EVALUATION OF EMERGING POLLUTANT DEGRADATION THROUGH THE HYBRID PROCESS OF REVERSE OSMOSIS/ELECTRO-OXIDATION AIMING AT HOSPITAL WASTEWATER TREATMENT

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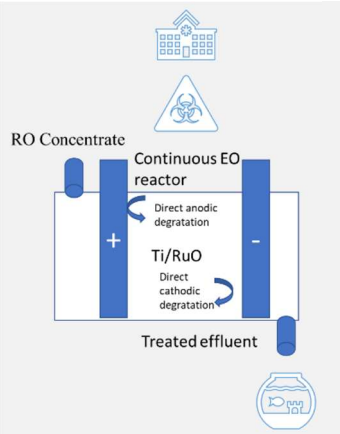


Currently, various organic compounds are detected in drinking water distributed to the population, among them, emerging pollutants (EP) which have aroused increasing interest from the scientific community due to their negative impact on public health. In this sense, there is a growing scientific search for the development of efficient effluent treatment processes, not only for the removal of these contaminants but also for the degradation of these compounds. The present study aims to develop a hospital effluent treatment process that degrades EP, preventing the compounds present in this effluent from ending up in water resources. A hybrid treatment process with reverse osmosis (RO) and electro-oxidation (EO) using DSA electrodes will be used. where the RO concentrate will be treated by EO. To develop the study, hospital effluent collected in a municipality in southern Brazil was used. Ultra-performance liquid chromatography (LC-MS/MS) was employed for effluent characterization and evaluation of EP degradation. At the end of the EO process, 99% of pollutants were eliminated within 12 hours. In terms of societal contribution, the study aims to obtain treated effluent with suitable conditions for disposal into water bodies, aiming for the concept of zero discharge of contaminants into nature.

Introduction

According to Dias (2023), the primary route of contamination of water resources with pharmaceuticals and endocrine disruptors is the discharge of sewage, both in raw form and from treated effluents through conventional processes, as EPs are not removed by them and end up being released into water bodies, posing a major global concern [1]. The presence of EP together with Bacteria in the hospital effluent acts by selecting bacteria with resistant phenotypes, contributing to the proliferation of antibiotic-resistant bacteria in the environment, posing risks to humans and animals [2]. Among the possible technologies for removing EPs from water bodies and industrial effluents is reverse osmosis, a type of membrane separation process that uses hydrostatic pressure as the driving force, widely used in effluent treatment. Studies have already shown the technical and economic feasibility of RO applied to remove EPs from hospital effluents [3]. However, the use of RO for hospital effluent treatment only separates EPs, requiring a storage location for the effluent concentrate generated by RO. In this sense, advanced oxidative processes, such as electro-oxidation, have shown promise for degrading these pollutants and bacteria present in the RO concentrate [4]. EO involves the generation of hydroxyl radicals (OH•), which are reactive oxidizing agents that promote the degradation of numerous pollutants, including EPs and bacteria [5]. The produced radicals (OH•) are known for their rapid and non-selective oxidation of organic contaminants in water and effluents [6].

Material and Methods

For the development of the study, hospital effluent from the Municipal Hospital of Estância Velha was used To develop the study, hospital effluent collected in a municipality in southern Brazil was used. The volume of effluent collected was with 0.2 m². After collection, the effluent will be characterized by (LC-MS/MS). Following the initial characterization, the effluent was treated in the RO equipment, manufactured by Sultech, with a Film-Tec RO membrane model BW30-4040, at a temperature of 25°C and a feed pressure of 4 bar. At the end of the experiment, aliquots of 100 mL were taken for characterization of the permeate and concentrate from RO by LC-MS/MS, and 2 L of the RO-treated concentrate were taken for EO assays. The EO assays were operated in recirculation, in a bench-scale system, where 2 liters of the RO concentrate were placed in the feed reactor, recirculated by a pump to the module. The module used was an acrylic type filter press with flow distributor for parallel flat plate electrodes (100 mm x 100 mm). The flow rate used in the assays was 75 L/h, controlled by a rotameter (0-250 L/h, Blaster Controls). The electric current applied was from a power supply (Manaus PS 6000 0-32V 0-6A, Icel). An electric current of 75 mA/cm² was evaluated, utilized Ti/RuO_2 as electrode material. For sample characterization, a sequential mass detection system composed of a Waters TQS Micro Detector, triple quadrupole, was used. For bacterial identification, the samples were seeded using the exhaustion technique in MacConkey agar (Biolog) and General Chromogenic agar (DIFCO - BD (Becton Dickinson)), and incubated in a 37°C oven for 24 hours. From the obtained growths, different colonies were isolated according to their color, size, and appearance. These were subcultured by exhaustion and incubated in a 37°C oven for 24 hours on the same media until pure cultures (with the same characteristics) were obtained. From the colonies isolated on General Chromogenic agar, a slide was made and stained using the Gram method. Colonies that appeared as Gram-negative bacilli were seeded in biochemical tests

and incubated in a 37°C oven for 24 hours. The media used were: Triple Sugar Iron Agar (TSI) (KASVI), Simmons Citrate Agar (KASVI), Lysine Iron Desacaboxilase Agar (LIA) (HIMEDIA), MIO Agar (Motility, Indole, and Ornithine) (Titan Biotech Ltd.), SIM Agar (Sulfide, Indole, and Motility) (DIFCO - BD (Becton Dickinson)), Urea Agar (KASVI), Phenylalanine Agar (KASVI).

Results and Discussion

The results of the electrooxidation experiments are presented in Table 1. The current used was 75 mA/cm² was evaluated for 12 hours.

Table 1. Effectiveness of (EO) process in degradation of pharmaceutical compounds.

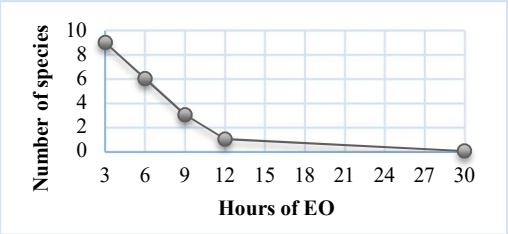
Compound	RO Concentrate (µg/L)	Concentration after EO (µg/L)
Estradiol	2.23	0.00
Ethinylestradiol	0.160	0.00
Salicylic Acid	0.02	0.00
Triclosan	4.7	0.00
Amoxicillin	7.15	0.00
Azithromycin	0.36	0.00
Ciprofloxacin	0.02	0.00
Sulfamethoxazole	0.002	0.00
Bisphenol A	8.320	0.98
Atenolol	0.47	0.00
Propranolol	0.034	0.000
Carbamazepine	0.17	0.00
Diazepam	0.01	0.00
Fluoxetine	0.05	0.00

Source: Author's own (2024)

Table 1 provides detailed results demonstrating the effectiveness of the EO process in degrading various pharmaceutical compounds within a 12-hour experimental period. Through electrochemical oxidation reactions facilitated by the EO process, structural transformations occur in the target compounds, resulting in a significant reduction in their concentrations in the RO concentrate samples. The results indicate that the concentrations of most pharmaceutical compounds, including, were reduced to undetectable levels (0.00 µg/L) after undergoing EO treatment. This demonstrates the effectiveness of the EO process in degrading a wide range of pharmaceutical contaminants commonly found in hospital effluent. However, it is important to note that the degradation of bisphenol A exhibited a less pronounced reduction in its concentration, with 0.98 µg/L remaining after EO treatment. Although this reduction is significant compared to the initial concentration in the RO concentrate (8,320 µg/L).

Among the bacterial communities found, 86% belonged to the Enterobacteriaceae family and 14% to the Enterococcaceae family. Multidrug-resistant strains of *Serratia spp*.

Graph 1 The graph 1 shows the behavior of bacterial degradation as a function of time.



Source: Author's own (2024)

The reduction of 10 bacterial species to complete absence within a 30-hour period, as shown in Graph 1, highlights the remarkable effectiveness of EO treatment in microbial elimination. Initially, the diverse presence of these bacterial species reflects the typical composition of untreated hospital effluent, containing various microorganisms and potential pathogens.

Conclusions

Based on the results presented, both in the efficacy of eliminating multidrug-resistant strains of *Serratia spp*. and in the degradation of pharmaceutical compounds, EO demonstrated its ability to significantly reduce the concentrations of these pollutants in hospital effluent, contributing to the promotion of public health and the preservation of the environment.

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