

New challenge: The Contaminants of Emerging Concern in water

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Currently the presence of the known “Contaminant of the Emerging Concern (CECs)” is one of the main preoccupations and challenges for the treatment and for the quality of water. CECs are synthetic or naturally occurring chemicals that have the potential to enter the environment and cause known or suspected adverse ecological and human health effects.

In the latest years, the Contaminants of Emerging Concern (CECs) have raised the public attention because they have recently been detected at trace level concentrations not only in wastewater treatment plant effluents, but also in drinking water. But, what do you mean by “emergent”? and what is the difference with the conventional contaminants?

The conventional contaminants are known chemical substances, fully described in the regulations and whose toxic effects on human health and on the environment are well studied. A typical example is the water contamination by heavy metals, and particularly mercury. We have all happen to hear about mercury levels in water, in fishes and everyone remembers the ritual of measuring the temperature with the mercury thermometer. Many studies exist, demonstrating the toxicity of this metal and the risk to human health, especially highlighting the effect on fetal development and on the first years of human beings’ life, according to the World Health Organization (WHO). Given the scientific evidence of its toxicity, in 2014 a UE directive came into force, banning the marketing of household devices that contain mercury in order to prevent a potential human exposition.

On the other hand, the consumer and welfare society caused the “modern“ problem of the CECs, that are defined as synthetic or naturally occurring chemicals present at very small concentration (in the range of nanogram or microgram per litre). The development of new and more sensible analytical methods allowed the detection in water matrix of these substances which have the potential to enter the environment and cause known or suspected adverse ecological and human health effects.

We have a clear idea about the significance and the impact of pollution by means of illegal and toxic discharge by industries into rivers or seas, but do we know how our daily activities, like taking the medicines, doing the laundry, having a shower or going to the bathroom, affect water contamination?

"Every daily action in our houses causes water contamination"

CECs are daily use substances and for this reason they are not perceived like contaminants. In this category we find pharmaceuticals (antibiotics, analgesics and antihypertensives), personal care products (ingredients contained in perfumes, make up, sunscreen lotions), surfactants (present in the detergents), the illicit drugs, the sweeteners, caffeine and nicotine, the pesticides and the endocrine disruptors (defined as chemical substances that can alter the hormonal system, causing feminization and abnormal sexual development).



The intensive, unnecessary and excessive use of antibiotics has caused another concern: the generation of “super-bacteria”.

The bacteria are increasingly finding the way to turn themselves invincible to the antibiotics. Figure 1 is a drawing that represents this phenomenon, where the bacterium Jerry mouse (of the cartoon Tom and Jerry), due to some circumstances has become unbeatable and immune to antibiotics’ attack. This is a consequence of uncontrolled use of antibiotics in daily activities by humans (represented by Tom cat) and only later, Tom realizes that his arm (the antibiotic) cannot do nothing in the battle against the bacterium Jerry. This example reflects the important impact of the antibiotics in our society, resulting in an absence of sanitary weapons against the bacteria attacks (human infectious disorders). Therefore, it is necessary to act on several fronts by increasing our knowledge (in order to develop new technologies and new antibiotics) and tackling the international increase of this phenomenon, keeping in mind that we will be not always winning this battle.



Figure 1. Antibiotics resistant bacteria (Cephalosporins as example of antibiotic).

CECs have been detected in wastewater effluents, natural waters (rivers, lakes and sea), groundwater and also in drinking water. In order to understand the reason, the seriousness of the problem and the failure in the system, it is important to introduce the concept of integral and urban water cycle (Figure 2). Drinking water is distributed and consumed in houses, workplaces, industries and in agriculture. After its use, it is collected through the sewer system and it is conducted in the wastewater treatment plant (WWTP), where it is treated in different steps and then discharged back

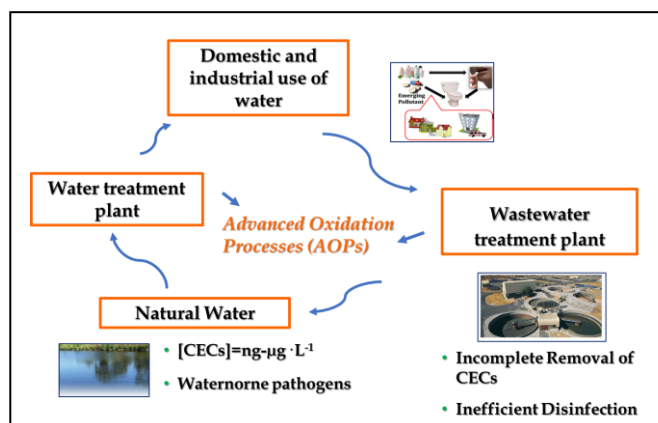


Figure 2. Integral and Urban Water cycle.

in the environment under the best

conditions. The cycle begins again by taking water from the natural environment, by later treating it in the water treatment plants and later supplying it to the end users for its use and consume.

With a clear concept of urban water cycle in mind, where is the failure in the system that causes the presence of the CECs in the natural water? And why can we find for example caffeine in tap water?

In order to answer to this question, it is necessary to consider other characteristics of the CECs: they are persistent and bio-resistant, in other words they are not degraded by the action of the microorganisms, or only partially. The wastewater treatment plants are not well designed for the

complete removal of CECs and, for this reason, they are considered as the main anthropogenic source for the release of these compounds into the environment.

"The wastewater treatment plants are the main anthropogenic source for the release of CECs into the environment "

After the release in the environment, they can undergo degradation for different causes or they can be detected in drinking water at very small concentrations because of the very low removal efficiency in the water treatment plant.

Consequently, it is fundamental to: 1) know the toxic effects of these substances on the human health and on the ecosystem at short and long term, 2) investigate and develop new analytical methods in order to detect compounds that are present at very low concentration 3) develop new technologies to remove these contaminants and implement them in the treatment plant in order to obtain a high quality water and protect the environment.

The protection of natural resources is critical and vital for the current society, its contamination is a complex problem and 'Ensure availability and sustainable management of water and sanitation for all', is one of the sustainable development goal according to the WHO.

"Water is life, don't waste it"

The research plays an important role at all stages and in the latest years a lot of projects have been founded in order to find answers to several big and emerging challenges. Among them, the ETN project AQUALity (N. 765860) aims to figure out the environmental destiny of the CECs, develop analytical tool to detect new contaminant, not yet discovered, and finally investigate new technologies for the degradation of different compounds, finding sustainable solutions for the environment. In the latest years, the Advanced Oxidation Processes (AOPs) have been proved to be effective, efficient and a valid alternative for the decontamination and disinfection of water. They are based on the generation of highly reactive species, through chemical reactions driven by light. However more investigation is needed in order to find the better technology, taking into account factors like costs, performances and sustainability of a treatment of water at large scale.

Last but not least, researchers have also the important function of informing and communicating concepts and the results obtained in laboratory to the society in order to create awareness in the general public about the global environmental problems. Only in this way, the citizen will be able to understand that his participation in this struggle is active and that it is possible to live in a sustainable way as guest and not as owner, only by acting consciously and consuming in a responsible manner.

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