ANTICANCER DRUGS IN THE AQUATIC ENVIRONMENT: WHERE SHOULD WE ACT AND IS MEMBRANE FILTRATION A SOLUTION TO THIS PROBLEM?

Maria Beatriz CRISTÓVÃO[1,2], Raphael JANSSENS[3], Jorge BERNARDO[2], Andreia BENTO-SILVA[4], Patricia LUIS[3], Bart VAN DER BRUGGEN[5], Kashyap KUMAR DUBEY[6], Mrinal KANTI MANDAL[7], Maria Rosário BRONZE[1,4,8], João GOULÃO CRESPO[2], Vanessa JORGE PEREIRA[1,8]

1. iBET - Instituto de Biologia Experimental e Tecnológica, Oeiras, Portugal, b.cristovao@ibet.pt, mbronze@ibet.pt, vanessap@ibet.pt

2. LAQV-REQUIMTE/Department of Chemistry, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal, j.andrebernardo@gmail.com, jgc@fct.unl.pt,

3. Materials and Process Engineering, UCLouvain, Louvain-la-Neuve, Belgium, raphael.janssens@uclouvain.be, patricia.luis@uclouvain.be

4. Faculdade de Farmácia Universidade de Lisboa, Lisboa, Portugal, abentosilva@ff.ulisboa.pt

5. KULeuven, Leuven, Belgium, bart.vanderbruggen@cit.kuleuven.be

6. Bioprocess Engineering Laboratory, Department of Biotechnology, Central University of Haryana, India, kashyapdubey@cuh.ac.in

7. National Institute of Technology Durgapur, M.G. Avenue Durgapur, West Bengal- India, mrinalmandal@gmail.com

8. Instituto de Tecnologia Química e Biológica António Xavier, Universidade Nova de Lisboa, Oeiras, Portugal

RESUMO

Palavras-Chave: Anticancer drugs; Occurence; Wastewater effluents; Nanofiltration

1. INTRODUÇÃO

Cancer is the second highest cause of death worldwide, with one in every six deaths attributed to this disease (World Health Organization, 2020). In 2018, there were approximately 18.1 million new cancer diagnosis, 43.8 million people living with cancer and 9.6 million deaths attributed to cancer (Ferlay et al., 2018). By 2040, the annual new cancer cases and the annual deaths due to cancer are projected to be 29.5 million and 16.4 million, respectively (Ferlay et al., 2018), indicating that the consumption of anticancer drugs will drastically increase.

Similar to other pharmaceuticals, anticancer drugs are excreted by patients and discharged into wastewater treatment plants (WWTPs). However, most of these drugs, have limited biologically degradability and thus, conventional WWTPs are expected to inefficient remove them, leading to a continuous discharge of these drugs into the aquatic environment.

Even though anticancer drugs have received less attention in occurrence studies compared to other classes of pharmaceutical compounds, these drugs have a highly potent mechanism of action. They are designed to kill rapidly growing cells such as those found in cancer tumours. However, since many of these drugs present lack of selectivity, they attack both tumour and healthy cells, and may cause cytotoxic, genotoxic, mutagenic, teratogenic as well as endocrine disruptor effects in eukaryotic living organisms (Johnson et al., 2008).

The aim of this work is to monitor the occurrence of anticancer drugs in the aquatic environment and to develop an effective treatment solution to avoid the release of these drugs into the environment.

2. ENQUADRAMENTO

Currently, there are still no strict legislations concerning monitoring pharmaceuticals in the environment, only selected compounds are included in a Watch List under the Water FrameWork directive 2018/840/EU. However, worldwide knowledge of real concentrations of anticancer drugs in the aquatic environment will help future risk assessment studies and, if necessary, will lead to the upgrade of wastewater treatment facilities.

2.1. Predicted concentrations of anticancer drugs

Prior to implementing a monitoring program, it is important to define at what concentrations anticancer drugs are expected to occur and which molecules are more prone to be found in the aquatic environment. Consumption data of up to 123 anticancer drugs was collected in Portugal, Belgium and India and used to estimate the concentrations of these drugs in surface waters of these regions (Cristóvão et al., 2020). Based on this study, anticancer drugs are expected to be present in the aquatic environment at nanograms per litre levels.

Moreover, in terms of a treatment perspective, it is important to define what is the major entry route of anticancer drugs into the environment. The results of this study showed that 94% of the total amount of anticancer drugs were delivered to outpatients, indicating that household effluents are the primary input source of these drugs and thus, upgrading the treatment in the domestic wastewater facilities should be the focus (Cristóvão et al., 2020).

2.2. Occurence of anticancer drugs in wastewater effluent

Based on the predicted concentrations, an analytical method was developed to detect the presence of six anticancer drugs in wastewater effluents (Cristóvão et al., 2021a). Several grab wastewater effluent samples were collected throughout a year and three of the target drugs (capecitabine, cyclophosphamide and ifosfamide) were detected at concentrations ranging from 7.8 to 46.3 ng.L^{-1}. Additionally, the suitability of using pharmaceutical-polar organic chemical integrative samplers (POCIS) to monitor the target drugs in wastewater effluents was assessed and similar results were found between the concentration of capecitabine detected with POCIS (32.4 ± 1.3 ng.L^{-1}) and the concentrations obtained from grab samples. The use of passive samplers brings the advantages of being easy to implement, less costly and less time consuming.

2.3. Is membrane filtration a solution?

The viability of different nanofiltration membranes to remove anticancer drugs from different matrices (laboratory grade water, synthetic urine and wastewater effluent) was addressed at laboratory scale to select the membrane with the best performance (Cristóvão et al., 2019). Several pilot scale assays were then conducted at a WWTP to test the effectiveness of the proposed solution at different periods of the year and under different contaminant loads. Nanofiltration proved to be a promising solution for the removal of these contaminants from wastewater effluents, with rejections higher than 94% (Cristóvão et al., 2021b).

3. CONCLUSÕES

Most anticancer drugs have low biodegradability, therefore, degradation in conventional WWTP is expected to be low. Indeed, the occurrence of anticancer drugs in wastewater effluents corroborates that conventional WWTPs are not effective on their removal and thus, many of these drugs may be continuously discharged into the aquatic environment. Toxicology studies should be performed to understand the impact of the occurrence of these compounds in the aquatic environment to define if they should be considered in legislation and if WWTPs should upgrade their treatment processes.

If so, nanofiltration could be a promising solution to ensure a high removal of anticancer drugs from wastewater effluents and dimmish their release into the aquatic environment.

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