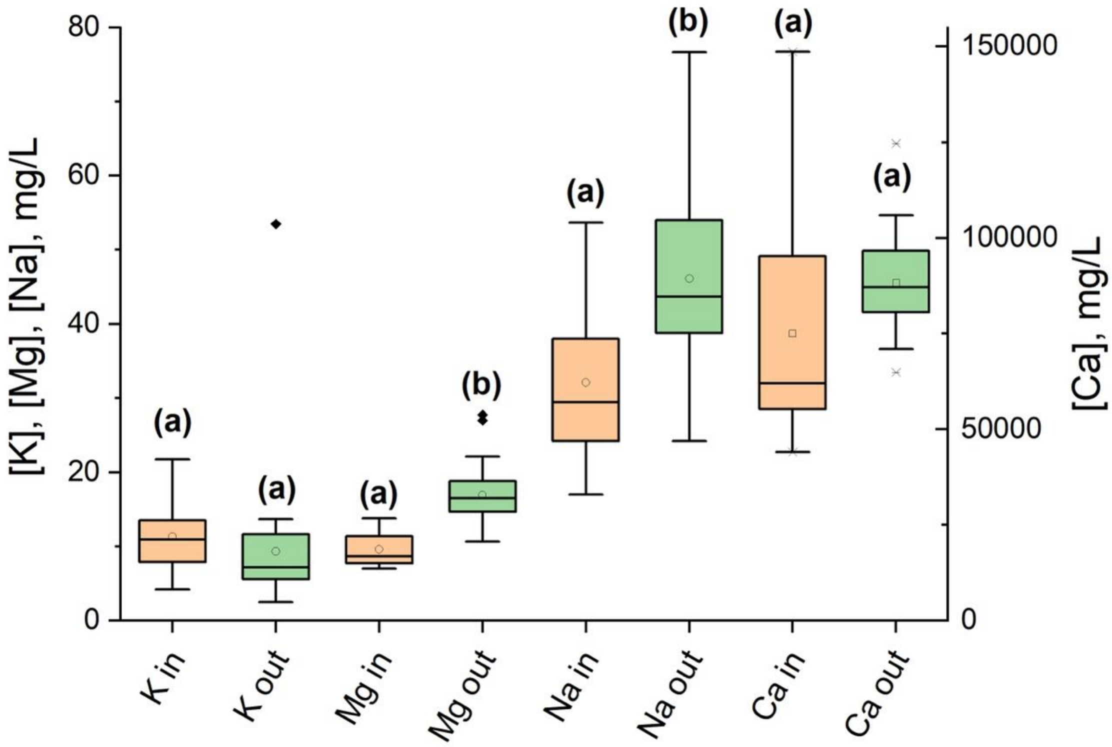


Figure 3

Figure 4

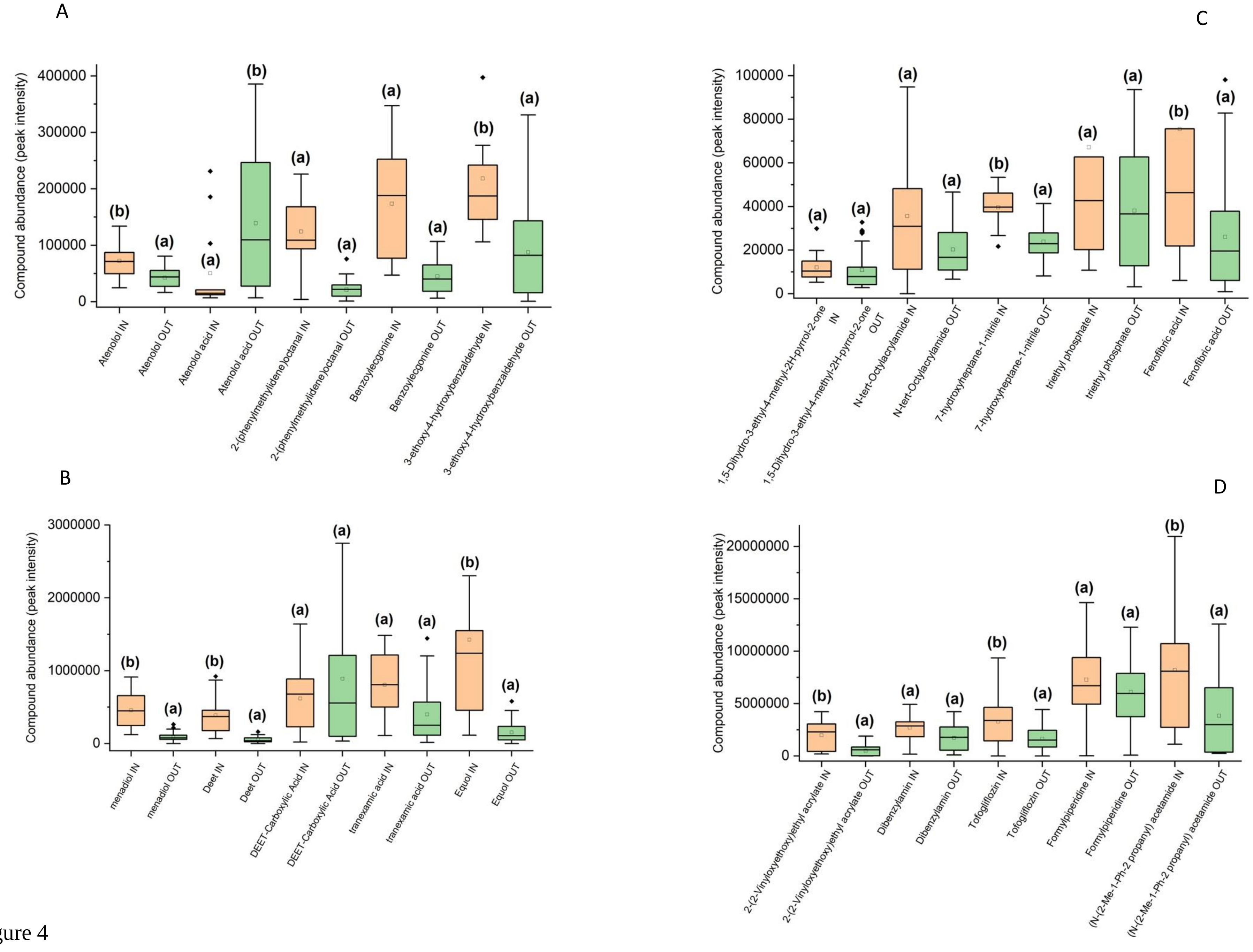


Figure 4

Figure 5

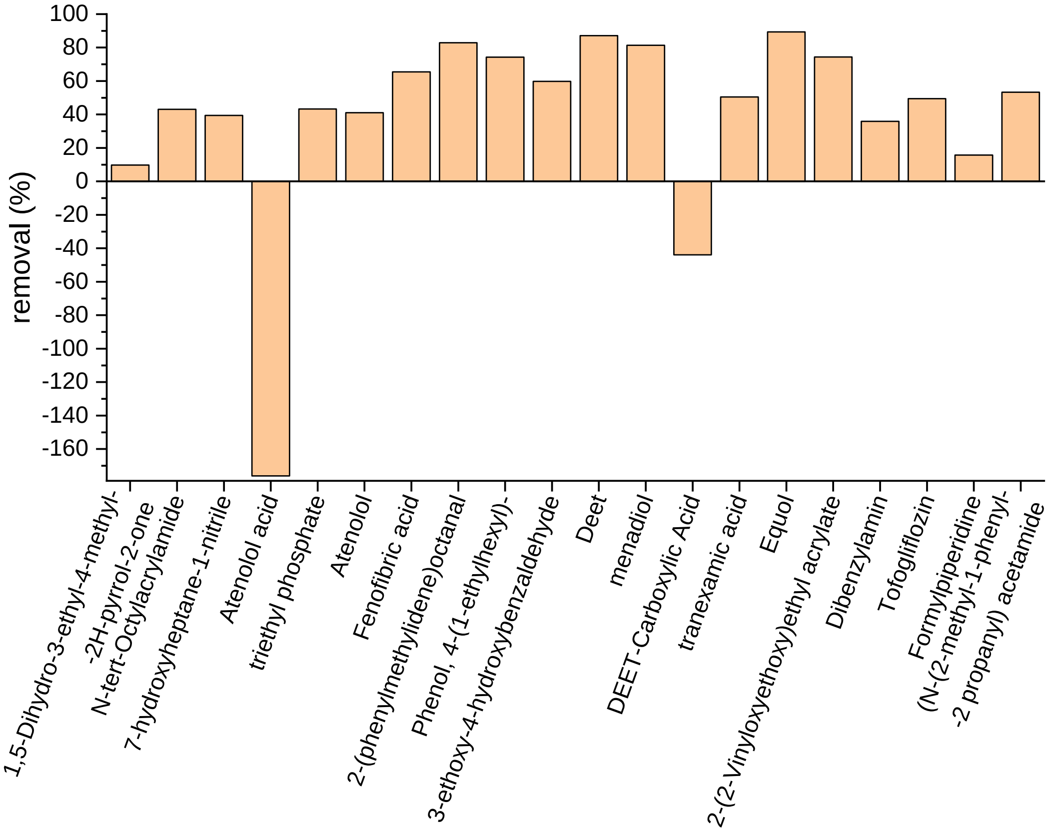
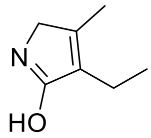
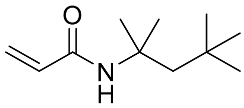
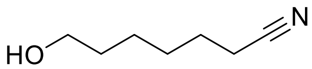
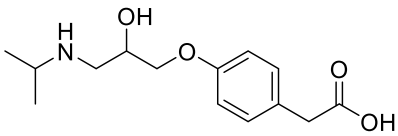
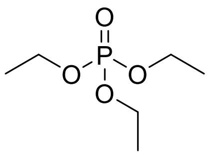
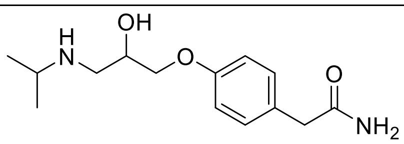
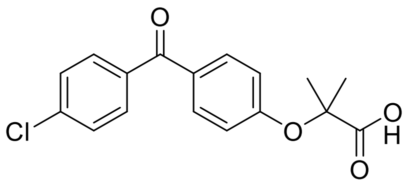
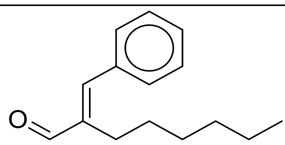
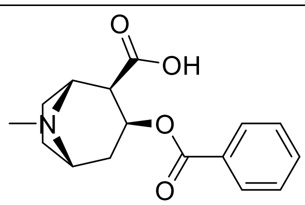
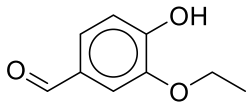
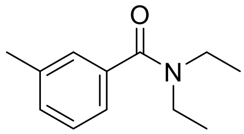
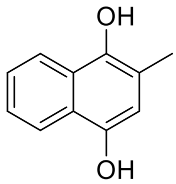
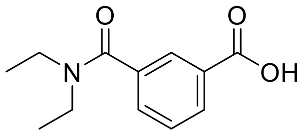
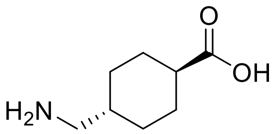
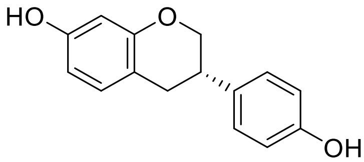
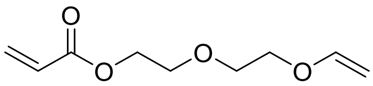
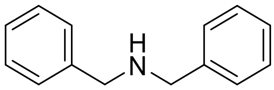
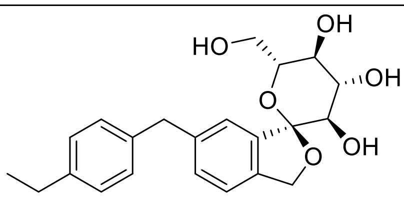
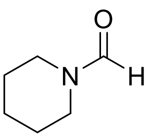
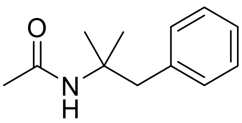


Figure 5

Table 1. CECs detected in the influent wastewater employing the database of Norman network and then refined by Sciex OS software.

Organic pollutant	**Molecular formula**	**Molecular configuration**	**Use**
1,5 dihydro - 3 - ethyl - 4- methyl - 2H - pyrrol- 2 one	C7H11NO		Chemical used for the preparation of Glimepiride, and its intermediates, used as antidiabetic agents.
N-(1,1,3,3 tetramethyl butyl) acrylamide	C11H21NO		Cosmetic (protects against UV rays)
7 hydroxyheptane 1 nitrile	C7H13NO		Industrial and manufacturing fields
Atenolol acid	C14H21NO4		“Cardioselective" beta-adrenoceptor antagonist
Triethyl phosphate	C6H15O4P		Plasticizer
Atenolol	C14H22N2O3		Beta blocker pharmaceutical
Fenofibric acid	C17H15ClO4		Food diets
2-(phenylmethylidene)octanal	C15H20O		Natural product found in *Plectranthus glabratus*
Benzoylecgonine	C16H19NO4		Metabolite of cocaine

3 etoxy 4 hydroxybenzaldehyde	C9H10O3		Food additive
Deet	C12H17NO		Mosquito repellent
Menadiol	C11H10O2		Food supplements
DEET-Carboxylic Acid	C12H17NO		Mosquito repellent
Tranexamic acid	C8H15NO2		Used in medicine against fibrinolysis
Equol	C15H14O3		Food supplements
2 - (2-vinyloxyethoxy) ethyl acrylate	C9H14O4		Chemical used to make special coatings, dehydrating agents, adhesives
Dibenzylamine	C14H15N		Chemical harmful to aquatic life
Tofogliflozin	C22H26O6		Drug for the treatment of diabetes mellitus
Formylpiperidine	C6H11NO		Solvent
N-(2-methyl-1phenyl-2propanyl) acetamide	C12H17NO		Derives from phentermine that is similar to amphetamines and acts at

			the level of the nervous system

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Conceptualization	Claudio Cocozza, Gennaro Brunetti, Claudio Di Iaconi, Giuseppe Mascolo
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Resources	Claudio Cocozza, Gennaro Brunetti, Claudio Di Iaconi, Giuseppe Mascolo
Data Curation	Claudio Cocozza, Claudio Di Iaconi, Sapia Murgolo, Andreina Traversa, Francesco De Mastro, Marco De Sanctis, Valerio Guido Altieri, Claudio Cacace, Gennaro Brunetti, Giuseppe Mascolo
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Writing - Review & Editing	Claudio Cocozza, Claudio Di Iaconi, Andreina Traversa, Giuseppe Mascolo
Supervision	Claudio Cocozza, Gennaro Brunetti, Claudio Di Iaconi, Giuseppe Mascolo, Andreina Traversa
Project administration	Claudio Cocozza, Gennaro Brunetti, Claudio Di Iaconi, Giuseppe Mascolo
Funding acquisition	Claudio Cocozza, Gennaro Brunetti, Claudio Di Iaconi, Giuseppe Mascolo